Chapter 18

National Innovation Systems: A Capabilities Approach[1]

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Abstract

This chapter describes the concept of National Innovation Systems (NIS) using capabilities approach and provides an empirical analysis to measure the concept. The discussion on the concept shows how the understanding of governments' innovation policy shifted away from a narrow stand point of direct involvement to the innovation to a broader concept that includes a complex system of institutions, infrastructure, human resources and the policy. Using this concept, the determinants of the national innovation system of the countries are discussed and different capabilities related to the system are identified. Finally, an explanatory factor analysis (EFA) is applied to identify main capabilities related to the National Innovation Systems.

1. Theoretical Foundations on National Innovation Systems (NIS)

The global interconnectedness in the 21st century has greatly increased the scope of competition and highlighted the importance of knowledge, research, and innovation in driving global economic growth. As knowledge-intensive economies have become key drivers of competitiveness, attention has also focused on the relationship between government and innovation. This chapter examines the evolving understanding of innovation policies, utilizing a model based on the capability approach to defining national innovation systems.

1 This chapter is based on some parts of unpublished doctoral dissertation of the author (Satoglu, 2016).

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1.1. The Origins of National Innovation System Approach

Ever since the Industrial Revolution at the end of the 19th century, technology has been acknowledged as a driving force for progress at the national level. This recognition was particularly reinforced during the era of intense competition between countries leading up to and following the World Wars, which prompted governments to become actively involved in technology development. At this time, economists developed the "Theory of Market Failure" and acknowledged the necessity of direct government involvement in basic science. According to this approach, basic science should be supported through public funding. The market failure theory posits that, even though firms are central players in market economies, a competitive market will invest less than the optimal amount in basic research (Nelson, 1993). Additionally, welfare economists have highlighted the absence of Pareto optimal conditions for adequate resource allocation for research. They argue that the social returns from investing in basic research are significant and higher than private returns of the same activity. The reason behind this claim is the uncertainties associated with basic research. A profit-seeking firm can never be certain of capturing all of the benefits of its sponsorship -the so-called *appropriability problem*- due to external factors that affect its ability to capture all profits created by innovation. Furthermore, there is always the risk of imitators profiting more by investing less. Given that firms are risk-averse and tend to make short-term decisions regarding resource allocation, they would not invest sufficient resources in technology development. In addition, as basic science is seen to be the main source of new ideas in the 1950s and the 60s, innovation is believed to be achieved only by large investments in R& D by industrialized countries. In other words, market incentives for research investment are found insufficient (Lundvall, 1992).

All these arguments were the basis for the belief that market equilibriums fail to provide sufficient funds for basic science. Thus, scientific research should be supported through public subsidy. As a result of this common perspective, government direct funding on R&D was seen strategically significant throughout the first half of the 20th century. On the other hand, recently the reality has changed tremendously. Since the mid-1960s, it is observed that civilian R&D has grown rapidly in the industrialized area, both in real terms and as a percentage of GDP. In addition, the notion of strategic organizations of the firms opened new roads for the economies.

On the other hand, Schumpeterian criticism to the linear model underlines the belief that innovation is the "economic application of a new idea." The creation of innovation depends on how the knowledge and the learning process are managed. So, the innovativeness of a national economy cannot be explained by linear model and found dependent more on the capabilities of a firm or a nation to make use of knowledge instead of introduction of radical innovation and high R&D investments into basic science. According to Cantwell and Janne (1999), the problem for creating technology development is not market failure for the knowledge and skills created by R&D, but a lack of the tacit capability that is needed to exploit such knowledge. In other words market failure would not be a relevant argument for the firms that are capable of exploiting the returns from the R&D investment. Recent opportunities in cross-border activities justify the new perspective for the significance of firm level innovation in the global economy.

In this context, in the late 1980s, the innovation system approach became increasingly popular. The ultra-national institutions such as World Bank, UNCTAD, EU, OECD all adopted the broad definition of the innovation system approach in their analysis. Opposing to the neoclassical paradigm, innovation system approach argues the tacit component of the innovation that knowledge, which is critical for innovation and results in national growth, is localized and cannot be transferred easily.

From the neoclassical economics perspective, New Growth Theory provided theoretical justification for the new understanding for private sector's involvement in innovation. The theory argued the existence of potential increasing returns from higher levels of capital investment that would provide private firm to gain from innovative investment.

According to Romer, "Growth in this model is driven by technological change that arises from international investment decisions made by profit-maximizing agents." (Romer, 1986) From a micro-level perspective, knowledge has become the principal weapon in competition for profits and corporate survival. Due to the fact that modern economy is a "knowledge-based economy", the sharply rising knowledge intensity made business strategy makers to learn more on how to attain that knowledge while governments were changing their roles. In addition, it is obvious that under the changing determinants of the international business environment, the role of the governments as a public research subsidizer has to be revised.

It is certain that with recent theoretical extensions, there is more room for private investment, but it is obvious that even in the new growth theory the role of the governments and management, organization and strategies of the private agents are neglected. Teece argues how markets and economic organizations complement each other for innovation. Managers have critical roles to play inside the organization and they can also shape the evolution of technologies and markets themselves (Augier and Teece, 2009) and, governments can facilitate innovative activities by taking roles in the socio-economic organization for the process. To sum up, although new growth theory provides theoretical grounds for many implications of the recent innovative systems, for a better understanding of economic performance of the countries, a more complete understanding of the role of management and entrepreneurship in enterprise performance, and of enterprise performance in economic development and innovation is necessary. In this regard, in the following section, a more detailed analysis of the national systems of innovation will be discussed.

1.2. Towards a broader Perspective for the National Innovation Systems

The discussions on national innovation systems can be seen in the lights of the theories that put knowledge into the production recipe and describe it through an environmental context in which the firms are embedded.

The narrow definition of the national innovation has focused on science and technology relationship and measured it through direct public investments for the basic research. However, in the last three decades, while the global market, its rules, volume, and structure have changed dramatically, correspondingly, the understandings of the national system of innovations and the roles of governments in these systems have transformed, broadened and diversified. Thus, the main weakness of the narrow approach has been seen in its limitation to explain varieties of innovation across sectors, countries, firms and their institutions (Cantwell and Janne,1999). For instance, at the institutional level, each country has variety of capabilities, different levels of technological capability accumulation that affect their patterns of in NIS. But, the linear model of innovation that involves direct government involvement to the innovative activities are not enough to address such diversities. In other words, when the countries differ in their technological capital accumulation, absorptive capabilities, infrastructure and institutions, their capabilities for generation of location and firm-specific advantages also differ. But, the conventional definition for the innovation lacks evaluates such progresses.

Knowledge Spillovers

The advances in national innovation system enable us to understand the complexity of technology creation. Technology development is a complex procedure that includes the relationships among the actors of the system such as firms, universities and government research institutes. These interactions among the technology-involved actors and institutions are keys to comprehend the innovative performance of the countries. In other words, in today's world two main characteristics of NIS are knowledge generation and transmission.

Knowledge is shared and distributed, and its transmission through learning is essential for such a society to make effective use of it. In this regard, networks and linkages that provide spillovers recently undertake significant roles in knowledge creation and diffusion. The integrated networked corporations with absorptive capacity create the necessary knowledge for competition using these channels. Thus, for our argument of the existence of a reverse relation, the key foundation actually lays at the fact that internal R&D is necessary but not sufficient for innovation. In recent years, several studies emphasized the role of 'spillover effect' for innovation and growth. Since spillovers suggests the unintended nature of the knowledge flow from the point of view of the individual actor undertaking research, it is logical to argue the higher intensity of spillover is probably in more knowledge based and intensive innovative systems. Spillovers suggest the transfer of knowledge frequently takes the form of non-market interaction. In fact, the more knowledge intensive an activity is, the more it depends on non-market interaction. As a result, clustering of activity, both geographically and in terms of inter-industry linkages is common in many industries, particularly in high-tech sectors such as biotechnology, electronics and computers, and software. Clustering facilitates the sharing and transfer of knowledge, competence, and skills. Thus, a well-established innovation mechanism is the driver for innovation creation especially for the developed nations where their main industries are knowledge-intensive.

It is also significant that countries with persistent growth show sectoral diversity in their production portfolio towards more capital and techno-intensive sectors (Vertova, 1995). High intensity of knowledge within a sector/country means more spillover externalities within that country's national innovation system to be shared and collaborated by the firms located within the system. In turn, that would promote the rate of innovation positively.

Analyzing innovation within an economic system is certainly an idea firstly adopted by Schumpeter. In his studies on long-run economic and social change, he focused in particularly on the crucial role played by innovation and the factors influencing it. Schumpeter broadened the perspective from focusing only on cost reducing new machinery to include other types of innovation as well such as product innovation, organizational innovation. (Mokyr, 2005) He defined innovation as "new combinations" of new or existing knowledge, resources, equipment and so on (Schumpeter, 1949). He also pointed out the difference of innovation from invention "the original idea for a new product or process" in a way that innovation is a specific social activity carried out within the economic environment and conversed into a commercial product, while inventions in principle can be carried out everywhere and without any intent of commercialisation. He was emphasizing the dynamic nature of the economic system instead of stationary processes of neoclassical theories.

Freeman by quoting from Schumpeter points out that innovation constantly revolutionizes the economic structure and that 'this process of creative destruction is the essential fact about capitalism' (1990, quoting from Schumpeter 1943). Freeman developed his theory in a broader direction and "multiple sources of information inputs from within and outside the innovating organization and the importance of a 'national system of innovation' as the supporting network of scientific and technical institutions, the infrastructure, and the social environment (Freeman, 1990)".

Recently, following the belief in 'Innovation is the basis of profit', firms are more actively involved in the innovation process. The role of the governments in the innovative performance of their country shifted to a broader capability creation such as institution and network building, and maintaining local infrastructure. In other words, in today's world two main characteristics of NIS are knowledge generation and transmission through several channels (Arranz et al., 2020). The system helps to provide ground to the users and producers of knowledge and also enables institutional arrangements for an efficiently functioning system. In other words, the roles of governments grow out as an agent that facilitate the creation of tacit capability which is required for innovativeness. In order to compete or imitate each country must have its own tacit capability for knowledge transmission. Therefore, a well-functioning government would help to lower the costs by actively joining the capability and institution building process.

Nelson conceptualized National Innovation Systems as '*a set of institutions whose interactions determine the innovative performance ... of national firms.*' (Nelson, R. (ed.), 1993) In his approach, institutions and actors of specific industries play decisive roles and create diversity of innovation approaches in different countries. To Pavitt and Patel, NIS are "the national institutions, their incentive structures and their competencies that determine the rate and direction of technological learning in a country" (Patel, P. and Pavitt, K.L.R.,1994). The national institutions refer basically to business firms, universities, public and private institutions that generate general education and vocational training. The incentive structures can be exemplified as government support for basic research, monopoly profits gained for innovation, the pressure for imitation, intellectual policy protection, and the competitiveness stems from international differences (Nelson, 1992). Finally, international technology gaps, inter-firm differences in competence are the competencies of NIS. These definitions address three main components: First, having peculiar characteristic of the national borders: 'locality'; second, historical perspective for innovation referring to the roles of individual firms and other actors: 'institutional setting of the country'; and third, having different patterns of 'learning' across nations as an extension from the first two elements. In this broader environmental perspective of innovative system of a country the central role of R &D manpower and the need for a strong technological base at national level are strongly emphasized. But, national spending on R&D relatively diminishes and government begins to contribute to instructional "capabilities" to absorb and promote innovation through maintaining local infrastructure and institution buildings, network buildings and through joining human capital creative activities such as supporting research universities and training programs. Another function of the government might be to appeal FDI into their country in order to benefit from spill-over technology effects.

In brief, NIS analysis approach argued in this chapter tries to address all the main components of its broad concept and explores country-specific capabilities related to the system.

1.3. Capabilities Approach in NIS Literature

Incorporation of technology into a systematic policy analysis is not easy to conceptualize and measure. Therefore, to address embeddedness of the process several works used 'capabilities' approaches.

Social capability, as a word introduced by Rosovsky (1973) has seen as a key component for the strength of the national innovation and growth. Nations that have the capability in adapting best practice technology and economic organization are expected to have technical competence. Level of education, experience in the organization and management of the large scale enterprises, financial institutions and markets capability of mobilizing capital on a large scale and trust in business life are characteristics of the social capability (Abramovitz, 1986). However, due to the ambiguity of these properties, measurement of social capability reduced to a form of measurement of educational attainment that is a very limited element to address the concept of the 'social capability' of Abramovitz.

At the firm level, Cohen and Levinthal (1990) argued 'absorptive capacity' to understand "knowledge creating companies" and explained it as 'ability of a firm to recognize the value of new, external information, assimilate it and apply it to commercial ends."

In recent years, newly industrializing countries have brought new perspectives on the dynamics of the global economy in terms of openness and advances in technological capabilities. From Korea, 'technological capability' of Linsu Kim has become popular and is used as a composite term for production capability, innovation capability and the investment capabilities of a nation. The word is conceptualized as "ability to make effective use of technological knowledge in efforts to assimilate, use, adapt and change existing technologies" (Kim, 1997). So, the concept addressed broader perspective that the organized R&D for technology development but also exploitation capability.

These terms has emerged as the aspects of technology development and suggested and empirically analyzed in recent years in the innovation literature (Edler and Fagerberg, 2017). Fagerberg (2007) used explanatory variables in identification of the NIS and emphasized social capabilities and the political system in addition to the innovation related indicators for a NIS. He found a big overlap in these capability related concepts and addressed the weakness of the empirical work in the area.

2. Determinants of National Innovation Capabilities

The most significant weakness of the research on the capabilities based national innovation and development related empirical work is the lack of the appropriate data. Nevertheless, following the innovation system discussions of the 1990s (Lundvall, 1992; Nelson, 1993; Edquist, 1997), the research focus and subsequently the availability and the quality of the data on national innovation have improved. Particularly for the developed countries, thanks to the wide recognition of the significance of innovation, data construction to measure innovation-related indicators is widely supported. Scholars also developed ideas to find for easiness of the measurements. Table 1 summarizes how some capabilities are defined in the literature of NIS and which indicators are suggested to measure those capabilities. These efforts for the measurement of the NIS might increase our understanding for the role of the national innovation policy differences in development and FDI.

Table 1: Capabilities and related data used in the Literature

National Innovation System	Related Data
Innovation Capability	• R&D Expenditure • Number of Patents Granted • Number of Articles Published • Citations • University Rankings
ICT Infrastructure	• Personal Computers • Internet users • Fixed/ Mobile phone subscribers
Production Capability (Kim, 1997)	• ISO9001
Openness	• Trade • FDI
Social Capability (education) Baumol et al.(1989)	• T/pupil ratio in primary schools • Rates of enrollment in secondary and tertiary • Number of engineers/ natural scientists
Social Capability (Abramovitz, 1986)	• Law and order • Independence of courts • Property rights • Business Regulation • Corruption • Degree of democracy • Checks and Balances in Politics • Political and civil liberties
Financial Capability (Kim, 1997)	• The amount of credit (to private sector) • Capitalization of companies listed in domestic capital market
Historical Process *For inference	• Language • Religion • Ethnic Divisions • Colonial Legacy

Since two main characteristics of NIS are knowledge generation and transmission, technology development would differ from one country to another. "How one country can be better than another in technology development?" is the very basic question, which our capability approach for national innovation systems basically asks and tries to measure country performances for science, technology and innovation. However, it is not easy to measure how a nation can take advantage of basic research papers or commercial good ideas or spillovers around the system. Thus, innovation system approach deals with how knowledge is managed, transferred and utilized in order to result in innovative output. That's why learning and diffusion of knowledge in innovative activities (Lundvall, 2007) are very central in NIS approach.

Thus, in measurement of the National Innovation Systems, innovation policy is measured with several components. For an accurate measurement different approaches are adopted and social, institutional, technological and macroeconomic aspects of the systems are included to the analysis. In the previous studies, all analyses are basically focused on some key components; first what a nation spends on R&D and human capital of the country. Research and Development expenditures show resources to be used in innovation processes. Public R&D expenditures are not only direct support for research, but also expenditures for universities and government research programs. In addition R&D expenditures are not limited to public sector. As discussed in theory section, private agents spend increasingly more resources for research.

Human capital is integral to a nation's capacity of innovation and it competitiveness in global rivalry. Governments around the world provide increasing access to tertiary or higher level education for their populations, as science and engineering skills have become core to the development. Populations are empowered with better access to information via advances in technology and wider education at tertiary level. Skilled workforce is key to the knowledge intensive production. Thus, schooling components are significant and since Baumol et al.(1989) enrollment and schooling rates broadly included to the NIS measurements.

How many students are enrolled in science and technology disciplines has significant importance however there is little data on it. Despite the lack of proper data for each country for science-based education and their quality, it is known that access to higher education has increased in all around the world and high skill workers has higher mobility in global market.

Quality of the scientific research in a country can be measured through examining research-strength of its universities and the citation rates of the scientific publications from that country. Although in the last decade several private agents such as Shangai University Rankings and Times Education Rankings publishes university rankings and indexes for quality of publications, it is not easy to access data for the pre-2004 and the universities of a vast range of countries are not always listed in the top university lists.

Ability to access communication is also a key component for increasing integration to the world and contributes to the improvement of human capital through providing faster access to the information. That is why information and communication technologies (ICT) and related infrastructure of a country widely accepted as part of the innovation system of a country.

Quality standardization is an additional indicator for understanding a country's production capability. So, ISO 9001 certification as a high quality standardization for the firms can be added to the empirical analyses.

Although several innovations are not registered, number of Patents applied and granted by the inventor originated by a country is widely accepted reliable data to measure 'innovation capability' of a country (Kim, 1997). Thus, patent counts are one of the important determinants of the NIS.

As part of the broad NIS tradition, supportive national environment is key to understand social and institutional aspects of the system. Property Rights and freedom from corruption are qualitative assessments to address rule of law in a country. The property rights measures to what extent a country's laws protect private ownership and how strong the law enforcement is. A country with a stronger legal system and protection of the private ownership is expected to be more efficient for innovation since returns from private investment on R&D would be secured. Likewise, corruption, which reduces trust into the market, is negatively correlated with innovation (De Soto, 1989). Thus, freedom from corruption is recognized as a significant indicator for NIS.

Fiscal freedom is a component to address regulatory aspects of the government policies and their efficiency. The indicator is a composite measure of the level of taxation and demonstrates the burden of tax on individuals and firms. Likewise, government spending is a variable to be added to understand the size of the government consumption and burden as share of GDP. Although there is no ideal level for government expenditures, high budget deficits and excessive public debt is a burden for the society and results in inefficiency and the lack of further innovative investment.

Investment freedom evaluates incentives or restrictions for both foreign and domestic investment. Less restrictions on payments, transfers and transactions would stimulate investment rates and supports innovation systems. Similarly, monetary freedom is an indicator for price stability and inflation. Higher freedom would mean market efficiency.

Trade freedom is a measure for openness. Secondly, barriers for trade would limit product diversity of the local market. Thus, it is included as a critical component for the innovation system analysis.

Financial freedom explores the level of independence of the banking system. Higher financial freedom means lower public banks and less intervention to the financial institutions. If the banks, domestic or foreign, are free in their operations such as crediting, foreign exchange, then higher competition in capital markets and regulatory efficiency can be expected. Likewise, domestic credits provided to private sector as percentages of the GDP and market value of the domestic firms on the country's stock exchange market are added to the model to measure the efficiency of the financial sector.

Finally, we should address that several other determinants might be considered as part of the NIS depending on the measurability and data availability. Developed countries have abundance of data particularly in science field. On the other hand, developing countries data are limited in several useful indicators.

2.1.Explanatory Factor Analysis (EFA) as a Methodological Approach for NIS

Innovation, due to its complex and peculiar nature is hard to measure and compare in comparative analysis. Across the firms, industries, countries, and regions we have seen the variety of innovative activities and the complexity of the nature of technological accumulation. Nevertheless, desire for a better understanding of the innovation systems provided progress in our conceptualization and better data collection in recent years.[3]

First, we need to address problems in measurement of national innovations systems since NIS are very complex and for a panel analysis very heterogeneous. That's why a broad number of indicators are used in the analysis that makes "Factor Analysis" method critical as a methodology.

In measurement of the development of technological environment over time, Factor analysis helps us to work with several variables that we can limit their information and convert non-observable hypothetical variables. A set of correlated variables as we call them factors, address to the specific aspects of the innovation systems.

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3 A deeper analysis of the various measures can be found extensively in the works of Freeman, 1987; Grilliches, 1990; Patel and Pavitt,1994.

When the data has relatively large number of indicators, one of the most widely used approach for the construction of composite variables is the so-called "factor analysis". The simple idea behind the method is that similar indicators will be correlated and this fact can be used to reduce complexity of the large datasets (Basilevsky, 1994).

In our empirical analysis, we will use the explanatory factor analysis model and the results of factor loadings will help to identify capabilities related to the National Innovation System.

Data

The data to be used in this analysis, collected from several sources. [4] Although initially 200 countries and 27 relevant indicators are collected, for the problems of missing data, 79 countries and 21 indicators are included to the EFA analysis. We aimed to optimize the longest time period and widest country coverage. Likewise, during EFA analysis, three of the indicators are excluded for cross-loading problems.

In order to deal with problems related to time and country sizes, constant numbers are used and per capita measurement is preferred. The data is structured as panel data and covers 30 years from 1985 to 2014. Since we still have a missing data for many countries for some indicators, the total number of observations is 1746.

EFA Results

The results for the 1746 observations for the retained factors are given in the following table.

4 See Appendix A for details of data.

Table 2: Results for Factor Analysis

Variable	Human & Production Capacity (F1)	Macro Institutional Capability (F2)	Innovation Capability (F3)	Liberal Structure (F4)
Fixed and mobile phone subscriptions	0.93			
Internet users	0.86			
Gross Tertiary school enrollment	0.66			
Gross Secondary school enrollment	0.51			0.52
ISO 9001 certifications	0.61			
Freedom of Trade	0.55	0.39		
USPTO Patents granted			0.82	
USPTO Patents applications			0.75	
R&D expenditures			0.73	0.45
Domestic credit to private sector		0.48	0.49	
Market capitalization of the listed companies		0.4		
Property rights		0.79		
Freedom from Corruption		0.71		
Financial freedom		0.69		
Investment freedom		0.63		
Monetary freedom		0.44		
Fiscal freedom				-0.66
Government Spending				-0.75

** blanks represent abs(loading) <.35*

As a result of EFA analysis, National Innovation system scores are obtained for the 4 factors with eigenvalue >1. These factors explain 99% of the total variance in data.

The first factor loads highly on several variables related with social, technological and production capacity of the countries. Information and communication infrastructure, and education attainment as means of ability to access information have high loadings. In addition, this factor also correlates highly with ISO 9001 certificates that is an important aspect to understand production capability of a country. Freedom of trade that has 0.55 loading is also interpreted as part of the ability of accession of the system for more diversified and high quality products from global market. Thus, we labeled first factor as "human and production capacity"

F1: Human and Production Capacity: ICT infrastructure, education, ISO 9001 product registration and openness

Second factors loads significantly high in institutional aspects. The rule of law within a society that is measured through property rights and corruption indicators load 0.79 and 0.71 respective in factor 2. A strong judicial system and lower uncertainty within a country positively correlates with the national innovation system. Similarly, regulatory efficiency of the market (financial freedom) and credit availabilities in addition to the investment and monetary freedom scores are strongly and positively correlated in factor 2. Thus, we defined this second factor as macro institutional capability. The stronger the macro institutional capability, the countries would have more efficient national innovation systems.

F2: Macro Institutional Capability: Political freedom, fiscal freedom, property rights, education

The third factor correlates highly with innovation indicators. Patent numbers load 0.82 and 0.75 and public R &D expenditures have loadings as 0.73. This factor is also influenced by the credit to private sector which can be seen public sector support to private agents for their projects which would strengthen resources for innovation.

F3: Innovation Capability: Patents applications and grants, R&D expenditures, domestic credit to private sector.

The fourth factor loads highly and negatively on fiscal freedom and government spending indicators. These indicators measure if the taxes are burden for the market and how the government expenditures affect the efficiency of the market.

Higher tax burden and high government spending have negative impact on the national innovation. R &D expenditures and education scores also have significant loadings in this factor, that we found related with the overall structure of the government. Thus, fourth factor is labeled as "liberal

F4: Liberal Structure: Fiscal freedom, government spending, schooling and R&D expenditures.

3. Concluding Remarks

The recent global expansion of markets has necessitated the networking of actors and institutions for the development of national innovation. In this context, the roles of governments have shifted from being active and direct participants in the innovation process to serving as catalysts for the institutional framework of innovation. From this perspective, both governments and firms engaged in the innovation process interact with the market structure and other institutions.

One of the key takeaways from this chapter on innovation systems is a deeper understanding of the complexity of national innovation systems. It is clear that there is still much to learn about the various features of innovation policies across countries. However, the findings in this chapter provide sufficient tools for comprehending the linkages between systems and processes. This comprehensive view of the national innovation systems also aids in understanding the factors that influence national innovation institutions, as well as the related capacity, capability, and institutional structure in the creation and diffusion of technologies. In this regard, governments contribute to the development of instructional capability to absorb and promote innovation. This overall picture highlights the integrated nature of these relationships, while also emphasizing the need for a new understanding of technology development.

This chapter also offered an EFA analysis to measure the capabilities approach to the National Innovation Systems. Although there are real challenges in measuring the complexity and diversity of national systems and conceptualizing them, our explanatory factor analysis in this chapter identified four critical factors related to national innovation systems: Human and Production Capability, Macro Institutional Capabilities, Innovation Capabilities and the Liberal markets capabilities.

REFERENCES

Abramovitz, M. (1986). Catching up, forging ahead, and falling behind. *Journal of Economic History* 46, 386-406.

Arranz, N., Arroyabe, M. F., Schumann, M. (2020). The role of NPOs and international actors in the national innovation system: A network-based approach. Technological Forecasting and Social Change, 159, 120183. https://doi.org/10.1016/j.techfore.2020.120183.

Baumol, W. J., Batey Blackman, S. A., & Wolff, E. N. (1989). *Productivity and american leadership: the long view*, Cambridge, MA: The MIT Press.

Cantwell, J., Janne, O. (1999). Technological globalisation and innovative centres: the role of corporate technological leadership and locational hierarchy. *Research Policy, Elsevier, vol. 28(2-3), pages 119-144*.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 128-152.

De Soto, H., & Instituto Libertad y Democracia (Lima, Peru). (1989). *The other path: The invisible revolution in the Third World*. New York: Harper & Row.

Edler, J. & Fagerberg, J. (2017). Innovation policy: What, why, and how. Oxford Review of Economic Policy, 33(1), 2-23. https://doi.org/10.1093/oxrep/grx001

Edquist, C. (1997). *Systems of innovation: Technologies, institutions, and organizations.* London: Pinter.

Freeman, C. (1987). *Technology policy and economic performance: Lessons from Japan*. London: Pinter.

Freeman, C. (1990). Schumpeter's business cycles revisited. In A. Heertje and M. Perlman (Eds.), *Evolving technology and market structure: Studies in Schumpeterian economics (pp.* 17-38*)*. Ann Arbor: The University of Michigan Press.

Fagerberg, J. (1994). Technology and international differences in growth rates. *Journal of Economic Literature, 32,* 1147-1175.

Kim, L., (1997). *Imitation to innovation: The dynamics of Korea's technological learning*. Harvard: Harvard Business School Press.

Lundvall, B. Å. (1992). *National systems of innovation: Towards a theory of innovation and interactive learning.* London: Pinter Publishers.

Mokyr, Joel. (2005). Long-term Economic growth and the History of Technology. In Philippe Aghion and Steven Durlauf (eds). 1(1), Elsevier.

Nelson, R. R. (1992). National innovation systems: A retrospective on a study. *Industrial and Corporate Change*, *1*(2), 347-374.

Nelson, R. (Ed.). (1993). *National innovation systems. A comparative analysis*. New York/Oxford: Oxford University Press.

Pavitt, K. L. R. (1991). What makes basic research economically useful? *Research Policy, 20*(2), 109-20.

Patel, P., & Pavitt, K. L. R. (1994). National innovation systems: Why they are important, and how they may be measured and compared. *Economics of Innovation and New Technology, 3*(1), 77-95.

Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy, 94*, 1002-1037.

Rosovsky, H. (1973). *Japanese economic growth: trend acceleration in the twentieth century*. Stanford University Press.

Satoglu, E. B. (2016). *The Role of national innovation systems on FDI*. [Unpublished doctoral dissertation]. Rutgers University.

Schumpeter, J. A. (1943). *Capitalism, socialism, and democracy*. London: Allen and Unwin.

Schumpeter, J. A. (1949). *The theory of economic development (German original 1912)*. Cambridge, MA: Harvard University Press.

Vertova G., & Krugman, P. (1995). *Development, geography and economic theory.* Cambridge, MA: MIT Press.

APPENDIX A

Variable	Scale	Source
Gross Secondary school enrollment	per capita	WDI, Global Education Digest 2015
Gross Tertiary school enrollment	per capita	WDI, Global Education Digest 2015
Internet users	per 100 people	World Telecommunication Indicators, 2015
Market capitalization of the listed companies	% of GDP	World Development Indicators, 2015
Fixed and mobile phone subscriptions	per 100 people	World Telecommunication Indicators, 2015
USPTO Patents applications (residents)	per capita	USPTO, 2015
R&D expenditures	% of GDP	World Development Indicators, 2015
Property rights	Index 0-100	Heritage Foundation, 2015
Financial freedom	Index 0-100	Heritage Foundation, 2015
Fiscal freedom	Index 0-100	Heritage Foundation, 2015
Freedom from Corruption	Index 0-100	Heritage Foundation, 2015
Government Spendings	Index 0-100	Heritage Foundation, 2015
Freedom of Trade	Index 0-100	Heritage Foundation, 2015
Investment freedom	Index 0-100	Heritage Foundation, 2015
Monetary freedom	Index 0-100	Heritage Foundation, 2015
USPTO Patents granted (residents)	per capita	USPTO,2015
ISO 9001 certifications	per capita	ISO 9001 Surveys
Population		World Development Indicators, 2015
Gross Domestic Product	percapita, constant, 2005	World Development Indicators, 2015