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STI SUSTAINABILITY AND NATIONAL INNOVATION SYSTEM

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Abstract

Science, Innovation, and Technology are important dimensions for a country looking to achieve their socio-economic goals. It is essential that STI policies must align with sustainability goals of the country especially moving forward since a lot of emphasis is put on sustainable energy and eco-friendly practices. Different international organizations such as OECD, UNESCO, and World Bank have also emphasized the use of eco-friendly practices when dealing with STI policies. Green growth and green innovation have been discussed among these organizations as a way forward for innovation around the globe. National Innovation Systems must be formed in order to pursue STI policies, these systems can successfully integrate STI policies into the economic system of a country and also ensure a high potential for growth.

OECD continues to develop and improve indicators to measure STI policies; the measurement of such policies can help countries in improving their policies and achieving their STI goals more efficiently and effectively.

Keywords: Science, Technology, and Innovation Policy

Özet

Bilim, Teknoloji ve Yenilik bir ülkenin sosyoekonomik hedeflerini başarabilmesi için önemli unsurlardır. Bilim Teknoloji Yenilik Politikaları ülkenin sürdürülebilir amaçları ile uyumlu olmalıdır, özellikle sürdürülebilir enerji ve çevre dostu enerji uygulamalarına büyük önem verilmelidir. OECD, UNESCO, Dünya Bankası gibi farklı uluslararası organizasyonlar da Bilim Teknoloji Yenilik Politikaları üzerinde çalışırken çevre dostu uygulamaların kullanımının altını çizmişlerdir. Yeşil büyüme ve yeşil yenilik, bu organizasyonlar arasında inovasyon yolunda tüm dünyada ilerlemenin yolu olarak görülmüştür. Ulusal Yenilik Sistemi Bilim Teknoloji Yenilik Politikalarını yürütmek amaçlı şekillendirilmeli, bu sistemler Bilim Teknoloji Yenilik Politikalarını başarılı bir şekilde ülkenin ekonomik sistemine entegre edebilir bu şekilde gelişim için yüksek potansiyel sağlayabilirler.

OECD Bilim Teknoloji Yenilik Politikalarını ölçmek için göstergeler ortaya çıkarmaya ve ilerletmeye devam etmektedir. Bu tarz politikaların ölçülmesi ülkelerin kendi politikalarını geliştirmeye ve Bilim Teknoloji Yenilik hedeflerine daha verimli ve etkin bir biçimde ulaşmalarına yardımcı olmaktadır.

Anahtar Kelimeler: Bilim Teknoloji Yenilik Politikaların.

Introductıon

Science and technology is not only our perception of the natural world and natural world's relationship with human welfare but also constraints due to lack of resources. Essentially all public policies are established from the realities of the natural world and continued on the ground of constantly changing presumptions about our understanding of nature. So the perspective of science and technology is thus base to the formation of public policy.

Nations have foresights and socio-economic goals for their future. The most efficient tool to reach prescribed goals is a nation's competency of science technology and innovation (STI). Nation's STI policies show ways and procedure to reach/pursue this competency. For self-determined development STI may contribute ecological and social aspects of development through finding solutions for particular problems and strengthening a knowledge base (Sumner et al. 2009; STEPS Centre 2010). In addition, according to Bechmann (2009) and Hornidge (2011), governments that can direct Science, Technology and Innovation (STI) processes concerning knowledge-based economies have higher economic growth and prosperity than countries that don't implement such STI processes. But, the impacts of STI on society are more complex than their analysis.

1.FROM SCIENCE POLICY TO INNOVATION POLICY

Mainly science policy definitions state the set of policies towards development and usage of knowledge a research community. Sarewitz et al. (2004) defined science policy as a decision process between institutions' allocation and organization of the financial and intellectual resources that allow the conduct of scientific research and individuals. Science policy and the dimensions that have been considered as a part of the policy have changed over time. Till the 1990s, Ruivo (1994) proposes three paradigms for science policy: 'science as a motor of progress', 'science as a problem solver' and 'science as source of strategic opportunity'. First paradigm is 'science as a motor of progresses which appeared midst the post-war era, at the time science was deliberated as a main part for development. According to Arond (2011) for achieving different social and economic goals the US-government stated its obligation to actively support science. This will be identified as 'science push' model of innovation later. The model considers the conception of scientific knowledge creates positive effects in society regardless of it can be immediately applied or not. As a result of this paradigm, the US came to be the leading investor into scientific knowledge production in the shape of advancement in nuclear and military technology, later also taking on space research (Ruttan 2000; Mattelart

2003). According to Fagerberg et al. (2005), science and technology (S&T) institutes, national research priority areas, investment in research and development, and support of scientific knowledge production.

Second paradigm is 'science as a problem solver'. The 'science push' was continued with a 'problem solving' paradigm. The strategic significances more directed crack technical challenges, to solve problems and to contribute to economic growth. The model named as 'demand pull' to explain technological change. At the end of the 70's, innovations were a result of the model relying on market and industrial demands. The model was formed based on the importance of the demand to draw the most proficient innovators to work within a diversity of technological sectors (Schmookler, 1996). Also Mowery and Rosenberg (1979) state that both demand and offer are important factors for innovation to take place.

Third paradigm is 'science as source of strategic opportunity'. The last paradigm demonstrations states linkages between their general national policy objectives and the outputs of their research system, for example international competitiveness, as a result of collaboration in international research and the transmission of institutions for knowledge dissemination from academia to other stakeholders (Ruivo, 1994). This paradigm adopts a further convoluted and interactive method, though still centered around the research scheme.

The above three paradigms show us diverse views in science policy until the 1990s. Since then, the usage of 'science policy' as a term has deteriorated. It has taken the shape as either 'innovation policy' or 'science, technology and innovation policy', or other variations where innovation holds a vital part. According to Weingart (2011), since the 1970s innovation has been amongst the intentions of science policy, however, now there is a stronger emphasis within the policies is on innovation. The introduction of innovation within the design of science policy guided towards a new paradigm, which incorporated the ones before and went past the emphasis of science policies and study of research systems. Freeman (1995) and Lundvall et al. (2002) state that these changes were implemented through the 'innovation system', this underlies the current 'economic innovation' paradigm.

2. STI & SUSTAINABILITY

One of the increasing public concerns is sustainability issues. Also it remains at the high level on the agenda of policy makers. Terms like, 'green growth' 'green economy', 'eco-innovation', appear in official documents of governments and international organizations.

These alternate ideas of sustainability-oriented innovation must be seen in the greater perspective of environmental thinking, like 'ecological modernization' and 'sustainable development'.

The Ecological modernization idea comes right at 1980s for developing environmental reform in society. This theory developed for describing chancing relationship between economy, environment and society from the 1980s forward by European social scientists. Especially Germany and the Netherlands served best models to the application of ecological modernization policy strategy. Also according to Leggewie and Messner (2012), German policy and implementation are often counted as a good model of a conscious shift in the direction of renewable energy technologies.

Joseph Huber, Martin Jänicke, Udo Ernst Simonis, Klaus Zimmermann and Volker von Prittwitz are the most outstanding theorists of ecological modernization. In addition, the likes of Arthur Mol and Gert Spaargaren, Maarten Hajer, Albert Weale and Joseph Murphy have made substantial contributions for the expansion of the theory. There are some alternative discourses of the Ecological Modernization Theory (Hajer, 1995; Buttel, 2000). According to Mol (2010), there are some standards of knowledge such as 'industrial ecology', 'cleaner production' and 'industrial metabolism' that the discourse includes. The attitude is based on a belief of positive power of STI, backed by the fact that several technologies have an environmental bend. "Biotechnology is pictured as a promise to feed a growing world population of almost 9 billion people in a sustainable way" (Borlaug, 2000), or nanotechnology visualized as a promise to better the environment. According to Tratnyek and Johnson (2006) 'remediation technologies are already reality' also ease the reliance on fossil fuels is mounting too.

The second concept 'sustainable development' origin can be traced Brundtland report publication (WCED, 1987). The theory of sustainable development was originally defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987: 41), got fitted in the international schema in the first Rio conference of 1992. It was the first time in 1987 international organizations talked about growing concern and claimed by activist groups and civil society about the impact of technological developments consequences in industrialized countries like nuclear power, oil crisis, green revolution, amongst others. The growth of STI capabilities in developing countries seen as a means to manage environmental challenges (WCED, 1987).

Below different methods of international organizations about STI and sustainability issues detailed.

2.1 Organization for Economic Co-operation and Development (OECD)

Like economic innovation approach OECD approach of green growth means promoting economic development and growth by guaranteeing natural assets endure, providing resources and environmental services for our welfare and demand for greener growth model is growing concern for sustainability of the future economic growth (OECD, 2011). According to OECD (2011), innovation and the procedure of creative destruction will move towards new ideas, new business models and new entrepreneurs; it will lead to the creation of new jobs and establishment of new markets so innovation is a key factor for ensuring sustainability and growth to go together and government act is very important to shape environment for green innovation. In the 'fostering innovation for green growth' report OECD (2011) says 'Policies to foster green innovation should not only focus on the creation and supply of new technologies and innovations, but also on the diffusion and take-up of green innovations in the market place.' Such policies include policies to:

- Foster the wide dispersion of green innovation within and across countries
- Strengthen markets for green innovation
- Change consumer behaviour

Green growth is a way for reaching sustainable development via cost effective and efficient consumption practices and production (OECD, 2013a) and for reaching a sustainability oriented innovation system strong institutions and policies will require. In the report Putting Green Growth at the Heart of Development OECD recommends specially to developing countries to put green growth at the hearth of development because OECD believes that this suffer especially because of environmental pressures and still there is a continuous need on natural resources for growth. Also consumers' behavior should be targeted by "consumer policy and consumer education, as well as green labeling and certification" (OECD, 2013b).

OECD (2013a) predicts large costs and potentially irrevocable costs of failing to avoid environmental risks which will openly affect human health and adjust economic growth in its Environmental Outlook to 2050. Interestingly, between the years 1971 and 2010, the GDP increased at a steady rate while a wide gap remains among the developed and the developing

world, and the difference between the rich and poor continues to grow (UNCTAD, 2012; OECD, 2011). Green growth is addressed as essential part of ecological development and green innovation on product, process and technology level is very important according to OECD and it have to be involved in their green growth schemas by developing countries. Three measures that OECD proposed at 2013 report are to increase research and development cooperation worldwide by harmonizing research programs and transferring information; to increase technology allocation that built on a working national innovation system and to implement intellectual property rights systems which impose owners' rights of patents to inspire innovation (OECD, 2013b).

Completely OECD perspective to innovation for sustainability mostly depending on green technologies, green innovation enclosed systematic and economically and other methods of innovations for sustainability are not deliberated in the OECD conception.

2.2 WORLD BANK

In the report 'A Guide for Developing Countries' the World Bank mentions about the needfor green technology because of energy and natural resource restrictions on growth and limited environment capability to absorb CO2 emissions and pollution and they suggest innovations to conserving energy and resources with the expansion of non-carbonized and energy efficient technologies also contending that "more cross-national efforts to find innovative ways to deal with this and other issues of global public goods are urgently needed" (World Bank, 2010).

In 2012 World Bank directly addressed green innovation in the report 'Inclusive Green Growth'. They defined green innovation as the "development and commercialization of new ways to solve environmental problems through improvements in technology", and green technologies as "comprise many fundamentally different technologies to achieve more resource efficient, clean and resilient growth" (World Bank, 2012).

For fostering green innovations, the World Bank have some recommendations for developing and advanced countries. For developing countries these recommendations are based on the technology transfer concepts and innovation system. Also the World Bank recommends "developing countries putting their innovation level not only at the academic level and to limit local technology-push support to countries with enough technological capabilities" (World Bank, 2012). The World Bank recommends that "stable, long-term global public spending on R&D should be increased and channeled into programs that facilitate the development and

adoption of technologies applicable to developing countries" for the countries that have weak technological capacities (World Bank, 2012).

Also they talk about a vast monopolization of green technologies in some countries as statistics in terms of patents and they suggest advanced countries to produce frontier green technologies and accommodating them to local conditions after the technology transfer (World Bank, 2012).

In the report the World Bank says that every country should create its own policy according to their national precise circumstances to solve specific market failures. They recommend pillars like supporting entrepreneurship, new knowledge creations and dissemination, stimulating technology transfer in the report (World Bank, 2012).

2.3 United Nations Educational Scientific and Cultural Organization (UNESCO)

In the report World Social Science Report 2010, UNESCO examines the place of science in society and role of social sciences to solve global problems. The report also emphasizes the significance of interdisciplinary research aspiring to discuss global challenges like natural disasters and climate change. Also in the report UNESCO talks about the power of science to empower society and expansions of developing STI in the third world and they are only referring to innovate for sustainability in the terms of clean technologies.

In the publication Science for Peace and Sustainable Development 2013 UNESCO basically gives same conceptualizations. UNESCO talks about the importance of technological innovations in the terms of sustainability. Also in the report they highlight the importance of capacity development and governance to achieve technological innovations. In the report they mention about importance of STI for social and economic development but they don't give any reference about sustainability within STI systems as a whole.

In 2013, International Social Science Council (ISSC) and UNESCO published the second World Social Science Report and they focused the role of science for sustainability by the idea of transformative sustainability-oriented science and they underline the role of social sciences to frame environmental problems to understand human dimension of climate change with supporting transformation towards sustainability.

According to the World Social Science Report (2013), the question then becomes whether if developed based growth along with the exhaustion of natural resources and rising carbon emissions should be a model to be followed:

"A simple question put to all nations is whether more concrete, more buildings, more cars, more roads and more industry is really the best model for development. If there is a better model, then the challenge before social scientists is to help define and understand it, and to contribute knowledge about effecting a shift in human behavior and social practice towards a model of development and a lifestyle that leaves a much lighter carbon footprint and, it is to be hoped, a much greener world." (ISSC and UNESCO 2013).

3. NATIONAL INNOVATION SYSTEM

At the present day science and technology policies are one of the most important factors that affect country's economic performance but on the other hand it is not enough to implement science and technology policies merely to have a success on economic frame in a quick changing economic environment. Structures like national innovation systems helps countries to have a better economic performance with science and technology policies. Countries constitute their own national innovation systems and integrate their national innovation system with science and technology politics has successful outcomes. Rapid change in today's knowledge based economies and technological competition increased countries attentions on structures like NIS.

3.1 DEFINITIONS OF NATIONAL INNOVATION SYSTEM

A national system of innovation has been defined as follows:

" .. 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)

"... a set of institutions whose interactions determine the innovative performance ... of national firms." (Nelson, 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, 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)

The smooth operation of innovation systems depends on the fluidity of knowledge flows – amongst enterprises, universities and research institutions (OECD, 1997). Both implicit knowledge and expertise exchanged over informal networks, and codified knowledge, or information codified in publications, patents and other sources, are vital. The instruments for knowledge flows comprise of joint industry research, public/private sector partnerships, technology diffusion and movement of personnel (OECD, 1997)

According to OECD (1997) there are three factors that the national innovation system approach has taken on increased analytical importance in the technology field:

1. The recognition of the economic importance of knowledge;

2. The increasing use of systems approaches;

3. The growing number of institutions involved in knowledge generation.

National Innovation System States in general (DPT, 2000, p. 9);

- Obtaining new technologies containing product or product management, assimilating them, providing diffusion these technologies to the whole operations of the economy

- Product development, designing new products

- With the new product designing developing new production process, designing new method

- Designing new production machines needs by the new or developed production method

- Maintaining research and development activities feeding design and production process, producing required technology with scientific findings

- Systems which occurred from national institutions which have ability to organize research development, design, production, marketing process both inside and between themselves and developing new organization methods that reproduce again at the higher hub and relationships between these institutions.

3.2 INSTITUTIONS CONSTITUTES NATIONAL INNOVATION SYSTEM

According to Taymaz and OECD institutions are evaluated as those that generate national innovation system under six group concerning; producing, diffusing, safekeeping and using of scientific and technological knowledge. (Taymaz, 2001; OECD, 1999).

- Public and private concerns that located in technological innovation and network configuration that these firms constitute: At the present time firms are in sight primary resource of economic growth. Behind of this view, reality is firm's technological possession of competence on big changings on market, product or sources as a result of learning and accumulation on the process of productive activity.

- Research agencies: Public or private research agencies which are nonprofit organizations, produce / spread technology has very important role on national innovation system. Public labs, patent offices, and institutions that provide technological transfer can be categorized under this segment.

- Science system: In science systems universities have tasks like producing scientific knowledge, making an invention and training researchers

- Support bridges and organizations: Support bridges and organizations which involved in an activity like extending new technologies, defining standards of support services; offers support services to intuitions which make innovation activity for their technological substructure.

- Financial institutions: Financing of technological innovation activity has different characteristics from other investing activities. So technological innovation activities have been supported by some tools like research and development donations, loans, tax deductions. In addition to these, advanced technology oriented venture firms need fund, has a high potential to grow has to be supported.

• Institutions that develop, implement evaluate policy: Institutions that develop, implement evaluate policy have an important function in the system for establishing and functioning actively national innovation system, coordination of activities, protecting system from indirect problems.

3.3 MAIN TECHNIQUES USED IN NATIONAL INNOVATION SURVEYS

The OECD have used four techniques in national innovation surveys (OECD, 1997).

1. Joint research activities – These include technical activities and research done jointly by universities, research institutes, and firms using data available by government funding agencies, organizations, universities, etc. These joint research activities include both projects funded by civil society organizations, financing by university for its research, and any other type of contract research.

2. Co-patents and co-publications – These are measured through collecting patent records and analyzing publication indices. In general, the number of co-patents and publications developed with the collaboration of enterprises and universities must be included in this category.

3. Citation analysis – Users generally cite their sources hence a citation analysis can be utilized to assess the extent to which an enterprise has used information that was originally generated by universities or research institutions.

4. Firm surveys – Surveys can assist in realizing the degree to which a university or a public research institute is regarded as useful in terms of knowledge for innovative activities. These surveys also allow us to capture the informal links between industry and public research sector. Therefore, these surveys reveal the extent to which public knowledge differs according to the industry.

National innovation systems involve firstly research and development activities, education system, industrialization policy and science and technology policy of countries according to countries own conditions (Saçlı, n.a). On the other hand, including economy policies all national innovation systems that determined by the governments should count environmental problems. Because nonrenewable natural resources of world run short, water weather land pollution and scarcity increasing. So national innovation systems that determined with

observing and implementing environmental values are very important for providing and implementing development

Table 1: Core Knowledge Flows in National Innovation Systems

Core knowledge flows in national innovation systems	
Type of knowledge flow	**Main indicator**
Industry alliances	
Inter-firm research co-operation	Firm surveys
	Literature-based counting
Industry/university interactions	
Co-operative industry/University R&D	University annual reports
Industry/University co-patents	Patent record analysis
Industry/University co-publications	Publications analysis
Industry use of university patents	Citation analysis
Industry/University information-sharing	Firm surveys
Industry/research institute interactions	
Co-operative industry/Institute R&D	Government reports
Industry/Institute co-patents	Patent record analysis
Industry/Institute co-publications	Publications analysis Citation analysis
Industry use of research institute patents	Firm surveys
Industry/Institute information-sharing	
Technology diffusion	
Technology use by industry	Firm surveys
Embodied technology diffusion	Input-output analysis
Personnel mobility	
Movement of technical personnel among	Labor market statistics
industry, universities and research institutes	University/Institute reports

Source: OECD (1997)

Conclusıon

Different studies have found the importance of STI policies in the growth and sustainability of a country. STI policies are generated in order to improve competencies and achieve long-term goals that may not be otherwise realized. Moving forward, organizations such as UNESCO and World Bank have called upon countries to invest in green innovation that can help both developed and developing nations. Some measurement indicators for STI policy have been created by OECD. These indicators include different dimensions that measure the STI effectiveness and the extent to which STI policies are being implemented. In order to better understand the impact of STI policies, a more in-depth review of literature is required. Furthermore, a country analysis should be preferably on Turkey in order to measure the STI policies in the country and to find its impact.

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