Complementarity between Human Capital and Research and Development Activities

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Abstract
National Innovation System (NIS) approach specifically focuses on the interactions among the components of system as the basic dynamics of innovation process. Thus, there is a complementarity between the components of system which arises from the interactions among them as the most significant factor effecting innovation performance of whole system. The aim of this study is to examine the complementarity between Human Capital and Research and Development (R&D) activities in NIS. Using Canonical Correlation Analysis method, we calculate the interactions among the set of variables related to Human Capital and R&D activities within the European countries. Empirical findings indicate that there is a significant interaction between components of Human Capital and R&D. As argued by NIS approach, these two dimensions are linked together by a set of two-way dynamic relationships. Thus, deeper understanding of the impact of R&D on innovation performance needs combined analysis getting R&D and Human Capital together. The most important policy implication of the results is that policies focusing to enhance only one component of system are not enough to improve innovation performance since there is a complementarity among components of NIS. For example, innovation policies like European Union aiming to increase R&D-to-GDP ratio to certain level is not enough without systemic design of other factors related to Human Capital.

Keywords: National Innovation System, Research and Development, Human Capital.

Introduction

During the last decades, a number of studies have investigated that innovative capability of nations are closely related to their economic performance. Accordingly, scholars in the field of innovation studies have focused on the dynamics of innovation process as a basic source of productivity growth. However, there is no agreement on what indicators should be used for measurement and assessment of innovation process in the literature. Nonetheless, in the1970s and 1980s, it can be argued that Research and Development (R&D) activities have been perceived as one of the main driving force of innovation process. Accordingly, the innovation studies focused on the indicators like expenditures on R&D and direct results of R&D like the number of scientific publications and patent. It seems that innovation process has been mainly analysed by the linear models based on the causality relation from R&D activities to innovation. Accordingly, innovation process begins with basic and applied research and advances through testing invention in commercial market by firms. Thus, innovation is seen as an output of a linear process performing in a sequential order (Samara, et. al, 2012: 624).

From the beginning of the 1990s, systemic perspectives have been widely used to examine the dynamics of innovation process. In the framework of systemic perception of innovation, it has been argued that innovation exists in a system consisting of different components and performs depending on interaction of these components. Thus, while systemic perception became main approach to understand the innovation process, economists focused on the range of indicators symbolising different components of innovation system as the basic analytical tools. Under this line of view, the thinking analysing innovation process from a systemic perspective at the national level has been called “National Innovation System (NIS) approach”. In the framework of systemic perception, NIS approach argued that interaction or complementarity among the system components is a significant factor effecting innovation dynamics and performance.

NIS approach has changed the views concerning with the R&D activities as a basic dynamic of innovation process. Systemic perception argued that all components in the system can fulfil their functions by only inter-acting each other. Thus, R&D activity as a component of the system can also fulfil their functions by only inter-acting other components of the system. In other words, the impact of R&D activity on innovation process is an endogenous factor affected by other components of NIS. Therefore, we have limited insights on the drivers of innovation process at national level if we focus on R&D activity as a basic dynamic of NIS. Ignoring the complementary among system components also results in misuse and even abuse of policy implication concerning with R&D activities.

Under this line of view, our study aims to show the complementarity among the components of NIS. Accordingly, we have empirically examined how Human Capital accumulation and R&D activities interact in the generation of innovation process in European countries over the period 2000-2013. Thus, we try to investigate the argument of NIS approach concerning with the complementarity among Human Capital and R&D activities in the innovation process of Europe. Our paper is organised after this introduction as follows. Second section describes the existing literature on the effectiveness of R&D activities and their complementarity relationship with Human Capital. The third section presents the data, methodology and empirical results. Final section concludes and makes some policy implications.

Literature Review

R&D activities include the creative works undertaken on a systematic way in order to accelerate the knowledge accumulation, which enhances to use new application resulting in productivity growth. Accordingly, R&D expenditure may be considered as an investment increasing knowledge base related to more efficient production methods in an economy. Looking at the literature, it seems that there are a lot of studies indicating the impact of R&D activities on the economy. Most of these studies focusing on the impact of R&D activities on economic growth come from the endogenous growth theory scholars. However, although systemic perception argued that interactions among the components of innovation system affect the performance of innovation process by providing incentives for each other, these interactions between R&D activities and other components in innovation system have been ignored by scholars of endogenous growth theory. For example, they focused on either on human capital accumulation or on R&D as engines of endogenous growth. Thus, productivity growth of economy is ultimately determined by either the larger the stock of human capital or the more resources spent on R&D.

In the framework of this line, there are three main studies which are developed by Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1992). All of these studies concerning with R&D based technological progress assume that the stock of human capital is fixed and exogenously determined while analysing the impact of R&D activities on productivity growth. Romer (1990) defines technological change as the basic dynamic of productivity growth, which is based primarily on expenditures on R&D. Accordingly; Romer argued that decreasing returns to scale has been prevented by the knowledge sourced from R&D activities. Grossman and Helpman (1991) have also clearly pointed out that the relationship between R&D expenditure and productivity growth. They treated RD activities as a significant source in innovation process. Aghion and Howitt (1992) put the idea of creative destruction into formal mathematical terms indicating the significance of R&D activities in their models as an alternative explanation of endogenous growth.

More recently, Prodan (2005) analysed the relationship between R&D investment and patent applications in OECD countries for the period covered from 1981 to 2001. Empirical findings showed that there is a positive correlation between R&D and patent applications. Moreover, the increase of R&D expenditure in business sector increased the number of patent applications more than increase of R&D on general. Falk (2007) estimated the impact of R&D expenditure of high-tech sector on long-term economic growth by using panel data for OECD countries from 1970 to 2004. Empirical findings showed that R&D investment in the high-tech sector have strong positive effects on GDP per capita in the long-term. Thus, he provided empirical evidence of the relationship between R&D intensity and economic growth for high-tech industries in OECD countries. Guloglu and Tekin (2012) examined possible causal relations among R&D expenditures, innovation and economic growth in high income OECD countries by using panel vector autoregressive model for the period between 1991 and 2007. Empirical evidence showed that R&D activity has a significant effect on economic growth by accelerating technological progress. Thus, empirical results indicated the causal relationship from R&D to innovation and economic growth as presumed by endogenous growth theory. Finally, Gumus and Celikay (2015) determined the relationship between R&D expenditures and economic growth by employing a dynamic panel data model in 52 countries for data from 1996 to 2010. They also indicated that the effect is weak in the short run but strong in the long run for developing countries.

Consequently, it is broadly accepted that R&D is one of the most important factor of economic growth by enhancing technological capabilities of an economy. Thus, RD activity has generally been a subject attracting considerable attention in policy circles since these kinds of activities have the potential to enhance innovative capacity of countries. Because of this reason, most of the policymakers establish explicit target or the levels of R&D spending. These targets are often expressed RD as a specified level of GDP, which is called R&D intensity. Accordingly, most of the nations have aggressively devoted more and more resources to R&D activities to improve innovation capacity. In conclusion, setting R&D spending targets based on R&D intensities (Gross Expenditure on Research and Development as a share of GDP) has been the most popular part of science and technology policy in many countries. However, looking at the literature, systemic perception of innovation as another significant approach noted that RD expenditure is an important vehicle for achieving innovation only when there is sufficient capacity created in innovation system.

Most of the innovation theory scholars argued that system approach is essential to understand the innovation process and thus produce better policy implication. Indeed, National Innovation System (NIS) approach has also become the most popular analytical tool to examine the basic dynamics of innovation process at the macro level (Carlosson, 2007: 861). This kind of systemic thinking about innovation at the national level was developed by three main studies: Freeman (1987) at Science Policy Research Unit (SPRU) in the United Kingdom, Lundwall (1992) at the IKE Group in Denmark and Nelson (1993) at Columbia University in the United States. Beyond its spread among the academic community, the approach of NIS has also been increasingly used by international organizations as an analytical framework for the study of innovation (Teixeira, 2013: 2). Consequently, NIS approach gets diffused across the national and international organizations and academic world as a theoretical framework in order to analyse innovation process at national level.

NIS approach examines the innovation process in a national system consisting of different components and relationships among them which generate and use of new and economically useful knowledge (Lundwall, 1992: 12). Thus, innovation is generated in a system consisting of different components. Every component in NIS has a function to promote innovation process and thus promote innovation performance of system. Every component has also an intensive relationship with other components and these interactions among components significantly affect their functional performance and thus whole system performance. That means interactions between the components of system effect innovation performance of whole system. Thus, the concept of NIS specifically postulates the interactions among components in order to indicate the complex dynamics system characteristic of innovation process. In conclusion, interaction and complementarity among the system components is a significant factor effecting innovation dynamics and performance. Therefore, to achieve high level of R&D need significant structural properties for getting better innovation performance. R&D activities as one component of NIS can fulfil their functions by only inter-acting other components of NIS for promoting of innovation performance.

Under this line of view Park and Park (2010) empirically investigated the relationship between R&D expenditure and industrial structure in OECD countries. They used the data covering the reference period 1978-1995 for 22 member countries. The correlation analysis of study revealed that there exist a significant relationship between R&D structure and industrial structure. Thus, they argued that the portfolio of R&D investment be aligned with the portfolio of industrial structure. Kim et al. (2011) analysed the different factors affecting the performance of R&D activity in 254 Korean IT-related businesses during the two-year period between 2005 and 2007. They found that external networking and technology commercialization capabilities significantly determined the performance of R&D activity on innovation process. Accordingly, they concluded that firms must develop their external networking and commercialization capabilities rather than narrowly focusing on R&D activities.

Sjögren (1998) developed a model which specifically analyzes the effects of R&D activity and Human Capital at the same time in order to capture the interaction between them. He indicated the mutual relationship between Human Capital and R&D activity. He argued that R&D activity is limited importance for growth in the long run without human capital accumulation. He also pointed out that investment in R&D can increase the accumulation of human capital. Neagu (2011) empirically investigated the link between the investment in R&D and the accumulation of human capital in European Union underlying the case of Romania. Empirical findings indicated that there is mutual relationship between human capital and R&D activity. Accordingly, human capital accumulation stimulates both inputs and outputs of the R&D investment while R&D investment is also leading to an accumulation of high quality human capital. Thus, he concluded that appropriate innovation policy measures have to be taken the complementarity effect of human capital on R&D activities.

By using panel co integration analysis, Castellacci and Natera (2013) tried to measure how national system of innovation evolves over time for 87 countries in the period 1980-2007. While R&D expenditure was defined as an input of innovative capability, some other indicators symbolised the absorptive capacity like Human Capital. The empirical results indicated that innovative capability and absorptive capacity variables are linked by a set of long-term structural relationship. They suggested that policy-makers should provide the building blocks among the innovation policy applications since innovation processes is a complex evolving system. Finally, Yeldan (2012) analysed the interactions among the basic dynamics of knowledge-driven growth to make better policy implication for the Turkish economy within the context of a general equilibrium model. He specifically seeks answers to the following question: for a government which policy choice would be better; promotion of human capital formation through subsidies to education in order to develop human capital, or promotion of new R&D advances through subsidies for R&D activities? Empirical findings indicated that public policy should be directed toward hybrid policy applications related to RD activity and Human Capital rather than only focusing on one isolated policy choice since there is a complemenatrity between policy alternatives.

Data, Methodology and Empirical Results

In this section, our research study adopts a dynamic analysis perspective and focus on the empirical examination of interactions among the basic system components. By focusing much more on this interaction in innovation process, our basic aim is to make NIS approach more realistic and feasible to improve policy design and implementation. Accordingly, we calculate the interactions among the set of variables related to R&D activities and Human Capital within the European countries. We have identified the data set related to Research and Development (X_1, X_2, X_3) and Human Capital (Y_1, Y_2, Y_3) in Table-1. We used the most recent and available annual data from EUROSTAT under the thematic subtitle of Science and Technology over the period from 2000 to 2014. We have considered 12 European countries which are Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and, United Kingdom.

In order to investigate the relationship between related components of NIS, we will use the Canonical Correlation Analysis (CCA) as a system identification method. CCA is a generalisation of the technique of regression of one variable on another. To evaluate the simultaneous relationship between X-variable set and Y-variable set, the observed variables in each set must somehow be combined together into one synthetic variable. Thus, synthetic variables are created by applying a linear equation to the observed X-variable set and Y-variable set. Thus, CCA focuses on the correlation between a linear combination of the variables in the X-variable set and Y-variable set such that the correlation between the two canonical variables maximized (Sherry and Henson: 2005: 39).

This empirical model can be described briefly like below (Johnson and Wichern, 2007: 539-541). Assume that, there are original two data set: X-Variable Set (X1, X2,.......Xp) and Y-Variable Set (Y1, Y2,.......Yq). Dual canonical variables U_i and V_i are derived by the linear combination of observed original data set indicated below.

$$U_i = a_{i1} X_1 + a_{i2} X_2 + \ldots\ldots + a_{ip} X_p$$
$$V_i = b_{i1} Y_1 + b_{i2} Y_2 + \ldots\ldots + b_{2ip} Y_p$$

The criteria for determining the number of dual canonical variables (s); (U_i ,V_i) s = Min (p , q) and (a_{i1}, a_{i2}, ... a_{i1p}) and (b_{i1}, b_{i2}, ... b_{i1q}) are called canonical vectors. Thus, linear components of the data set can be redefined as follows:

$$U_i = a' X$$
$$V_i = b' Y$$

Then the variance and covariance of canonical variables can be calculated as follows:

$$\text{Var}\,(U_i) = a` \,\text{Cov}\,(X)\, a = a` \,\Sigma_{11}\, a$$
$$\text{Var}\,(V_i) = b` \,\text{Cov}\,(Y)\, b = b` \,\Sigma_{22}\, b$$
$$\text{Var}\,(U_i\,,\, V_i) = a` \,\text{Cov}\,(XY)\, b = a` \,\Sigma_{12}\, b$$

Thus highest correlation coefficients (**R_i**) for canonical vectors a and b and therefore the canonical variables U_i and V_i can be obtained from the following formula;

$$R_i(U_i, V_i) = (a` \Sigma_{12} b)/(\sqrt{(a`\Sigma_{11} a)} \sqrt{(b`\Sigma_{22} b)})$$

In the framework of canonical correlation analysis also produces "Canonical Loadings of the Original Variables with their Canonical Variables" and "Canonical Loadings of the Original Variables with opposite Canonical Variables" in order to indicate the impact of original variables on own and other canonical variables. Accordingly, while analysing the interactions among capacity components, we try to indicate both the whole impact of capability components (Canonical Correlation Analysis) and the relative importance of variables related to every components (Loading and Cross-Loading of Original Variables Analysis).

In the framework of analytical methodology indicated above, we set up Model-1 shown in Table-1 in order to measure the interactions among basic capacity components. Model 1 indicates the interactions among the set of variables related to capacity components of Research and Development (X_1, X_2, X_3) and Human Capital (Y_1, Y_2, Y_3). As argued by National Innovation System approach, it is expected that variables related to R&D activities and Human Capital are linked together by a set of two-way dynamic relationships. The intuition is pointed out between two components of R&D and Human Capital as follows: On the other hand "Human Capital Productivity Effect" may operate from Human Capital to R&D. Accordingly, successful policy applications towards human capital boost innovative R&D activity over time. Firstly public policies towards enhancing human capital may result in an increase in productivity of human capital. Later, this likely strengthens the productivity of the country's R&D sector, which increases the amount of resources devoted to R&D activities. On the one hand "R&D Innovative Activity Effect" may operate from R&D to Human Capital. Accordingly, successful R&D activity may sustain the development of human capital over time. Firstly, R&D investments and innovative efforts may increase the country's technological performance and commercial success. Later this tends to increase the country's pool of financial resources, some of which will be reinvested to increase its level of infrastructure that enhances human capital in the future (Neagu, 2011: 540).

Empirical results of Cannonical Correlation Analysis based on the theoretical framework indicated above are shown in Table-2, Table-3, and Table-4. Findings of canonical correlation coefficients for data set of the capability components relating to R&D and Human Capital (Model-1) in Table-2 show that all canonical correlations are significant, which indicates that capability components have strong interrelationships among themselves. Canonical loadings and cross-loadings relating to first canonical correlation coefficient between Human Capital and R&D shown Table-3 and Table-4 specially emphasize the significance of variables such as "graduates from doctorate education" and "labour force as the share of personnel employed in R&D" in co-evolution of these two components. Thus, Table-3 and Table-4 also indicate the interactions among components related to Human Capital and R&D by presenting the relative importance of each original variables for own canonical variable and opposite canonical variables, respectively. All these results indicate the significant interaction between the capability components of R&D and Human Capital.

Thus, empirical findings of our study show that capacity component of NIS are linked by a set of two-way dynamic relationships, which represents a co-evolution process and thus a key mechanism driving the growth of NIS in the long-run. Indeed, NIS is dynamic systems whose evolution is driven by a complex set of two-way self-reinforcing relationships. Therefore, any given change in one of the factors composing the NIS has a set of direct effects on several other variables of the system, as well as a set of indirect effects that are mediated through other factors in the model. These co-evaluation or two-way dynamic relationships among the capacity component also indicate the complementarity among components of the system. Therefore, focusing only a single component of innovation system is not enough to investigate the dynamics of innovation process. That means innovation processes cannot be decomposed into several isolated phases that take place in a strictly proceeding sequence. Our empirical findings clearly indicate that components of NIS are linked together by a set of two-way dynamic relationships. From this perspective, the effectiveness of innovation policies depends not only on how the individual innovation policies perform in isolation, but on how they interact with each other. Therefore, innovation policies should include a comprehensive and co-ordinated set of actions rather than focusing only a single policy in order to promote efficiency of components in innovation process.

Table-1: Canonical Correlation Analysis for data set of Human Capital and R&D (Model-1)

<table>
<tr><td colspan="2">Capacity Variables of Human Capital Component</td><td>Canonical Variables of R&D Expenditure</td><td>Canonical Coefficient</td><td>Canonical Variables of Invention/ Innovation</td><td colspan="2">Capacity Variables of Research and Development Component</td></tr>
<tr><td>X_1</td><td>R&D performed by Business (% GDP)</td><td rowspan="3">U_1
U_2
U_3</td><td rowspan="3">R_1
R_2
R_3</td><td rowspan="3">V_1
V_2
V_3</td><td>Total expenditure on education (% GDP)</td><td>Y_1</td></tr>
<tr><td>X_2</td><td>R&D performed by Government (% GDP)</td><td>Graduates in upper secondary education -per 1000 population aged 25–34</td><td>Y_2</td></tr>
<tr><td>X_3</td><td>R&D personnel (% of the labour force)</td><td>Doctorate graduate per 1000 population aged 25–34</td><td>Y_3</td></tr>
</table>

Table-2: Canonical Correlation Analysis (Model-1)

Pair of Canonical Variables	Canonical Correlation	Squared Canonical Correlation	Wilk`s Lambda	Chi-Square	df	P value
U_1 V_1	0.930	0.865	0.108	47.536	9	0.000

U_2 V_2	0.882	0.778	0.167	39.725	4	0.000
U_3 V_3	0.711	0.506	0.241	8.355	2	0.017

Table-3: Loadings of the Original Variables with their Canonical Variables (Model-1)

	Research and Development - Variable Set (X_1 X_2 X_3)		
	X_1	X_2	X_3
U_1	0.676	0.280	0.763
	Human Capital - Variable Set (Y_1 Y_2 Y_3)		
	Y_1	Y_2	Y_3
V_1	0.568	0.754	0.895

Table-4: Cross- Loadings of the Original Variable with opposite Canonical Variable (Model-1)

	Research and Development - Variable Set (X_1 X_2 X_3)		
	X_1	X_2	X_3
V_1	0.633	0.248	0.729
	Human Capital- Variable Set (Y_1 Y_2 Y_3)		
	Y_1	Y_2	Y_3
U_1	0.536	0.719	0.853

Conclusion

National Innovation System (NIS) approach asserts that dynamics of innovation process are basically driven by the interactions among the components of the system. The purpose of our study is to analyse these interactions in order to empirically investigate the dynamics of innovation process as complex evolving systems. Thus, our analysis mostly takes into account the “mutual functional patterns” of capacity components related to NIS. Accordingly, we perform Cannonical Correlation Analysis on the relationship between components of R&D and Human Capital in NIS of European Countries to measure the complementarity among them.

Empirical findings indicated that there are strong interactions among the variables relating to components of Human Capital and R&D in NIS of European Countries. Thus, we clearly presented that performance of NIS is characterised by its cross linking between the different components of the system. Our empirical findings have provided rich insights into the complementarity among the components of NIS as basic dynamics of innovation process. Consequently, as the analytical framework outlined based on NIS approach, it should be given increase insights towards circular causal relationships among components as a basic dynamic of innovation process. Therefore, focusing only a single component of innovation system cannot be enough to investigate the dynamics of innovation process.

These results concerning with the basic dynamics of innovation process also generate significant implications for the policy design process. Policy makers should consider the complementarity among components of NIS for better policy implications. From this perspective, the effectiveness of innovation policies depends not only on how the individual innovation policies perform in isolation, but on how they interact with each other. Therefore, the increase of R&D intensity at country level is a necessary but not sufficient condition for promoting innovation system efficiency. Single policies which are isolated each other are ineffective since these policies don't care the interactions among the basic components of NIS. Therefore, effective innovation policy performance requires combining a range of policy measures. For example, innovation policies like European Union aiming to increase R&D-to-GDP ratio to certain level is not enough without systemic design of other components like human capital.

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References

Aghion, P. and P. Howitt (1992). A Model of Growth through Creative Destruction. *Econometrica,* 60, 2 (March) 323-351.

Carlsson, B., (2007). Innovation systems: a survey of the literature from a Schumpeterian perspective. In: Hanusch, H., Pyka, A. (Eds.), *Elgar Companion to Neo-Schumpeterian Economics*. Edward Elgar, Cheltenham, pp. 857–871.

Castellacci F. and Natera J. M. (2013). The Dynamics of National Innovation Systems: A Panel Co integration Analysis of the Co-evaluation between Innovative Capability and Absorptive Capacity, *Research Policy*, 42, 579-594.

Falk Martin (2007). R&D Spending in the High-Tech Sector and Economic Growth. *Research in Economics*, 61, 140-147.

Freeman, C. (1987). *Technology Policy and Economic Performance: Lessons from Japan*. London: Pinter.

Grossman, Gene M., and Elahnan Helpman (1991). *Innovation and Growth in the Global Economy*, MIT Press, Cambridge MA.

Guloglu B. and Tekin R. B. (2012). A Panel Causality Analysis of the Relationship among R&D, Innovation and Economic Growth in High-Income OECD Countries, *Eurasian Economic Review*, 2 (1), 32-47.

Gumus E. and Celikay F. (2015). R&D Expenditure and Economic Growth: New Empirical Evidence, *Journal of Applied Economic Research*, 9 (3), 205-217.

Johnson R. A. and Wichern D. W. (2007). *Applied Multivariate Statistical Analysis*. Sixth Edition, Pearson Education Inc. NJ, United State.

Kim K. S., Lee, B. G., Park, B. S. and Oh, K. S. (2011). The Effect of R&D, Technology Commercialization Capabilities and Innovation Performance, *Technological and Economic Development of Economy*, 17 (4), 563-578.

Lundvall, B.-Å. (ed.) 1992. *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London, Pinter Publishers.

Neagu O. (2011). How the Investment in R&D is related to the Human Capital Accumulation? The Case of Romania. *Annales Universitatis Apunlensis Series Oeconomica*, 13, 2, 539-548.

Nelson, R. (ed.). 1993. *National Innovation Systems: A Comparative Analysis*, Oxford Unv. Press

Park, Y. and Park G. (2010). "When Does a National Innovation System Start to Exhibit Systemic Behaviour?" *Industry and Innovation*, 10, 4, 403-414.

Romer, Paul, M. (1990). Endogenous Technological Chang. *Journal of Political Economy*, 98 (5), 71-102.

Prodan I. (2005). Influence of R&D Expenditures on Number of Patent Applications: Selected Case Studies in OECD Countries and Central Europe, *Applied Econometrics and International Development*, 5 (4), 5-22.

Sherry A. And Henson K. R (2005). Conducting and Interpreting Canonical Correlation Analysis in Personality Research: A User-Friendly Primer". *Journal of Personality Assessment*, 84 (1), 37-48.

Sjögren A. (1998). Human Capital R&D and Economic Growth. *Working Paper Series in Economics and Finance* No: 238.

Teixeira A.C. (2013). Evolution, roots and influence of the literature on National Systems of Innovation: a bibliometric account, Cambridge Journal of Economics, 8, 1-34.

Yeldan E. (2012). An Applied Endogenous Growth Model with Human and Knowledge Capital Accumulation for the Turkish Economy, *Ekonomi-tek*, 1 (2), 21-60.

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