NATIONAL INNOVATION SYSTEMS: WHAT THE NATIONAL TECHNOLOGY INITIATIVE BRINGS TO TÜRKİYE

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Abstract

The national innovation system includes market and non-market institutions that affect the pace and direction of innovation and technological diffusion in a country. In this way, the determinant of the technological developments that shape the development is the national innovation system of the country. The national innovation system is shaped according to the strategic development areas of the country. From the most basic level to the most advanced studies, science centers, research centers, universities, the private sector, and public institutions constitute Türkiye's national innovation system. Türkiye has crowned the contributions of the national innovation system with the "National Technology Initiative". In this section, institutions related to national innovation systems and the shaping process of science and technology policies in Türkiye will be discussed. In addition, the national innovation systems literature will be mentioned and the terminology will be analyzed with the bilimetric method. Thanks to the findings obtained, prominent topics and the tray of research networks became possible. In this context, when we examine the institutions that frequently work on national innovation systems, it is possible to talk about a dominant effect on EU member countries. On the other hand, it has been exemplified as an important case study in terms of identifying important concepts and subject areas that are open to development, and developing a data-based R&D policy. With the analysis we have carried out in this context in our study, the concepts for the determination of the nodal points that have reached the level of saturation in the context of national innovation systems and the areas that are open to development and relatively untouched have been determined. Thanks to this information, it has been possible to make inferences about the future of innovation systems. When the analyzes of the studies are examined, it is possible to say that the national innovation systems are considered as a whole and that the issues such as R&D performance, private sector, and policy-making take place at the base. By developing a data-based policy, Türkiye will move forward to become a self-sufficient leading power in its region, producing high technology and added value, not a market, in the digitalized world with the National Technology Initiative. In this sense, it can be said that the National Technology Initiative is a struggle for existence for our future generations as a struggle for independence.

Keywords

National innovation systems, Science centers, Research centers, Scientometric, Innovation

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Introduction

National innovation systems refer to the network that is holistically shaped and developed by public and private sector organizations that create, import, change and disseminate new technologies with their activities and interactions (de la Mothe & Paquet, 1998; Molas-Gallart, 1999; Nasierowski & Arcelus, 1999). When the literature is examined, it is seen that national innovation systems are defined in different scopes. It is stated that research-oriented institutions such as micro-level R&D units, technology institutions and universities form the basis of the national innovation system. In the macro sense, there is also a broad perspective that includes institutions related to learning and financing processes, where other institutions that affect the innovation process are defined as solution partner stakeholder structures (Archibugi, 1996). In this context, market and non-market institutions that affect the speed and direction of innovation and technological diffusion in a country constitute the ecosystem of the national innovation system (Schaaper, 2009). In the historical development, public resources can be defined as the main incentive factors in funding research and supporting national innovation systems (Archibugi, 1996; Archibugi et al., 1991; Archibugi & Iammarino, 1999; Castellacci & Archibugi, 2008).

National Innovation Systems and Technology Policies of the Science

National innovation systems are not only related to national science and technology policies, but also open to global interactions. In this sense, it would be appropriate to look at the historical process related to national and international studies on science technology strategies, education and R&D practices. The development of new technologies, the end of the cold war, and the dissolution of the Soviet Union have had a number of effects on the international political system. It is possible to say that one of the most important changes in technology policy practices, especially in the 1980s, was observed in the USA, which was directly affected by the developments in the political system. The USA has made progress by basing its traditional technology policy on the policies it includes within the scope of mission differentiation, especially in order to be technologically ahead in the military industry (Nelson & Nelson, 2002). Thanks to this policy effect, it has been observed that new policies have been shaped in the USA in order to encourage technological diffusion, especially in public research centers and universities.

When the developments on the side of the European countries, which constitute another pillar of the global system, are examined, it is seen that these countries encourage to reflect scientific achievements and scientific inventions to technological application areas, and thus to increase added value by developing low-cost and high-value products. The solution defined as the European paradox - not achieving the targeted success - is; benefiting from high-level scientific research results for economic and social development and developing long-term policies in this regard (Karol & Kattel, 2009).

Turkish Science and Technology Policies Formation Process

As the introductory chapters of this book explain, the country's primary goal from the final years of the Ottoman Empire to the early years of the Republic was to close the two-hundred-year-old gap caused by the failure to reach the level of contemporary civilizations and participate in the industrial revolution. By the end of the twentieth century, truly indigenous, national, competitive, and independent high-level industrial initiatives and investments had been achieved. When considered in terms of national developments, it is possible to examine Türkiye's technology and innovation policies in three periods after the

1960s (Romijn & Türel, 1998). TÜBİTAK and Marmara Research Center were established in the period of 1963-1980, which can be defined as the period of import substitution industrialization policies. During this period, priority was given to the development of basic research in public institutions and universities, and experts and researchers were sent to study abroad in order to develop qualified human capital. In the second period between 1980-89, industrialization policies that prioritized exports were adopted. In 1983, the Science and Technology Supreme Council (BTYK) was established in order to coordinate science policies. In this period, the establishment of an institution associated with the economic development, social development and national security objectives of research and development policies in the field of science and technology is very important in terms of the publication of the Turkish Science Policy, which is known as Türkiye's first science policy document (Saatçioğlu, 2005). As an important development of the third period, the Turkish Science and Technology Policy document covering the years 1993-2003 was accepted at the second meeting held by BTYK in 1993. This document laid the groundwork for the Science and Technology Breakthrough Project to be adopted in 1997 within the VII. Five-Year Development Plan and Türkiye's Science and Technology Policy documents. With these documents, the following statement about the establishment of our national innovation system is included for the first time.

"The establishment of our National Innovation System as soon as possible, which means that all institutions and mechanisms that will be needed in order to carry out scientific and technological research and to transform the findings of these research into economic and social benefits, and that they can be operated in a systemic integrity..."

Perhaps the first step of this innovation system is the science centers that have become widespread today. Science centers aiming to increase the interest of new generations in science are among the factors that ensure the spread of science in all segments of society. Thanks to science centers, scientific developments and innovations and academic culture are spreading to all age groups. Science centers increase the interest and interest of visitors in science with their educational and practical workshops. There are science museums and centers managed by various institutions in Türkiye. Science centers have become widespread, especially thanks to the mission given to TUBITAK with the decision taken by the Supreme Council of Science and Technology in 2011. The "Science Centers Evaluation Report" published by TÜBA analyzes the current situation of science centers in a multidimensional way and includes suggestions for their activation and dissemination (2020).

While science centers increase the interest of children and young people in science, advanced research centers contribute to the national innovation system of our country within the framework of supporting research infrastructures. Turkish Accelerator and Radiation Laboratory (TARLA) in Ankara, METU Solar Energy Research and Application Center (GÜNAM), METU Micro Electro Mechanical Systems (MEMS) Center, Bilkent University National Nanotechnology Research Center (UNAM), Sabancı University in Istanbul Centers such as Nanotechnology Research and Application Center (SUNUM), Çekmece Nuclear Research and Training Center (ÇNAEM) and İzmir Biomedicine and Genome Center (İBG) in İzmir conduct science-based research that will enable our country to produce innovative products. The cooperation of these centers and the private sector has the potential to bring Türkiye forward in global competition.

Recently, new strategies have been introduced and developed in R&D incentives for universities, scientists, research centers and even the private sector, especially through the

organization of the Ministry of Science, Industry and Technology (now called the Ministry of Industry and Technology) and other stakeholder institutions such as TÜBA, TÜBİTAK, KOSGEB and YÖK. With the transition to the presidential system, the share allocated to R&D expenditures in the budget has exceeded 1% (Figure 1). Although this rate is lower than the majority of G20 countries, it is an important indicator for our country in terms of supporting a sustainable R&D strategy.

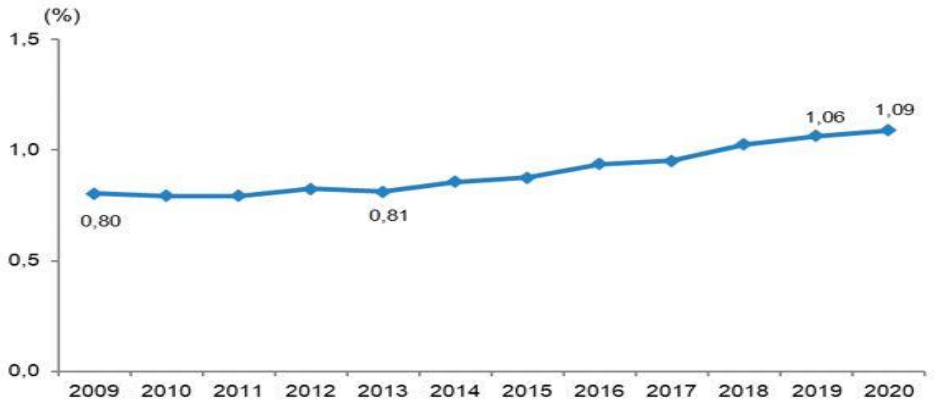

Figure 1. *Share of R&D expenditure in GDP, 2009-2020*

Source: Turkstat, 2020

We should mention that the qualified engineer staff trained by Istanbul Technical University, Middle East Technical University and the technical universities established afterwards and high technology institutes in Türkiye have formed the basis of the National Technology Initiative. The contributions to Türkiye's development of politicians with engineering backgrounds who served as President and/or Prime Minister, such as Süleyman Demirel, Necmettin Erbakan, Turgut Özal and Binali Yıldırım, and the valuable technocrats and bureaucrats who served as their companions in their administration, are valuable. Mentioning these names with phrases such as "king of dams", "heavy industry, not installation", "technological transformation of Türkiye" and "transportation revolution" is an indication of their success. Institutions that set a roadmap for Türkiye's development in the historical process, such as the State Planning Organization, Ministry of Development and Presidency of Strategy and Budget, also have played an important role in the financing and planning of some kind of executive activities.

We are grateful to those who contributed to the planning of the long story about the investments in energy, transportation, information technologies and advanced industrial infrastructures in our political history and the current success of the National Technology Initiative, from its performers, managers, engineers, technical staff and all other workers. As can be seen, the National Technology Initiative is a breakthrough shaped by the contributions of all stakeholders. The success of this breakthrough is only possible with a strong will and strong leadership. The sensitivity and importance given by our President to this issue is very valuable.

National Innovation Systems Literature

In the light of these developments, the continuity of the ecosystem is a necessity for the national innovation systems to work harmoniously with all their components within the scope of countries' differentiation strategies and efforts to create competitive advantage.

Considering that national innovation systems are equivalent in the international literature; it is obvious that following the perspectives of other countries or nations on innovation systems is of strategic importance and determining differentiation strategies is necessary in terms of competition policies. The analyzes of the research focuses on which the topics discussed in the international literature are clustered are important guiding signs. Developing special policies for the development of science and technology policies, such as the determination of the strategic priorities of the countries for themselves and the determination of national differentiation strategies, will provide important outputs in terms of national interests. In this section, a series of bibliometric data analysis studies were carried out on the research on national innovation systems, using the relevant keywords from the databases, and the results were evaluated in order to determine the prominent topics within the framework of national innovation systems.

Results

When we examine the institutions that frequently work on national innovation systems, it is possible to talk about a dominant influence of EU member states (Figure 2). This is due to the work of the European Commission Joint Research Center (JRC), which operates as a science and technology reference center to support the formulation, development, implementation and monitoring of EU policies through scientific research. Operating in seven research centers in five-member states in total, JRC has laboratories and research facilities in Geel in Belgium, Petten in the Netherlands, Karlsruhe in Germany, Ispra in Italy and Sevilla in Spain.

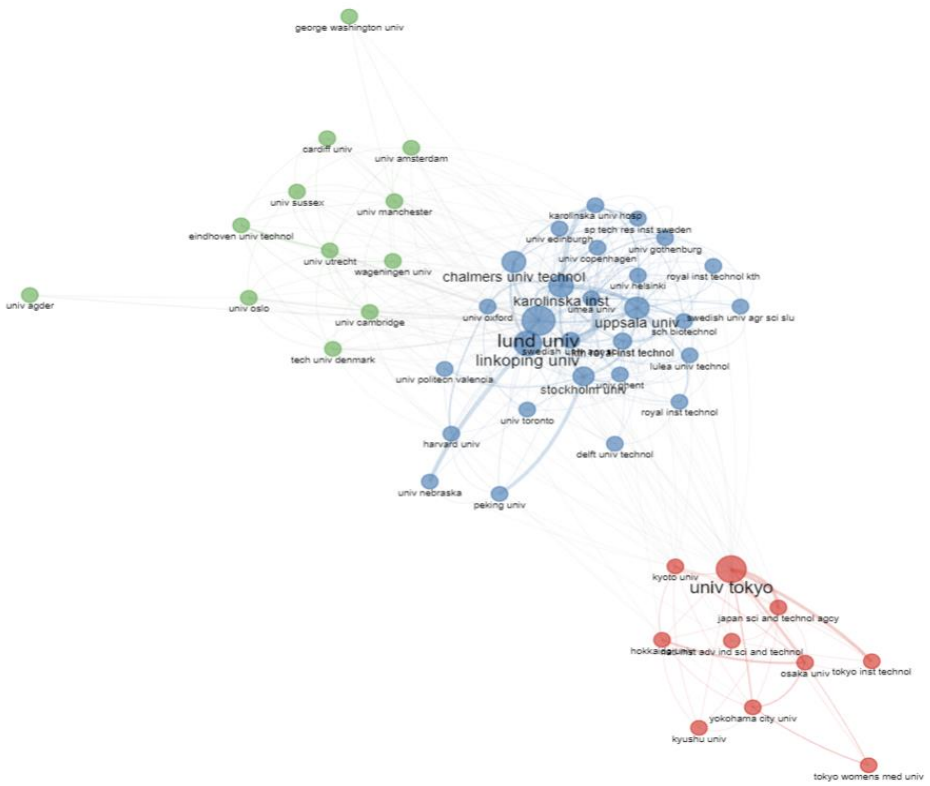

Figure 2. *Organization network for national innovation systems research*

In the light of the completed analyzes, it has been seen that national innovation systems are mostly dealt with in the axis of the concept of research and development. It focuses on clustered discussions on concepts such as basic science technology policy development, knowledge management, leadership, and decision-making of national innovation systems, which are observed to be frequently discussed in terms of their potential to provide competitive advantage. The concept map revealed by the visual keyword co-occurrence analysis, which includes the basic dynamics of the national innovation system, is presented below. International research carried out within the framework of national innovation systems is centered around four clusters (Figure 3).

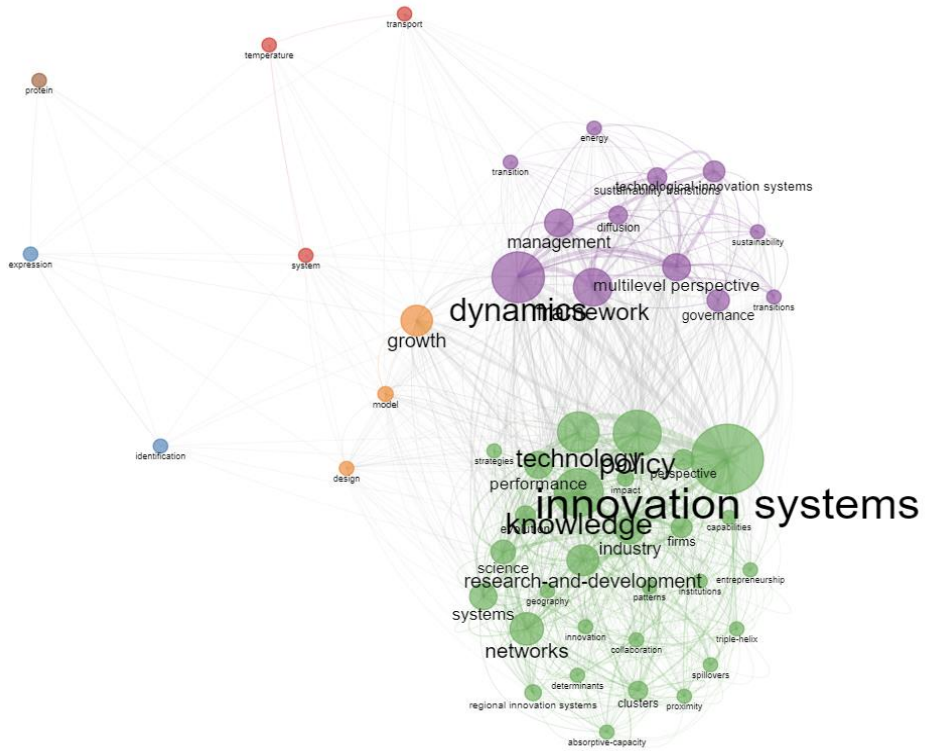

Figure 3. *Keyword Co-occurrence analysis for the national innovation systems survey*

Social network analysis was carried out to determine the roles of the concepts in the network. "degree" indicates the level of connectivity with the obtained data, "betweenness centrality" indicates the level of being in the transition/bridge position between the concepts, "High Aggregate Constraints" indicates high constraint ratio, and "Low Aggregate Constraints" values are presented. In this regard, "Knowledge", "Technology", "Management", "Innovation", "Impact", "Model", "Firms", "Research-And-Development", "Systems", "Industry" and "Product Development" It can be said that these concepts are the nodes with the highest level of connectivity for national innovation systems, and the interaction level of these concepts is high. When we look at the most important nodes, which are in the middle of the relations in the network, in other words, the edges pass over the shortest route, "Performance", "Knowledge", "Technology", "Management", "Innovation", "Research-And-Development", "Impact", "Model", "Firms", "Systems", "Product Development", "Perspective", "Industry", "Determinants", "Strategy", "Capabilities", "Framework", "Absorptive-Capacity" ", "Networks", "Collaboration" were at the top of the list.

According to the structural gap theory, it is stated that nodes located in bridge positions between different communities have advantages because they control the basic information diffusion paths. In our study, with the analysis we have carried out in this context, concepts for the determination of nodal points that have reached saturation level and relatively untouched areas open to development in the context of national innovation systems have been determined in this context, "Performance", "Firm Performance", "Knowledge", "Challenges", "Innovation", "Technology". "Research-And-Development", "Diffusion", "Investment", "Competition", "Framework", "Perspective", "Model", "Science", "Impact", "Product Development", "Generation" , "Strategies", "Financial Performance" and "Systems" were found to be terms that reached the saturation level of the concepts, while "Classification", "Entrepreneurship Education", "Data Envelopment Analysis", "Sociotechnical Systems", "Care", "Varieties", "Principles", "Technology Management", "Multilevel Perspective", "Level", "Politics", "Job-Satisfaction", "Relative Efficiency", "Multinational-Enterprises", "Constraints", "Knowledge Acquisition", "Work - Rarely studied areas of the terms "Environment" and "Agency" appears to be prominent.

Table 1. *Co-occurrence Analysis Results*

Degree	**Betweenness centrality**	**High Aggregate Constraints**	**Low Aggregate Constraints**
Performance	Performance	Performance	Classification
Knowledge	Knowledge	Firm Performance	Entrepreneurship Education
Technology	Technology	Knowledge	Data Envelopment Analysis
Management	Management	Challenges	Sociotechnical Systems
Innovation	Innovation	Innovation	Care
Impact	Research-And-Development	Technology	Varieties
Model	Impact	Research-And-Development	Principles
Firms	Model	Diffusion	Technology Management
Research-And-Development	Firms	Investment	Multilevel Perspective
Systems	Systems	Competition	Level
Industry	Product Development	Framework	Politics
Product Development	Perspective	Perspective	Job-Satisfaction
Perspective	Industry	Model	Relative Efficiency
Determinants	Determinants	Science	Multinational-Enterprises
Capabilities	Strategy	Impact	Constraints
Strategy	Capabilities	Product Development	Knowledge Acquisition
Framework	Framework	Generation	Work-Environment
Networks	Absorptive-Capacity	Strategies	Agency
Absorptive-Capacity	Networks	Financial Performance	Journals
Collaboration	Collaboration	Systems	Capitalism

When the literature is examined, it is stated that especially structural factors (relative size of sectors) and internal factors (differences in R&D intensity within sectors) are the main reasons for the gap between R&D organizations (Grassano et al., 2021). In this respect, it can be said that industrial and innovation policies are necessary to increase the number and size of companies in sectors with high R&D intensity (Munari et al., 2016; Zack, 1999).

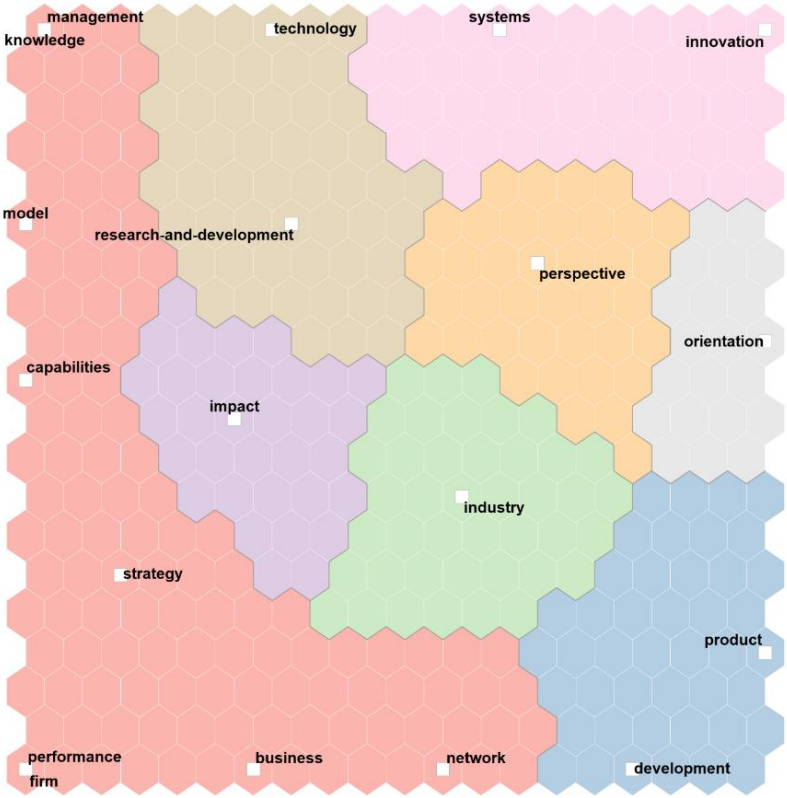

Figure 4. *Self-organizing map of keywords*

In order to better determine the dominant components of the four main clusters revealed by keyword analysis, the self-organizing feature map method was used. The method is also expressed as an unsupervised machine learning technique used to produce a low-dimensional representation of a higher-dimensional dataset while preserving the topological structure of the data (Kohonen, 2012). When we look closely at the prominent topics in the co-occurence analysis, it has been determined that the themes obtained with SOM are very close to each other. When evaluated within this framework, when it is necessary to make inferences about the dynamics of national innovation systems, the studies on the subject in the literature, especially "Technology", "Research and Development", "Innovation Systems", "Knowledge Management", "Strategy", "Capabilities", "Firm Performance", It is possible to say that it is directly associated with the terms "Business" and "Network".

When the analyzes of the studies are examined, it is possible to say that the national innovation systems are considered as a whole and that the issues such as R&D performance, private sector and policy making take place at the base. Strategic efforts, defined as the recent R&D ecosystem policies and incentives in our country, have become synonymous with the concept of the National Technology Initiative. It is possible to say that the Ministry

of Industry and Technology plays an active role in the management of processes, especially from the determination of leverage sectors to the publication of programs for priority areas.

The Ministry of Industry and Technology carries out special studies for the development of policies and strategies for the digital transformation of individuals and companies and the development of the digital economy at the national level. The Ministry undertakes the task of coordinating the determination and follow-up of the strategies within the scope of the National Technology Initiative, and also enables institutions to learn from each other by developing policies for the creation of cooperation, solidarity and coordination among stakeholders such as the public, private sector and universities.

Although the National Technology Initiative comes to the fore with the aim of developing high-tech brand products belonging to Türkiye, this Initiative actually expresses a multidimensional strategy and perspective from education to international relations, from development to sustainable life (Kacır, 2022). In addition, this Initiative is a multi-faceted set of policies that ensures the independence of the country, reduces foreign dependency, and protects the welfare of citizens by establishing a self-sufficient ecosystem. National Technology Initiative, the company currently carrying out nearly 7,000 R&D activities in more than 80 technoparks in Türkiye, with more than 1,600 R&D and design centers, the IT sector, advanced technology sectors, R&D, design, and innovation activities. It will contribute to the development of human resources working in these areas, the transformation of the workforce, and the development of digital transformation (Bayraktar, 2022).

In Türkiye, efforts are also made to increase the level of cybersecurity and information security of information and advanced technology products and systems, to produce domestic and national products in the field of cybersecurity, to expand the use of domestic and national products throughout the country, to strengthen the data center and data processing infrastructure and to develop the cybersecurity ecosystem. The PhD science awards program are one of the incentives by the Turkish Academy of Sciences within the scope of TEKNOFEST, enables the youth of our country to use advanced information technologies and to develop artificial intelligence-supported special software and design programs in many scientific fields, from engineering, health, education, economy to international relations, especially engineering, within the scope of the National Technology Initiative (TÜBA, 2022). Some of the duties of the Ministry of Industry and Technology General Directorate of National Technology are to take measures to increase the competencies of individuals and businesses, to develop and disseminate smart systems based on these technologies, to implement support and incentive programs, and to coordinate programs and projects through big data analysis and artificial intelligence studies.

Taking the necessary measures for the development and competition of the informatics and advanced technology sectors is as important as policy development. Increasing the production of science-based, national, and original high-tech products and systems is possible by training qualified manpower. In this context, it is a part of special strategies aimed at raising the necessary manpower for the sustainability of the National Technology Initiative with special incentives, as well as the identification and follow-up of research universities based on mission differentiation among universities and regional development-oriented universities by YÖK. There are 20 state universities in the Research-Oriented Mission Differentiation program. Foundation universities are also included in the Research-Oriented Mission Differentiation program, and a total of 3 foundation universities are included in the program (YÖK, 2022).

Table 2. *Universities Focused on Regional Development*

University	Development Area
Bingol University	Agriculture and Watershed Based Development
Burdur Mehmet Akif Ersoy University	Diversified Integrated Development Model in Agriculture and Livestock
Düzce University	Environment and Health
Kırşehir Ahi Evran University	Agriculture and Geothermal
Uşak University	Leather, Textile and Ceramics
Aksaray University	Sports and Health
Kastamonu University	Forestry and Nature Tourism
Mus Alpaslan University	Animal Husbandry
Recep Tayyip Erdogan University	Tea
Siirt University	Agriculture and Livestock
Artvin Coruh University	Medicinal-Aromatic Plants
Bartın University	Smart Logistics and Integrated Region Applications
Hitit University	Machinery and Manufacturing Technologies
Kirklareli University	Food
Yozgat Bozok University	Specialization in the Field of Industrial Hemp

Source: (YÖK, 2020)

The Future of Innovation Systems

In the literature, there are suggestions and discussions regarding the withdrawal of public institutions from the role of funding and the execution of project budgets in cooperation with the private sector (Archibugi & Filippetti, 2018; Beise & Stahl, 1999; Cohen et al., 2002). In our country, it is very important to direct/manage the support of the state on the national innovation systems of the National Technology Initiative with all stakeholders at any stage of the R&D processes and to support special thematic areas for the needs of the country with clustering and special incentives. Our country has been adversely affected by the heavy costs and inefficient results of repetitive studies and infrastructure expenditures in the past, which do not take into account its own strategic priorities and realities, do not turn into products as academic studies, fund supports based on purely scientific projects, are disconnected from industry and production, do not have the ability to solve problems. In the light of these evaluations, policy makers and relevant stakeholder organizations brought up the proposals for the development of new strategies, taking lessons from the fact that high technology, which is consumed rapidly, creates serious additional costs to the public budget due to the gradual decrease in our competitive power with the world in the light of dizzying developments in the scientific field (Science and Technology Supreme Council, 2012). In the light of these data and suggestions, a more efficient ecosystem was established with the National Technology Initiative, and solution-oriented projects that generate added value were prioritized.

Considering the high cost of establishing national innovation systems and the special importance for countries, this process requires special planning, coordination and consistent policy follow-up in the interests of the country. The innovation process (Satell, 2017), which previously consisted of isolated individual efforts and linear structures, is a very valuable phenomenon that should be considered as a much more collective and complex process today. For this reason, the contributions of the National Technology

Initiative to our country in the short-medium and long-term are obvious. In this case, it is obvious that just doing research, offering research opportunities or working with stakeholders is not enough. The emergence of new and disruptive technologies has turned into an important challenge for all stakeholders of national innovation systems, especially states, as a socioeconomic necessity, to closely examine the impact it has on employment and business models. In this competitive environment, countries that can qualify their human capital and provide employment opportunities in appropriate and productive environments will be successful.

The research brought up by Archibugi and Filippetti (2018) sought an answer to the question of whether it is important that R&D activities are carried out by private enterprises rather than universities or government research centers. In this study, the authors underlined that both the public R&D capacity and the share in this field have decreased in the context of total R&D investment in most of the OECD countries, while emphasizing that the intensity of science and innovation policy has recently been directed towards the development of knowledge-based societies and the appropriateness of links between the public and private sectors. In other words, a large part of new knowledge or innovative knowledge is produced in the private sector today (Archibugi & Filippetti, 2018). The private sector puts forward practices with the awareness that it is vital to stay competitive and act faster in solving problems and reducing costs. If it does not attach importance to country-specific cooperation with relevant stakeholder organizations in this regard, there is a risk that the external dependency of the private sector will become permanent, and it will put its own future under mortgage.

In Lieu of a Conclusion: Importance of National Innovation Systems for Türkiye

In order for Türkiye to develop critical technologies nationally and to have a share in value chains by offering competitive products and services in high-tech fields, policies that will increase its global competitiveness and ensure its economic and technological independence must be evaluated holistically. Industry and Technology Strategy, which was developed for this purpose and within the scope of the 100th anniversary targets of the Republic of Türkiye, consists of 5 main components: "High Technology and Innovation", "Digital Transformation and Industry Initiative", "Entrepreneurship", "Human Capital" and "Infrastructure". consists of a roadmap. In this long-term struggle, within the scope of 2023-2053-2071 targets, Türkiye will be a self-sufficient leading power in its region that produces high technology and added value, not a market in the digitalized world with the National Technology Initiative. In this sense, the National Technology Initiative is a struggle for existence for our future generations as a struggle for independence. Winning this war will only be possible with the will of the decision makers and the effort and work of the youth of the country.

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TÜBA President, Prof. Muzaffer Şeker received his Ph.D. in Human Anatomy at Leicester University, Faculty of Medicine in England. In 2000, he became an associate professor and in 2006, he became a full professor. He worked as an instructor in the United Arab Emirates for two years. Dr. Şeker served as founding rector of Necmettin Erbakan University between 2010 and 2018. TÜBA President Dr. Şeker, who currently also teaches at the same university, has been a member of many national and international academic organizations and non-governmental organizations. Dr. Şeker also has bachelor's degree in public administration. Prof. Şeker has been the President of TÜBA since May of 2019.