AÜİİBFD
Anadolu Üniversitesi İktisadi ve İdari Bilimler Fakültesi
Anadolu University Journal of Economics and Administrative Sciences

Cilt: 25, Sayı: 2, Yıl: 2024
e-ISSN: 2687-184X
https://dergipark.org.tr/en/pub/anadoluiibfd

Makale Türü / Submission Type: Araştırma Makalesi / Research Article
Başvuru Tarihi / Date Submitted: 25/08/2023
Kabul Tarihi / Date Accepted: 27/09/2023

DOI: 10.53443/anadoluibfd.1350168
2024, 25(2), 30-68

EVALUATION OF HELIX INNOVATION MODELS AND TECHNOLOGY DEVELOPMENT ZONES IN TÜRKİYE WITHIN THE NATIONAL INNOVATION SYSTEM FRAMEWORK*

Yağız BİRİNCİ[2], Esin KILIÇ[3]

Abstract

Economic growth and sustainable development, as well as increasing competitiveness in international markets, depend on the establishment of a knowledge-based socio-economic structure. Helix innovation models (HIM) are used to prepare the ground for a knowledge economy, society, and democracy, and to make economic growth and development sustainable. The triple HIM, focusing on the creation, diffusion, and commercialization of knowledge through triple network structures and hybrid organizations, is an effective model for fostering innovation and entrepreneurial culture. The model, obtained by including media-based and culture-based public and civil society actors in the triple helix structure, is referred to as the quadruple HIM. The triple and quadruple HIMs are expanded to include the natural environment factor in the quintuple HIM. Türkiye's national innovation system (NIS) has been designed within the scope of the triple HIM. The contribution of technology development zones (TDZs) in Türkiye to the NIS has been evaluated within the framework of HIMs and the entrepreneur and innovative university index. In this context, it has been concluded that enhancing intellectual property performance and economic and social contributions, as well as developing university-industry collaboration, are necessary.

Anahtar Kelimeler: National Innovation System, Helix Innovation Models, Technology Development Zones.

JEL Kodları: D02, L32, O38

ULUSAL YENİLİK SİSTEMİ ÇERÇEVESİNDE SARMAL İNOVASYON MODELLERİ VE TÜRKİYE'DEKİ TEKNOLOJİ GELİŞTİRME BÖLGELERİNİN DEĞERLENDİRİLMESİ

Öz

Ekonomik büyüme ve kalkınmanın sürdürülebilir kılınması ve uluslararası pazarlarda rekabet gücünün arttırılması, bilgi temelli sosyoekonomik yapının oluşturulmasına bağlıdır. Bilgi ekonomisine, toplumuna ve demokrasisine zemin hazırlamak ve ekonomik büyümeyi ve kalkınmayı sürdürülebilir hale getirmek için sarmal inovasyon modelleri kullanılmaktadır. Üçlü ağyapılar ve hibrit organizasyonlarla bilginin yaratılmasını, yayılmasını ve ticarileşmesini konu alan üçlü sarmal inovasyon modeli, yenilikçilik ve girişimcilik kültürünün oluşturulması için etkili bir modeldir. Üçlü sarmal yapıya medya tabanlı ve kültür temelli halk ile sivil toplum aktörünün dâhil edilmesiyle elde edilen model, dörtlü sarmal inovasyon modeli olarak adlandırılmaktadır. Beşli sarmal inovasyon modelinde ise üçlü ve dörtlü sarmal inovasyon modeline, doğal çevre faktörü eklenmektedir. Türkiye'nin ulusal yenilik sistemi, üçlü sarmal inovasyon modeli kapsamında tasarlanmıştır. Türkiye'deki teknoloji geliştirme bölgelerinin ulusal yenilik sistemine katkısı, sarmal inovasyon modelleri ve girişimci ve yenilikçi üniversite endeksi çerçevesinde değerlendirilmiştir. Bu bağlamda, fikri mülkiyet performansı ile ekonomik ve toplumsal katkının arttırılması ve üniversite ve sanayi işbirliğinin geliştirilmesi gerektiği sonucuna varılmıştır.

Keywords: Ulusal Yenilik Sistemi, Sarmal İnovasyon Modelleri, Teknoloji Geliştirme Bölgeleri.

JEL Codes: D02, L32, O38

---

* Eskişehir Osmangazi Üniversitesi, Sosyal Bilimler Enstitüsü, İktisat Anabilim Dalı'nda, Dr. Öğr. Üyesi Esin Kılıç danışmanlığında Yağız Birinci tarafından "Kurumsal İktisat Perspektifinde Teknoparkların Ulusal Yenilik Sistemine Katkısı: ETGB-ATAP Örneği" başlığı ile tamamlanarak 05.10.2023 tarihinde savunulan Yüksek Lisans tezinden türetilmiştir.

[2] Yüksek Lisans mezunu, ygzbrnc1@gmail.com, https://orcid.org/0000-0002-4716-3478
[3] Dr. Öğr. Üyesi, Eskişehir Osmangazi Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, esinkilic@ogu.edu.tr, https://orcid.org/0000-0003-1681-5186

INTRODUCTION

Knowledge, nowadays, emerges as one of the production factors and serves as the fundamental building block of innovative products that arise in research and development laboratories. Developed and developing countries design their national innovation systems (NIS) with a focus on knowledge in order to sustain economic growth and development and enhance international competitiveness. The NIS is the practical manifestation of knowledge, science, and technology policies. These policies act as a compass in the formation of the NIS and play a pioneering role in constructing it through institutional mechanisms.

The triple helix structure, representing government-university-industry collaboration, promotes the generation, utilization, dissemination, capitalization, and commercialization of knowledge from an interdisciplinary and transdisciplinary perspective. The three pillars of the helix collaborate and assume each other's roles to facilitate knowledge-based sustainable economic growth and development. Thus, the power of innovation is directed toward society-oriented services and investments. Technology development zones host the actors of the triple helix structure to systematically establish regional economic development. By fostering mutual and interactive collaboration, they facilitate the spread of an entrepreneurial and innovative culture. With its complex yet systematic, flexible, agile, and institutional design, technology development zones contribute to the development of the NIS.

The quadruple helix innovation model (HIM), based on governance principles and the understanding of co-creation, emerged by adding civil society and public actors to the institutional actors of the triple helix structure. The quadruple HIM associates the plurality and diversity of knowledge and innovation paradigms with the concept of knowledge democracy. Accordingly, there is a mutual causality relationship between the advancement of the knowledge economy, society, and democracy, and the quality of democratic governance. This relationship between the quality of democracy and knowledge and innovation paradigms represents the socioeconomic development process from an evolutionary and institutional perspective. In the quintuple HIM, the natural environment factor is added to the triple and quadruple HIMs. The quintuple helix structure, which is a new subsystem of knowledge and innovation paradigms, is designed to sustain economic growth and development. The triple HIM and its new approaches enhance the quality of the knowledge economy, society, and democracy, and accelerate knowledge-based socioeconomic evolution.

The triple HIM and new approaches enhance the quality of the knowledge economy, society, and democracy, and accelerate the knowledge-based socio-economic evolution. Türkiye, which lags behind in following the global technological change and transformation process, has been unable to complete the transition from an industrial society to a knowledge society due to the failure to effectively implement knowledge, science, and technology strategies and establish a knowledge-driven national will. In this context, the first part of the study is devoted to the knowledge economy and innovation models, while the second part focuses on the evaluation of Türkiye's knowledge, science, and technology strategies and the situation of technology development zones.

The aim of this study is to evaluate the collaboration between universities, industry, and the government, as well as the factors that enhance the economic and social contributions, intellectual property performance, and scientific and technological competence of technology development zones within the framework of innovation models. In line with these objectives, it is important to include the factors that will enhance the performance of technology development zones in the NIS and in the performance evaluation criteria of the system. The proposed solutions presented based on the findings of the study are expected to accelerate the knowledge-based socio-economic evolution process. The first part of the study is dedicated to the knowledge economy and innovation models, while the second part focuses on the assessment of Türkiye's knowledge, science, and technology strategies, as well as the status of technology development zones.

THE KNOWLEDGE ECONOMY

The knowledge economy, by its very existence, carries traces of socio-economic trends. The intellectual foundations of the knowledge-based economic structure can be traced back to Veblen and Schumpeter's economic analyses. Veblen, in his theory of evolutionary process, establishes a causal relationship between instinctive tendencies of human nature and technological progress, while Schumpeter, in his theory of capitalist economic development, relates individual behaviors with elite thought patterns to the needs of the capitalist economic structure. Veblen and Schumpeter, from an evolutionary and institutional perspective, evaluated the historical and cultural dimensions of technical knowledge within a dynamic developmental process (Demir, 1996, p. 95-96; Özbay, 2021, p. 96). Indeed, the structural characteristics of the knowledge economy largely confirm Veblen and Schumpeter's theoretical analyses based on cumulative causality principles.

The knowledge-based economic structure emerged with the technological revolution that occurred after the industrial revolution. The technological revolution has transformed the main actors in the production process, and knowledge has become the fundamental building block of the production process. During this process, the production, accumulation, transformation, and sharing of knowledge have been associated with the phenomenon of technological capability. Technological capability refers to the capacity and ability of institutions and organizations to "use, select, and develop the necessary technologies to create strategic competitive advantage" (Taymaz, 2004, p. 1). In the process of universal integration known as globalization, technological capability emerges as a determinant of socioeconomic well-being and the balances in the new world order. Therefore, the achievement of sustainable economic growth performance and competitive advantage in international markets has become dependent on technological capability (Saygılı, 2003, p. 5; Kevük, 2006, p. 322).

Contrary to popular belief, the knowledge economy, often confused with the use of high technology and information and communication technologies in the production process, is a structure that encompasses all social and economic processes. The knowledge economy, which gives functional quality to knowledge and characterizes the value of knowledge from a pragmatic perspective, is positioned within four fundamental features (Uçkan, 2006, p. 27):

- Creating the institutional and legal infrastructure that supports the effective and widespread use of knowledge in temporal and spatial contexts, the formation of an entrepreneurial ecosystem, and socio-economic transformation processes;
- Building a social structure where distinguished education and lifelong learning tools are made accessible, and a stable, creative, and flexible mindset is cultivated;
- Establishing a NIS and network structure that brings together businesses, science and research centers, higher education institutions, and public institutions, which contribute to national and international knowledge accumulation or capital, internalize knowledge accumulation, and provide demand-oriented solutions to socio-economic problems while adopting a competitive and innovative service approach;
- Designing science and technology policies that target the sustainability of the knowledge-based economic structure in a historical and cultural context.

In ensuring the transition to the knowledge economy, the establishment of a national will supported by political determination is of utmost importance. National will is the starting point for societal and economic transformation. Therefore, political organization and governance understanding hold significant importance in establishing a national will and transitioning to the knowledge economy. The key element in building a sustainable knowledge-based economic structure is the conceptual and managerial preparation of a national knowledge policy that is flexible, and stable, and advocates for the collective ownership of knowledge. The success factor lies in the development of a strategic business model that promotes collaboration, coordination, and network formation among strategically important sectors that drive the dynamism of the economic system (Uçkan, 2006, p. 27-28).

The NIS is the practical manifestation of knowledge, science, and technology policies. Knowledge, science, and technology policies are institutional mechanisms that give functionality to the NIS. In other words, they are the engine of the NIS. The performance of the NIS demonstrates a country's technological management capability. Technological management is “a process that involves planning, managing, controlling, and coordinating the development and implementation of technological capabilities to organize an organization's operational and strategic goals” (Ertekin, 2013, p. 17). This process encompasses the planning of science and technology policies and the implementation of activities related to technological investment and infrastructure within the framework of societal and economic development objectives (Ertekin, 2013, p. 28).

Technological management plays a critical role in enhancing the technological capabilities of public and private enterprises or integrated (public-private) corporate structures. Supportive activities of technological management include innovation and knowledge management. Innovation management is “the discipline of managing the innovation processes within an organization to successfully implement innovative ideas” (Çetindamar, Phaal and Probert, 2017, p. 261). Knowledge management, on the other hand, is “the entirety of strategies and processes aimed at creating, finding, acquiring, and mobilizing knowledge to enhance competitiveness” (Gümüştekin, 2004, p. 204). Knowledge is a prerequisite for creating innovation. Innovation necessitates the production and management of technical knowledge. Therefore, giving sustainability to knowledge production and management enables the successful implementation of innovative ideas (Durna and Demirel, 2008, p. 141). Knowledge and innovation management institutionalize under the framework of technological management through integrated structures based on collaboration between the state, industry, and universities. This institutionalization brings together the key actors of the NIS on a common ground and transforms the capitalization of knowledge into an organizational process.

The Triple HIM: The Government-University-Industry Collaboration

The government-university-industry collaboration, also known as the triple HIM, is used to accelerate the systematic transition to a knowledge-based socio-economic structure. The triple helix structure achieves knowledge production through Mode 1 and Mode 2. Mode 1 represents the fundamental research process that gradually changes the socioeconomic environment through university-focused scientific knowledge production within the framework of the linear innovation model. Mode 2 defines the new production method and functional use of scientific knowledge. Compatible with the non-linear innovation model, Mode 2 aims to produce interdisciplinary and transdisciplinary knowledge for identifying and solving socio-economic problems. The purpose and dissemination of knowledge highlight the fundamental difference between Mode

1 and Mode 2 (Keskin and Ovalı, 2022, p. 449; Kiper, 2010, p. 30). Indeed, Mode 1 has a traditional research methodology and researcher base that does not go beyond the disciplinary framework, while Mode 2 has an interdisciplinary and transdisciplinary research methodology and researcher base (Çınar, 2009, p. 22). The methodological and collective changes in knowledge production explain the differentiation in international competitive factors, the collaboration between the university and industry sectors, and the sophisticated and complex structure of technological development.

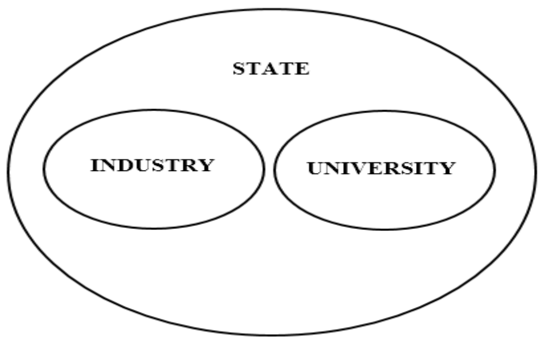
The linear innovation model refers to the execution of knowledge production within specific rules and standards. These rules and standards transform the process of knowledge commercialization into a bureaucratic organization and create an indirect network of relationships. The linear innovation model, used until the 1970s, gave way to the non-linear or evolutionary innovation model, where knowledge is produced with the aim of enhancing social welfare and involves direct interactions between parties. The direct interaction of parties shortens the process of identifying socio-economic problems, developing solution proposals, creating regulations, and generating embedded knowledge. Embedded knowledge, considered as output, accumulates and disseminates at the national or regional level. As a result, the need for technology transfer is reduced, and dependence on foreign countries is minimized. The triple HIM has a complex yet systematic, flexible, and agile organizational structure. It is an effective model for the dissemination of research, technology development, and innovation culture, as well as the capitalization and commercialization of knowledge (Kiper, 2010, p. 18).

The model was proposed by Loet Leydesdorff and Henry Etzkowitz in the late 1990s. Leydesdorff and Etzkowitz designed the triple HIM to analyze the dynamics of knowledge-based innovation systems and innovation processes from an evolutionary perspective. According to Leydesdorff and Etzkowitz, the government, industry, and university sectors converge and operate in a mutual but complex relationship (Göker, 2000, p. 5). Universities are significant institutional components of technical knowledge and scientific progress. The industry utilizes the produced technical knowledge for its application, marketing, and commercialization. The government provides financial support to the university and industry sectors, and designs and manages the organizational process. Unlike previous collaboration models, the triple HIM emphasizes the collective ownership of knowledge and establishes institutional relationships among the parties (Aycan and Şeker, 2013, p. 16).

The Triple Helix Configurations

Etzkowitz and Leydesdorff define the configuration of state, industry, and university in three forms from a historical and evolutionary perspective. The first one is the statist model. In the statist model, the nation-state encompasses the university and industry sectors and directs the relationships among them (Etzkowitz and Leydesdorff, 2000, p. 111).

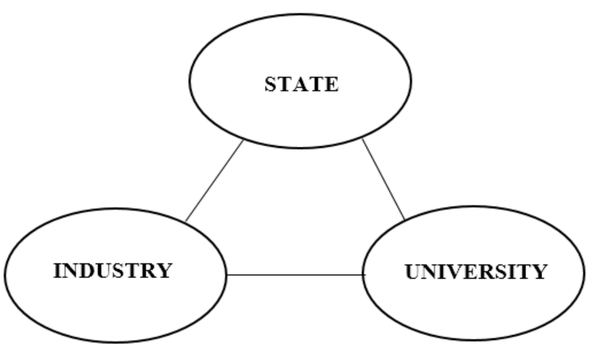
Figure 1: The statist model in the government-university-industry collaboration



Source: Etzkowitz and Leydesdorff, 2000, p. 111

Figure 1 illustrates the institutional relationship where actors are separate from each other, do not collaborate, or one actor dominates the others (Etzkowitz, 2002, p. 3). The state controls and coordinates the university and industry sectors, which have a weak institutional structure. Due to the hierarchical structure, technology policies are designed and implemented with a centralist approach (Kuş, 2017, p. 98). Etzkowitz and Leydesdorff consider the statist model as an unsuccessful developmental model due to the dominant role of the state and the lack of decision-making or decision-making authority for the university and industry sectors. The second form of the state, industry, and university configuration is the liberal model. In this model, institutional domains are separated, and the institutional relationship between actors is highly limited (Etzkowitz and Leydesdorff, 2000, p. 111-112).

Figure 2: The liberal model in the government-university-industry collaboration

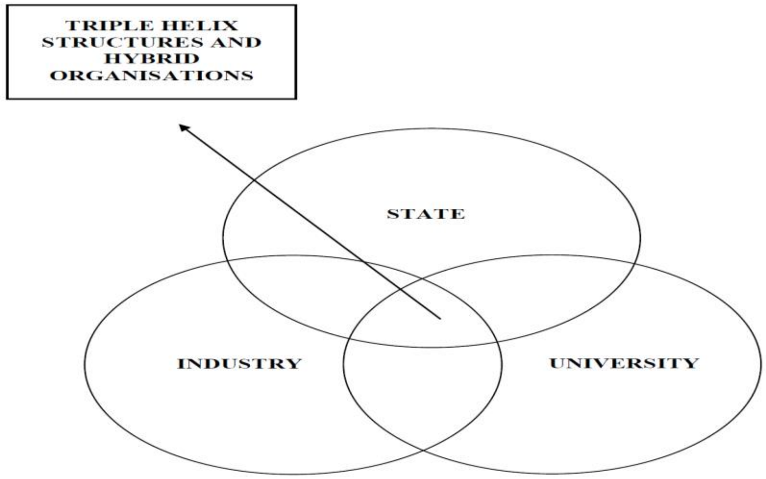


Source: Etzkowitz and Leydesdorff, 2000, p. 111

The liberal form of state-university-industry collaboration is shown in Figure 2. Etzkowitz and Leydesdorff (2000, p. 112) emphasize that in the liberal model, the laissez-faire policy is in effect, and this policy is applied as a shock treatment to reduce the dominant role of the state Therefore, the state assumes a position of regulating and overseeing the market. The university sector represents an institutional structure that provides a qualified workforce for the industry sector and generates knowledge through basic or applied research. The industry sector, on the other hand, represents an institutional structure that commercializes and markets knowledge with its competitive identity. In the liberal form, university-industry collaboration is seen as a disruptive, limiting, or inhibitory factor to competition. It is prohibited based on laws and regulations in line with conditions of perfect competition (Kuş, 2017, p. 99).

The third form of the state-industry-university configuration is the triple HIM. Unlike the statist and liberal models, this model represents a structure where boundaries are blurred, institutional domains overlap, and actors collaborate (Etzkowitz, 2002, p. 4). In other words, it is a hybrid organizational structure where each actor takes on the role of the other, and knowledge is capitalized in a mutual and interactive manner. Academic research groups, state laboratories operating in different sectors and technology levels, small and large-scale enterprises, intermediary organizations, and network structures are transformed into hybrid organizations. The primary purpose of hybrid organizations is to commercialize and capitalize on academic knowledge and establish a university-centered culture of innovation (Etzkowitz and Leydesdorff, 2000, p. 112; Koç and Mente, 2007, p. 9).

Figure 3: The triple helix in the government-university-industry collaboration



Source: Etzkowitz and Leydesdorff, 2000, p. 111

The triple HIM of state-university-industry collaboration is shown in Figure 3. Etzkowitz divides the triple helix configuration into three stages and defines the relationship between actors as follows (Türkiye-EU Business Dialogue, 2020, p. 13):

> "The triple helix is a helix innovation model where the knowledge process is transformed into capital through multidimensional mutual relationships at different points. The first stage of the model involves internal changes such as strategic alliances in all three helices, bilateral relationships among firms, or the development of the assumption of economic development by universities. The second stage is the formation of the influence of one helix on another. The third and final stage is the emergence of triple helix structures and creative organizations with new ideas and forms for advanced technology development through the interaction of the three helices. In the triple helix, university-industry-state relations are defined as relatively equal, interdependent, and constantly interacting institutional domains where one institution can assume the role of another and overlap with each other. The university plays the role of an incubator for firms, industry acts as an educator for universities, and the state assumes the role of providing venture capital through small business innovation research and other programs.".

Etzkowitz and Leydesdorff explain science and technology management, knowledge dissemination, social responsibility of science, and the level of institutional relationships using a HIM. The three helices of the helix form strategic alliances and mutual role changes to enable knowledge-based economic growth and development. Indeed, the university sector assumes the role of generating technology-based firms through incubation centers, while the industry sector takes on the role of providing vocational and technical education or conducting basic or applied research, thereby assuming the role of the university sector. The government sector establishes public laboratories operating in different sectors and technology levels to foster small business innovations and support the university and industry sectors like angel investor (Koç and Mente, 2007, p. 10). The triple HIM consists of three main components: actors at the micro level, institutional structures at the meso level, and laws, rules, and guidelines at the macro level (Kiper, 2010, p. 12; Aycan and Şeker, 2013, p. 16):

-Actors: The actors involved at the micro level are academia, the public sector, and the business world. They differ structurally and culturally. The ability of actors to fulfill their roles determines the degree of collaboration and convergence.

-Institutional Structures: The institutional structures operating at the meso level organize the production process by creating technical knowledge. In other words, they bring together the university and industry sectors on a common ground. The public sector provides financial support to these institutional structures and encourages the establishment of networks at national or international levels.

-Laws, Rules, and Directives: Laws, rules, and directives at the macro level define the normative framework of the triple HIM. The public sector, engaged in legislative efforts related to university-industry collaboration, defines the legal framework and establishes the operational mechanism of the model.

Triple helix configurations shed light on the evolution of government-university-industry collaboration in a historical context. The statist model, where the government has a dominant role, or the liberal model, where the government regulates and controls the market, has a framework in which actors have no autonomy in decision-making and their relationships are limited. In contrast to the statist and liberal models that stifle collaboration, the triple HIM emerges as a versatile model in which hybrid innovation structures, innovation interfaces, and coordinators facilitate mutual and interactive relationships among actors. Many countries today are striving to adapt to or fully develop the triple HIM (Sakınç and Bursalıoğlu, 2012, p. 97). The actors of the triple helix structure come together under the umbrella of a technology research and development zone, also known as a technology park (technopark). Technology parks are defined as "organized research and business centers where universities, research institutions, and industrial organizations conduct R&D and innovation activities in the same environment, where high-value-added products emerge, and where knowledge and technology transfer takes place among them; integrating academic, economic, and social structures" (Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü, 2023b, p. 3).

Stanford Research Park (SRP) in the state of California, United States, is the first developed technology park. SRP directs investments that focus on improving human and environmental progress, serving as a guide for scientists, providing local employment opportunities for university graduates, and promoting regional economic development. Stanford University has been used as an incubation center where emerging industries are protected, leading to the emergence of Silicon Valley through the influence of increasing entrepreneurial companies. Silicon Valley, established under the institutional leadership of Stanford University, has paved the way for the establishment of many science parks with its infrastructure, technical experts, consultancy services, technology transfer offices, and networks. SRP, hosting the R&D centers of leading companies worldwide since 1951, is located in the heart of Silicon Valley, surrounded by popular social areas and a rich art and cultural environment. The unique blend of nature and culture has made SRP an acclaimed research park (Eren, 2011, p. 47-52; Stanford Research Park, 2018).

The Quadruple HIM: The Government-University-Industry-Civil Society Collaboration

The quadruple HIM emerged by adding media-based and culture-based public, and civil society actors to the triple HIM. The fourth helix, representing the public and civil society, is associated with media, culture, social value systems, art, lifestyles, creative industries, and classes (Carayannis and Rakhmatullin, 2014, p. 235-236). The public and civil society play a key role in the successful achievement of knowledge, science, and technology policies or strategies that form the framework of the NIS (Carayannis and Campbell, 2011, p. 357).

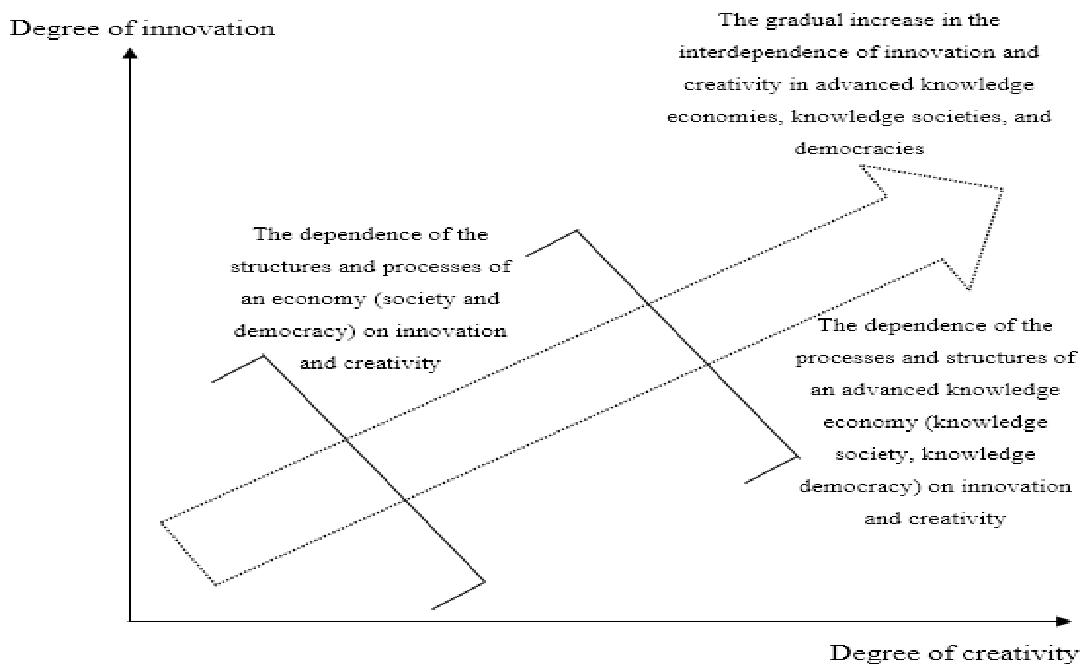
The quadruple helix structure achieves knowledge production through the combination of Mod 1 and Mod 2 via Mod 3. Mod 3, invented by Elias G. Carayannis and further developed with the contributions of David F. J. Campbell, is a multi-dimensional and multi-level systemic approach that conceptualizes, designs and manages the real or virtual stock and flow of information for generating, disseminating, absorbing, and utilizing knowledge. In other words, it is a method that accelerates the creation, dissemination, assimilation, and utilization of knowledge. It is based on a theoretical perspective of the knowledge-based global economy and society, shaped by socio-economic, political, technological, and cultural trends that influence the evolution of knowledge (Carayannis and Campbell, 2011, p. 335-336). It promotes interdisciplinary thinking and the application of transdisciplinary knowledge, allowing different knowledge production methods to coexist with different innovation models (Carayannis, Barth and Campbell, 2012, p. 3).

The acceptance and encouragement of pluralism or diversity in knowledge and innovation paradigms in knowledge economies and societies enable mutual and cross-learning of knowledge. Carayannis and Campbell emphasize that the competitiveness and superiority of a knowledge system largely depend on the collective evolution, specialization, and knowledge stock of different knowledge production methods and innovation models. Thus, the presence, capacity, and quality of harmonizing systems that bring together different knowledge production methods and innovation models demonstrate the competitive power of the knowledge system (Carayannis and Campbell, 2010, p. 51).

The pluralism and diversity of knowledge and innovation paradigms are linked to the dynamics and connectivity power of networks. This describes the pluralism of knowledge, innovation, harmonizing structures, and processes in interlocking clusters and networks (Keskin and Ovalı, 2022, p. 449). Carayannis and Campbell relate the pluralism and diversity in knowledge and innovation paradigms to political pluralism and diversity, proposing the concept of knowledge democracy. They emphasize that sustainable development should be achieved through the common evolution of the knowledge economy, knowledge society, and knowledge democracy. The quadruple HIM encourages knowledge democracy perspectives to support the production, application, sharing, and distribution of knowledge (Carayannis and Campbell, 2012, p. 19; Carayannis and Campbell, 2014, p. 14).

Figure 4 illustrates the increasing mutual relationship between innovation and creativity in advanced knowledge economies, knowledge societies, and knowledge democracies. The knowledge economy, which sustains sustainable economic growth and development dynamism, draws nourishment from creative and innovative knowledge flow. Knowledge, creativity, innovation, knowledge economy, and knowledge society undergo a common evolution. Advanced knowledge economies and societies essentially reflect the creative economy and society. The more advanced and mature the knowledge economy, society, and democracy, the greater the production of innovative and creative knowledge. Dubina, Carayannis, and Campbell define the creative economy as the creative linking of technical innovations with social innovations. In the quadruple HIM, they conceive of a creative economy that is valid for all sectors of the economy and all segments of society (Carayannis and Campbell, 2011, p. 339; Dubina, Carayannis and Campbell, 2012, p. 21-22).

Figure 4: The increasing mutual relationship of innovation and creativity in advanced knowledge economies, knowledge societies, and knowledge democracies



Source: Carayannis and Campbell, 2011, p. 341

The connection between knowledge, innovation, and democracy depends on the quality of knowledge and innovation-based democratic governance. There are four fundamental elements that indicate the quality of democratic governance: equality, freedom, control, and sustainable development. Campbell, Carayannis, and Rehman describe these elements as dimensions that conceptually define democracy. The term "dimension" brings a perspective beyond theory to the concept of democracy. In other words, different democracy theories are related to each other and compared based on their dimensions. They have associated these dimensions of democracy with the creativity and productivity of the knowledge and innovation system. Thus, the mutual relationship between the quality of democracy and the innovation system represents a socio-economic developmental process (Campbell, Carayannis and Rehman, 2015, p. 471; Çalıkoğlu, 2022, p. 34).

The components of artistic and art-based research-driven innovation provide iterative configurations and network connections within an interdisciplinary and transdisciplinary framework for knowledge production. In addition to the understanding of art that enhances creativity in the process of knowledge production and innovation, media, from a cultural perspective, support the approval of creative and innovative entrepreneurial ideas that will transform the NIS and contribute to the formation of an innovation culture within civil society. An innovation culture is the key to promoting an advanced knowledge-based economic structure. Giving the highest priority to innovation, knowledge, research, technology, and education in mass communication tools is of great importance in constructing an innovation culture. In this context, the interaction of technology, culture, media, and art positions civil society as the permanent user and implementer of the knowledge system and makes the economic development process sustainable (Keskin and Ovalı, 2022, p. 452; Carayannis and Campbell, 2009, p. 206-207).

The quadruple HIM is a stakeholder organization based on governance principles and the concept of co-creation. Socio-economic needs and problems are the common points where the creative economy and society intersect. The inclusion of information system users and implementers, in addition to the institutional actors of the triple helix structure, has expanded the framework of collaboration and initiated the process of commercialization based on open innovation of knowledge (Türkiye-EU Business Dialogue, 2020, p. 14-15). Civil society organizations and local and central government units are organizational structures representing society. These structures consist of local and regional communities aiming to analyze and address environmental and social issues at micro and macro levels. Organizational structures that establish connections between universities, industry, and the government through organized research and business development activities are integrated under the umbrella of a social collaboration region or also known as a social sciences research park (Sosyopark) (Çalıkoğlu, 2022, p. 33). The social collaboration region approach is developed to enhance interaction among social sciences, the public sector, civil society organizations, and private sector organizations, transfer theoretical knowledge relevant to societal needs into practice, and involve knowledge system users and implementers in the process of knowledge production (TÜBİTAK

Bilim, Teknoloji ve Yenilik Politikaları Daire Başkanlığı, 2018, p. 12). The definition and scope of the social collaboration region are expressed as follows (Çelik, 2016, p. 39):

> "A collaborative environment/region is designed for the production, sharing, and transfer of information and practices related to the organization and activities of local-central government units, civil society organizations, or private enterprise organizations. It allows institutions accepted as members or tenants to obtain the information and application, research, and development support they need. Within this framework, relevant institutions can also benefit from the university's academic staff, equipment, and other materials, as well as its accumulated knowledge. The collaborative environment/region functions as a management entity that provides support for all these aspects."

Rick Delbridge, who leads the development plans for Cardiff University's Social Science Research Park, and Adam Price, the Senior Program Manager at the UK National Science, Technology, and Arts Foundation, express that in technology research and development areas that are distant from the social environment, knowledge production starts at the workbench and ends with technology transfer or commercialization. They emphasize the need for social collaborations to gather new knowledge, produce and deepen collaboration with a wider range of actors. Price and Delbridge highlight the necessity of social science research parks that are open to researchers, students, citizens, customers, and stakeholders, interactive, entrepreneurial, and touch the heart of social life (Price and Delbridge, 2015, p. 11).

Cardiff University's Social Science Research Park is the first social science research park developed and adapted from the traditional science park model. The mission of this research park is to increase research and development activities along with interdisciplinary, innovative, and collaborative postgraduate research activities and create new employment opportunities. Its vision is to position Cardiff University and Wales as an international leader in designing, developing, and marketing research in the field of social sciences. Located in the Cardiff University innovation campus, the social science research park offers a public facility that promotes face-to-face interactions, breaks down barriers, and inspires out-of-the-box thinking based on the principle of co-creation. This facility brings together national or international institutions and organizations, researchers, policy-making and implementing units, university communities, governments, non-profit organizations, businesses, and the public, acting as a catalyst for change. The facility enables the testing of production prototypes and ideas by citizens, consumers, and end-users, creating a feedback mechanism that expands the boundaries of service innovation. The site includes exhibition areas, high-quality food service, recreational areas, visualization laboratories, and data facilities for computational social sciences and behavioral sciences, as well as flexible working spaces (Cardiff University, 2015a; Cardiff University, 2017a).

The interdisciplinary expert research groups within the research park work to solve social problems and develop new business models. Various institutions operating in different sectors collaborate with these expert research groups under the title of strategic partners to make the knowledge production process collective. Bringing expert research groups together with strategic partners encourages innovative individuals with a similar mindset to join the institution and collaborate on effective research. There are three main themes in which research is concentrated: Arts, humanities, and social sciences; Biomedical and life sciences; Physical sciences and engineering. The topics within these themes include various subtopics, such as business, economics, employment, civil society, communities, security, governance, public policy, health, education, welfare, culture, language, and identity. Biomedical and life sciences include subtopics such as cancer, mind, brain, neuroscience, and developmental and regenerative biology, while physical sciences and engineering include subtopics such as energy, sustainability, catalysts, advanced materials, and structures. The diversity of the research base enables research to be conducted from an interdisciplinary and transdisciplinary perspective. Expert groups conducting research and studies within these specified themes work with collaborative institutions and organizations to create policies that prioritize the public interest and aim to solve today's and tomorrow's problems (Cardiff University, 2015b; Cardiff University, 2017b).

The Quintuple HIM: The University-Industry-Government-Civil Society-Natural Environment Collaboration

The quintuple HIM emerged by adding the natural environment factor to the triple and quadruple HIMs (Carayannis and Campbell, 2010, p. 43). The quadruple and quintuple helix structures, defining the role, nature, and dynamics of regional collaboration-based fractal ecosystems, integrated firms, institutions, and other stakeholders within the spiral, dynamic, complex, fractal, nonlinear, and self-organizing higher-order learning architecture of Mode 3 knowledge production system (Carayannis, Grigoroudis, Campbell, Meissner and Stamati, 2018, p. 149). The natural environment has been included as a new subsystem in the models of knowledge and innovation. Thus, society is associated with the components of the natural environment, knowledge production, and innovation (Carayannis et al., 2012, p. 5).

The educational system, economic system, natural environment, media-based and culture-based public, and political systems constitute the sub-systems of society. In the circulation of knowledge among societal sub-systems and in an economy, knowledge becomes a source of innovation and accumulation, constituting the founding element of the quintuple helix system. Within the framework of the knowledge source, the five subsystems that are defined to analyze sustainability and establish sustainable development are described as follows (Carayannis et al., 2012, p. 5-6):

- Educational System: The first subsystem, the educational system, is defined through academies, universities, higher education systems, and schools. It is formed by the necessary human capital (students, teachers, researchers, academic entrepreneurs, etc.) through the investigation and dissemination of knowledge.
- Economic System: The second subsystem, the economic system, consists of industries, firms, services, and banks. It focuses on the economic capital of the nation-state (entrepreneurship, machines, products, technology, money, etc.).
- Natural Environment: The third subsystem, the natural environment, is a determinant for sustainable development and provides natural capital (resources, plants, various animals, etc.).
- Media-Based and Culture-Based Public: The fourth subsystem, the media-based and culture-based public, integrates two forms of capital. While the culture-based public has social capital (traditions, values, etc.), the media-based public has access to information (news, communication, social networks, etc.).
- Political System: The fifth subsystem, the political system, has political and legal capital (laws, plans, politicians, etc.). This system defines the general conditions of the nation-state, outlines future perspectives, and organizes and manages accordingly.

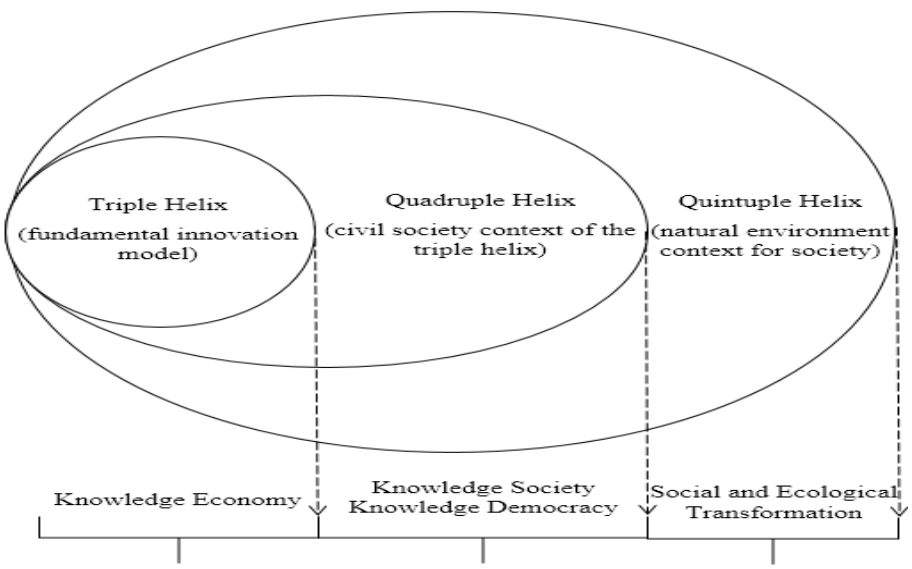
The societal subsystems influence each other with knowledge circulation through new, advanced, and pioneering innovations to achieve sustainable economic development (Carayannis et al., 2012, p. 7). Therefore, the natural environment of society is an unmissable opportunity to perfect the development and collective evolution of the knowledge economy, knowledge society, and knowledge democracy (Keskin and Ovalı, 2022, p. 454).

The World Wildlife Fund expresses that as a result of the destruction of natural habitats and the increase in greenhouse gas emissions, there has been a rise in global average temperatures, leading to global climate change (World Wildlife Fund, 2013). Increased human activity, evolving technology, population growth, production feeding consumption patterns, deforestation, uncontrolled industrialization, and economic growth based on carbon emissions have raised the Earth's temperature, disturbed the ecological balance, and made the climate crisis a serious threat to living organisms (Akın, 2006, p. 32; Ecer, Güner and Çetin, 2021, p. 126).

The quintuple helix structure defines the global climate crisis, which creates environmental and ecological concerns, as an opportunity window for knowledge production and innovation. It establishes a win-win relationship between knowledge, innovation, and ecology within the framework of sustainable development and creates synergy between the knowledge economy, knowledge society, and knowledge democracy (Türkiye-EU Business Dialogue, 2020, p. 15; Çalıkoğlu and Güneş, 2022, p. 462).

Figure 5 illustrates knowledge production and innovation within the context of the knowledge economy, knowledge society, knowledge democracy, and the natural environment of society. The European Commission defines social and ecological transformation as one of the greatest challenges for today's and tomorrow's economies and societies. The fifth helix represents the socio-ecological transformation of civil society and the economy. From natural sciences to social and human sciences, the quintuple HIM provides an interdisciplinary and transdisciplinary framework for sustainable development and social ecology (Carayannis et al., 2012, p. 4).

Figure 5: Knowledge production and innovation



Source: Carayannis et al., 2012, p. 4

Focusing on the interaction, development, and evolution of society and nature, the quintuple HIM emphasizes the importance of eco-innovation and eco-entrepreneurship in managing the socio-ecological transformation and sustainable development process within the context of the triple and quadruple HIMs (Carayannis et al., 2012, p. 5). The concept of eco-innovation is derived from the words "economy" and "environmental innovation". In 2004, the European Commission adopted the Environmental Technologies Action Plan (ETAP) through the Lisbon Strategy to develop and promote environmental technologies that would accelerate economic development and contribute to competitiveness while protecting the environment and benefiting from the potential of environmental technologies (Calleja and Delgado, 2008, p. 181).

The action plan focuses on removing barriers between research and markets, improving market conditions, and acting globally to change the understanding of competition and stimulate the use and commercialization of environmental technologies. ETAP defines eco-innovation as "the production, assimilation, and exploitation of a product, production process, service, or management and business method that is novel to the organization and which results, throughout its life cycle, in a reduction of environmental risk, pollution, and other negative impacts of resources use" (OECD, 2010, p. 38). The goal of eco-innovation is to achieve eco-efficiency and promote eco-design. To redirect sustainable development, prepare the ground for socio-ecological transformation, minimize the effects of the global climate crisis, use scarce resources efficiently and rationally, preserve biodiversity, and adopt environmentally friendly production and consumption, widespread and effective use of eco-innovative activities is essential (İncekara and Hobikoğlu, 2014, p. 2). Affected negatively by the Global Economic Crisis in 2008, the European Union (EU) shifted towards sustainable development and a green economic model to overcome the negative impacts of the crisis and turn it into an opportunity (Gevher and Acet, 2023, p. 248). In 2008, the European Commission revised the European Union Sustainable Consumption and Production/Sustainable Industry Policy Action Plan, published in 2009, to accelerate the transition to a low-carbon, knowledge-based, resource, and energy-efficient economic structure and released the Eco-design Directive to commercialize and promote environmental technologies. Along with this directive, the development of the Eco-innovation Action Plan for the commercialization and dissemination of environmental technologies was decided (Özçuhadar and Öncel, 2017, p. 30; Akses, 2014, p. 104).

Reducing waste and using products, materials, and production processes in an environmentally friendly and efficient manner is possible by imitating production and consumption flows in nature. Eco-design is defined as minimizing or preventing environmental impacts when designing any product or service, through the use of recyclable and renewable materials and reducing energy and raw material use. Eco-design aims to make industrial development inclusive and sustainable within the framework of a circular economy (Özsoy, 2018, p. 25-26; Kanbak, 2021, p. 51; İzmir Kalkınma Ajansı, 2020). Industrial ecology is, in essence, related to the concept of clusters, and clusters are interpreted as part of the national or international innovation and production system. Industrial ecology offers unique opportunities to add value to firms, businesses, institutions, and organizations within a cluster, creating mutual dependencies among actors and fostering synergy among them, thus making eco-industrial development a collective effort

(Kanbak, 2021, p. 54). The application area of industrial ecology is eco-industrial parks. The concept of eco-industrial parks was first introduced at the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. It has been accepted as a common reference term for the transition to sustainable production and circular economy practices (World Bank, 2021, p. 13).

Eco-industrial parks are the application areas of industrial ecology. Eco-industrial parks are defined as “industrial areas where product or service producers come together and cooperate to enhance their economic, environmental, and social performances and increase their mutual benefits” (United Nations Industrial Development Organization, 2017, p. 12). In other words, it is an industrial system where energy, water, and material surpluses are shared among product or service producers and where physical relations and mutual business agreements strengthen their symbiotic relationships (Şenlier and Albayrak, 2003, p. 27). Eco-industrial parks address topics such as resource-efficient clean production, industrial symbiosis, climate change, pollution, social standards, and more (World Bank, 2021, p. 13). The Kalundborg Symbiosis in the town of Kalundborg, Denmark, is the first developed eco-industrial park. Gyproc's establishment of its plant in Kalundborg to utilize butane gas from the Statoil refinery laid the groundwork for symbiotic relationships. Without conscious and strategic planning, collaboration among several neighboring industrial companies for economic gains increased environmental awareness and popularized the understanding of environmental management. Industrial companies sharing energy, water, and material excesses are physically interconnected and strengthen their symbiotic relationships through independent business agreements (OECD, 2010, p. 37; Ulutaş, 2017, p. 13; Kalundborg Symbiosis, 2022). Today, the Kalundborg Symbiosis is recognized worldwide and contributes to marketing Denmark as a green pioneer country. Production companies worldwide can learn from the circular model established in a small town in Denmark and discover new ways to be environmentally conscious.

A CORPORATE TOOL IN GOVERNMENT-INDUSTRY-UNIVERSITY COLLABORATION: TECHNOLOGY DEVELOPMENT ZONES

Technology Development Zones (TDZ), mostly known as “teknopark” or “teknokent” in Türkiye, “research parks” in America, “science parks” in the UK and France, and “technocity” in Japan, are part of the NIS. The different names of these zones in various countries do not lead to a conceptual loss, but they create changes in their objectives and targets. The goals and purposes determined by the institutional structure depend on the regional needs, socio-economic dynamics, and the functioning mechanism of the NIS (Harmancı and Önen, 1999, p. 3). TDZs serve as a corporate tool to make the NIS functional and stimulate collaboration between universities, industry, and the government. These organizations are deliberately designed to be the driving force behind regional development with the aim of technology development. TDZs bring together universities, industry, and the public sector on a common platform for the creation, dissemination, use, and commercialization of technical knowledge. Based on an evolutionary and institutional perspective, TDZs relying on linear and evolutionary innovation models eliminate financial concerns for young industries, support the spread of an innovation culture, direct the power of innovation towards community-oriented services and investments, and promote knowledge-based socio-economic transformation and regional economic development.

Success criteria for TDZs include national and international networks, the depth and breadth of commercial relationships, consultancy services provided to the industrial sector, license and product-service sales, joint research projects between universities and TDZ companies, the number of researchers transferring from universities to TDZs, and the number of registered patents. The expert and professional management teams of TDZs, their relationships with application and research centers, policies that encourage the establishment and development of knowledge-based companies, contemporary and qualified education opportunities, landscape and environmental arrangements, transportation facilities, and high-quality and low-cost housing areas are factors influencing the success criteria. In line with these criteria, TDZs are expected to increase technology transfer, convert R&D activities into investments, commercialize knowledge, and establish and grow technology-based entrepreneurial companies (Kiper, 2010, p. 51).

Strategies for Knowledge, Science, and Technology in Türkiye

The establishment of TDZs in developed countries roughly began in the 1970s, while developing countries followed the global technological and socio-economic change and transformation process with some delay. Prior to 1980, the Council of Ministers and the High Planning Council were responsible for preparing science and technology policies. However, the need for an autonomous organization for accurate technology policy determination led to the establishment of BTYK. In historical perspective, the Turkish Science and Technology Policy, covering the years 1993-2003 and accepted by BTYK, appears as one of the factors shaping the idea of establishing a TDZ in Türkiye. Until 2018, the Science and Technology High Council (BTYK) was responsible for preparing science and technology policies in Türkiye, and the Scientific and Technological Research Council of Türkiye (TÜBİTAK) is responsible for their implementation (Dağlı and Oğuztürk, 2018, p. 1483-1485). As of 2018, BTYK's establishment law was abolished and BTYK was replaced by Science, Technology and Innovation Policies Board (BTYPK).

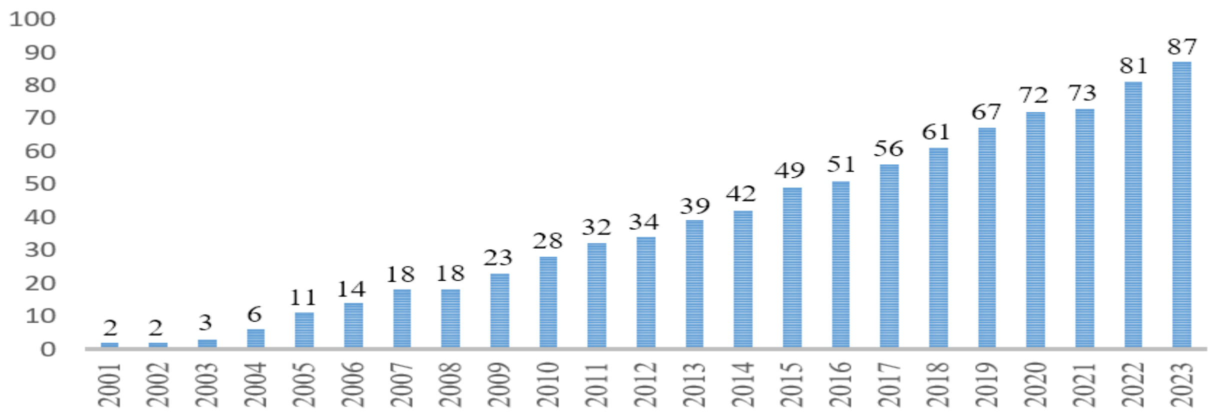
Until the 2000s, TÜBİTAK established the Technology Development Center (TEKMER) with the cooperation of Marmara Research Center (MAM) and KOSGEB with four universities. TÜBİTAK, emphasizing the importance of specialization in science and technology to enhance Türkiye's competitiveness in international markets, laid the foundation for MAM. Both TÜBİTAK and KOSGEB started to provide financial support and act as a bridge between universities, industry, and government institutions to foster an entrepreneurial culture in Türkiye. The adoption of the draft law prepared for the establishment of TDZs in 2001 was one of the most important steps taken in the knowledge-based socio-economic transformation (Demirli, 2014, p. 98). The Technology Development Zones Law, which came into effect on July 6, 2001, and was published in the Official Gazette under Law No. 4691, defines the objectives of TDZs as follows (Teknoloji Geliştirme Bölgeleri Kanunu, 2001):

> "The purpose is to generate technological knowledge through collaboration between universities, research institutions, and production sectors in order to transform the country's industry into a structure that is internationally competitive and export-oriented. This includes developing innovations in products and production methods, enhancing product quality or standards, increasing efficiency, reducing production costs, commercializing technological knowledge, supporting technology-intensive production and entrepreneurship, facilitating the adaptation of small and medium-sized enterprises to new and advanced technologies, creating investment opportunities in technology-intensive fields, providing job opportunities for researchers and skilled individuals, assisting in technology transfer, and establishing the technological infrastructure that will accelerate the entry of foreign capital providing high/advanced technology into the country."

Türkiye has made various initiatives to transition from an industrial society to an information society. However, the lack of organizational guidance for the development of the NIS and the insufficient importance given to science and technology policies have been major obstacles. To address these issues, the "Vision 2023: Science and Technology Strategies" was prepared, covering the years 2003 to 2023. Through the Vision 2023 project, the commercialization of knowledge was aimed at, and creating societal awareness of information technologies was identified as a primary goal. In line with these objectives, efforts were initiated to increase the number of TDZs, and it was decided to channel R&D expenditures to strategically important sectors (Kayalıdere, 2014, p. 80).

The number of TDZs established in Türkiye and actively operating between 2001 and 2023 is provided in Figure 6. Between the years 2001 and 2023, 87 TDZs were established and put into operation in Türkiye. However, the infrastructure work for 13 TDZs has not been completed yet (Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü, 2023a, p. 1).

Figure 6: The number of TDZs operating in Türkiye between 2001 and 2023



Source: The figure was created by the authors using information from Cansız, 2017, p. 41; Türkiye Cumhuriyeti Bilim, Sanayi ve Teknoloji Bakanlığı, 2018, p. 95; Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı, 2019, p. 72; 2020, p. 82; 2021, p. 107; 2022, p. 124; 2023, p. 126, and Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü, 2023a, p. 1.

The number of TDZs established within the framework of knowledge, science, and technology policies has shown an increasing trend over the years. However, to enhance the university-industry-government collaboration qualitatively and quantitatively, more investments in TDZs are needed. The strategic identification of regions for establishing TDZs is crucial to develop the surrounding areas and take advantage of demographic opportunities.

When actors come together within the TDZ, the transformation of entrepreneurial ideas into services starts in the pre-incubation centers and ends in the incubation center, also known as the innovation center. The pre-incubation center is defined in the Technology Development Zones Implementation Regulation as "structures that include service processes for consulting, mentoring, and project idea validation for individual or group entrepreneurs who have a business idea or project they want to implement but have not yet established a company". On the other hand, the incubation center is defined as "structures where office services, equipment support, management support, access to financial resources, critical business and technical support services are provided under one roof to entrepreneurial firms" (Teknoloji Geliştirme Bölgeleri Uygulama Yönetmeliği, 2016).

In the pre-incubation and incubation centers where companies go through their early stages, strategic planning is carried out by expert teams to commercialize entrepreneurial ideas, create risk capital, and provide management training. This way, all the financial and psychological doubts of the entrepreneurial firm are eliminated, and a corporate-supported roadmap is established. There is no restriction to benefit from incubation services, but a company that enters the incubation process is required to complete the incubation stage within 2 years (Çağıl, 2007, p. 40-41).

Table 1 shows the number of firms, total employment, and the number of entrepreneur academics within TDZs in Türkiye between the years 2001 and 2023. When Figure 6 and Table 1 are examined together, it is observed that the number of firms and employed personnel continuously increased due to the establishment of TDZs in different regions and the incentives provided by the government. As of 2023, within TDZs, 49.89% of the firms are involved in software and information technology, 5.87% in natural sciences and engineering, and 3.46% in biotechnology. These sectors constitute the top three in the sectoral distribution of firms within TDZs. The total employment in TDZs has reached 102.009. Of these employees, 85.552 are engaged in R&D, 1.322 in design, 7.109 in support, and 8,026 in other roles (Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü, 2023a, p. 2-4).

Table 1: Between the years 2001 and 2023, the number of firms within TDZs in Türkiye, the total employment, and the number of entrepreneur academics

Years	Number of Firms	The Total Employment	The Number of Entrepreneur Academics
2001	60	240	7
2002	80	300	10
2003	135	463	15
2004	324	3.795	23
2005	468	6.489	30
2006	546	9.081	47
2007	802	9.770	87
2008	1.154	11.093	153
2009	1.254	11.021	217
2010	1.515	13.397	279
2011	1.800	15.822	373
2012	2.174	19.498	497
2013	2.569	27.224	382
2014	3.016	30.729	542
2015	3.744	38.239	714

2016	4.217	40.172	783
2017, May	4.510	46.314	1.497
2018, February	4.794	46.236	1.005
2019, February	5.368	51.876	1.104
2020, March	5.673	58.313	1.194
2021, January	6.364	66.615	1.361
2022, September	8.237	85.322	1.741
2023, August	9.615	102.009	1.895

Source: The table was created by the authors using information from Cansız, 2017, p. 41; Zuhal, 2017, p. 63; Türkiye Cumhuriyeti Kalkınma Bakanlığı, 2018, p. 37; Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü, 2019, p. 24; 2020, p.2; 2021a, p. 2; 2023a, p. 2, and Ayyıldız, 2022, p. 5.

As seen in Table 1, the contribution of entrepreneur academics to industry and government collaboration also increased during the mentioned period. The provision of training support to firms by academics and the transformation of academic knowledge into industrial applications are crucial in both fundamental and applied research processes. According to Law No. 4691, academics can establish companies or become partners in any existing company within TDZs. Furthermore, academics can be employed by companies within the zone. The advantage for academics is that their earnings will not be affected by revolving fund deductions for the services provided. However, the disadvantage is that when providing services to firms outside the TDZ, income and value-added tax come into effect (Kiper, 2010, p. 85-88). TDZs are managed by a “company established as a joint-stock company in accordance with the law and responsible for the management and operation of the zone”. The duties and responsibilities of the management companies are defined as follows (Teknoloji Geliştirme Bölgeleri Kanunu, 2001):

> “The company responsible for the management and operation of the zone is obliged to carry out the planning and project development related to the zone, provide necessary infrastructure and superstructure services for the zone, carry out all kinds of services required for the zone, establish incubation centers and technology transfer offices, evaluate R&D or design projects and allocate space within the zone to approved entrepreneurs in accordance with the procedures and principles determined by regulations, manage the zone in compliance with the purpose stated in this law and relevant regulations, prevent non-compliance behavior of entrepreneurs and third parties, and take necessary precautions.”

According to the Technology Development Zones Law, companies in managerial positions within TDZs are exempt from corporate tax, income tax, and value-added tax until the end of 2028. This tax exemption facilitates the operation of companies within TDZs. Additionally, the exemption of employed personnel from income tax until 2028 encourages TDZs to create more job opportunities. The tax support provided to firms and personnel removes barriers for both foreign and domestic companies to invest in TDZs. Moreover, the inclusion of software, design, and R&D activities in the financial support program indicates the sectors in which firms should specialize (Çiçek, 2021, p. 199-200).

The Contribution of Technology Development Zones to the NIS

In the 1990s, the adoption of information technologies in the United States and the commercial dimension of globalization led to the emergence of a new world order known as the knowledge economy. From the 1990s to the present day, national innovation systems have become integrated within a structure that revolves around knowledge, resulting in significant changes in international competition, economic growth, and development. The NIS is based on a designed institutional framework, and within this institutional structure, TDZs play a crucial role. As TDZs contribute more to the NIS, the system's capacity to generate innovations also increases.

Table 2: Between 2001 and 2023, the contribution of TDZs to the NIS in Türkiye

Years	Completed Projects	Ongoing Projects	Export -Million Dollars (Cum.)	Patent Applications	Patents Registered
2001	10	90	3	4	3
2002	25	140	5	7	9
2003	78	400	10	10	15
2004	187	948	35	18	30
2005	398	1.300	80	29	55
2006	600	1.939	171	60	97
2007	2.156	1.504	340	120	149
2008	4.211	3.069	406	230	293
2009	5.874	3.403	501	244	297
2010	7.179	4.102	520	239	275
2011	8.052	4.979	543	265	282
2012	10.661	5.703	890	393	329
2013	11.247	6.997	1.511	432	268

2014	14.859	7.139	1.789	687	410
2015	18.318	8.525	2.333	1.022	591
2016	20.734	8.593	2.335	1.125	649
2017, May	23.007	8.915	2.600	1.121	640
2018, February	27.332	7.986	3.400	1.853	940
2019, February	31.011	8.858	3.800	2.314	1.063
2020, March	35.292	10.013	4.600	2.596	1.134
2021, January	39.034	10.654	5.600	2.775	1.262
2022, September	47.884	12.944	7.700	3.191	1.552
2023, August	53.838	14.528	10.000	3.499	1.786

Source: The table was created by the authors using information from Cansız, 2017, p. 41; Zuhal, 2017, p. 63-64; Türkiye Cumhuriyeti Kalkınma Bakanlığı, 2018, p. 37; Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü, 2019, p. 24-25; 2020, p. 2-3; 2021a, p. 2-3; 2023a, p. 2-3, and Ayyıldız, 2022, p. 5-6.

Table 2 shows the contribution of TDZs to the NIS in Türkiye between 2001 and 2023. In 2001, there were 10 completed projects in TDZs with an export value of 3 million dollars. However, by 2023, the number of completed projects increased to 53,838, and the companies in TDZs generated an export income of 10 billion dollars. As the number of completed projects increased, the value of exports also increased. Additionally, the increasing number of ongoing projects indicates the continuity of project supply in the TDZ. In 2001, companies made 4 patent applications, while in 2023, there were 3.499 patent applications, out of which 1.786 were qualified for patent registration.

In addition to the number of patent applications and registrations, the number of utility models is also an important indicator of the success of TDZs in the innovation process. A utility model is defined as the ownership right of industrial applicable goods and services. Compared to patents, utility models have similar functions but are more cost-effective and have a quicker registration process. However, the disadvantage of utility models is that their ownership rights only last for 10 years (Bilgiyi Ticarileştirme Merkezi, 2022). In Türkiye, companies in TDZ regions made 307 utility model applications in 2023, and 484 utility models were registered (Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü, 2023a, p. 3).

The production of knowledge starts at the workstation and ends with technology transfer or commercialization. Technology transfer refers to “the importation of needed technology from technologyproducing countries to increase productivity and achieve economic growth and development”. Technology transfer involves various complex processes, including adaptation, assimilation, application, and production. Vertical technology transfer involves purchasing the rights to innovative ideas that can create commercial gain directly or indirectly. The frequent use of vertical technology transfer by less developed and developing countries increases technology dependence and hinders the development of the NIS. On the other hand, horizontal technology transfer minimizes the risk of technology dependence. It involves transforming imported technology into value-added products through R&D centers with university-industry collaboration and transferring the accumulated knowledge to all units through network connections (Tiryakioğlu, 2011, p. 177-178). The first helix of the triple HIM is formed by entrepreneurial and innovative universities (EIUs) that host the interaction between industry and the public sector, playing a micro-level role among the actors in an evolutionary and institutional perspective. The number of EIUs and their economic performance determine the degree of collaboration and convergence among actors and enable the dissemination, capitalization, and commercialization of knowledge through network structures. Therefore, the control mechanism of relevant institutions and organizations is of critical importance to measure the economic performance of TDZs and shape the perspective of knowledge, science, and technology strategies in terms of innovation and entrepreneurship.

To trigger innovation and entrepreneurship activities and create a constructive competition environment among universities, the Entrepreneurial and Innovative University Index published by TÜBİTAK in 2012 is used to measure the economic performance of universities in this field. The index covers the 50 most EIUs and consists of 23 indicators under the dimensions of “scientific and technological research competence”, “intellectual property pool”, “collaboration and interaction”, and "economic and social contribution" (TÜBİTAK, 2023a). The indicator set and weighting information are explained as follows (TÜBİTAK, 2022a):

- Scientific and Technological Research Competence (%15): Consists of indicators such as the number of scientific publications (%2.5), citation count (%3.5), project count (%2), project fund amount (%3), award count (%1.5), and number of doctoral graduates (%2.5).
- Intellectual Property Pool (%20): Consists of indicators such as the number of national patent documents (%5.2), number of national utility model documents (%3), number of international patent applications (%5), and number of international patent documents (%6.8).
- Collaboration and Interaction (%25): Consists of indicators such as the number of industry collaborative projects (%5), funds of industry collaborative projects (%6), number of international collaborative projects (%5), funds of international collaborative projects (%6),

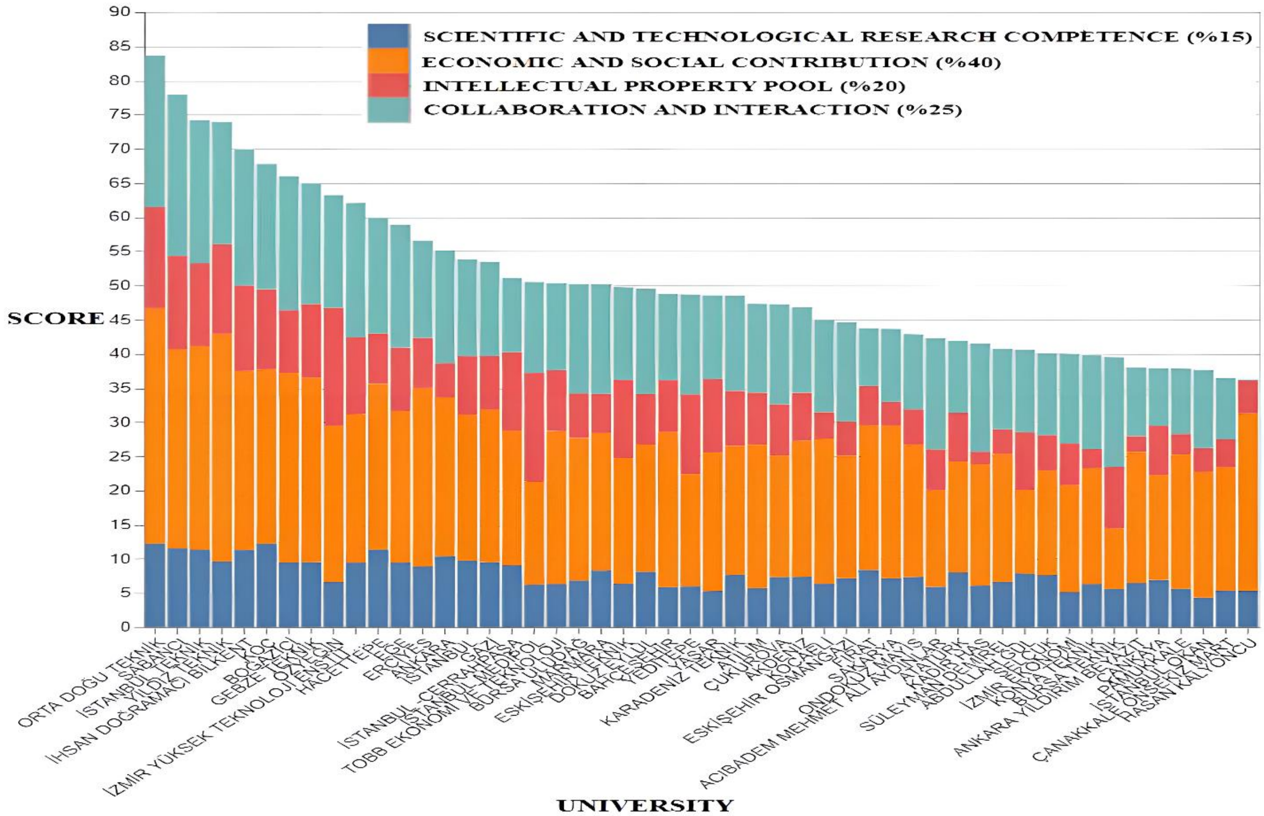
circulation count (%1.44), and number of students in TÜBİTAK's industry doctoral program (%1.56).

- Economic and Social Contribution (%40): Consists of indicators such as the number of companies by academics (%5.68), number of companies by students/graduates (%7.57), net sales revenue of companies by academics (%7.57), net sales revenue of companies by students/graduates (%10.41), number of licensed patents and utility models (%3.78), number of entrepreneurship support program companies (%3), and 4004-4005 project count (%2).

Figure 7 shows the dimension-based column chart of the top 50 EIUs in 2022. EIUs are ranked based on dimensions of scientific and technological research competence, economic and social contribution, intellectual property pool, and collaboration and interaction, along with their sub-indicators and weights. The top 10 universities with the highest scores are as follows: Middle East Technical University, Sabancı University, Istanbul Technical University, Yıldız Technical University, İhsan Doğramacı Bilkent University, Koç University, Boğaziçi University, Gebze Technical University, Özyeğin University, and İzmir Institute of Technology.

The dimension weight represents the maximum score that can be obtained in each respective dimension. The total dimension score of the top 10 universities is 70.31. The average dimension scores for these universities are as follows: scientific and technological research competence 10.34; intellectual property pool 12.65; collaboration and interaction 19.58; economic and social contribution 27.75. The total dimension score for the top 50 universities is 50.75, and their average dimension scores are scientific and technological research competence 7.79; intellectual property pool 7.95; collaboration and interaction 14.16; economic and social contribution 20.85 (TÜBİTAK, 2022b).

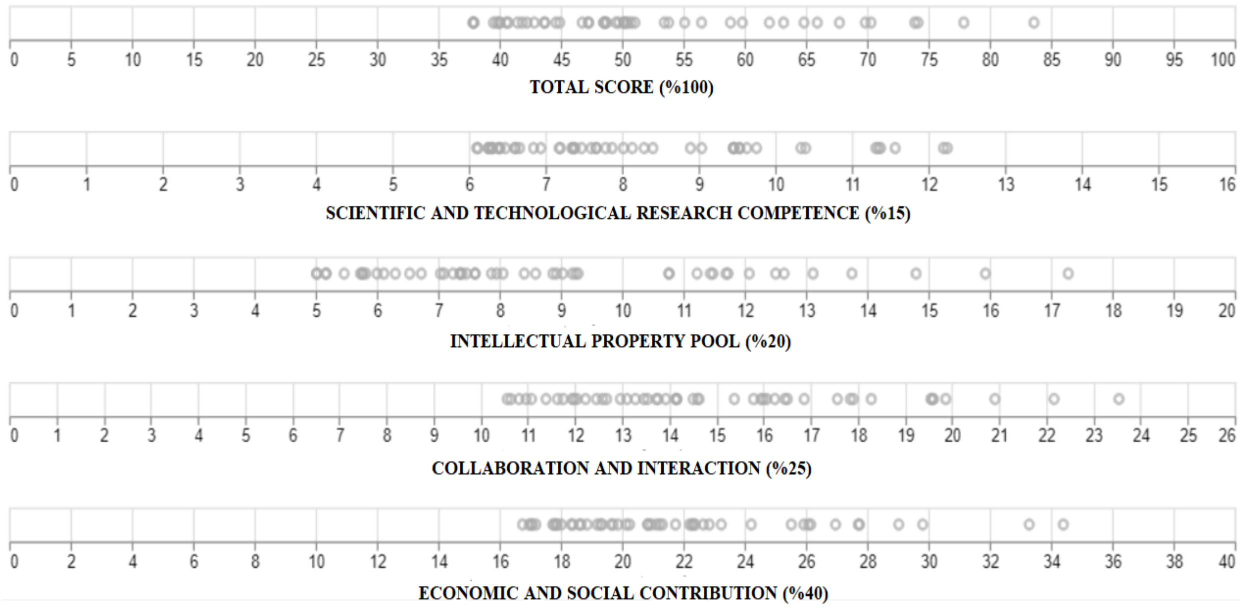
Figure 7: 2022 - Dimension-based bar chart of the top 50 EIUs



Source: TÜBİTAK, 2023c

Figure 8 shows the dimension-based comparative chart of the top 10 and top 50 EIUs in 2022. It is evident that the top 50 and top 10 universities perform better than other universities. To approach the performance level of the top 50 universities, improvements should be made in the dimensions of collaboration and interaction, as well as economic contribution and commercialization. On the other hand, to approach the top 10 universities, performance improvements should focus on the dimensions of intellectual property pool, collaboration, and interaction (TÜBİTAK, 2022b, p. 1-2).

Figure 8: The comparative dimension-based chart of the top 10 and top 50 EIUs in the year 2022, scaled between 0 and 100



Source: TÜBİTAK, 2023b

The dimension-based competency analysis provides insights into the alignment process of EIUs with the innovation models. Based on statistical data shared with the public by the Ministry of Technology and Industry and the TÜBİTAK, it is observed that many universities are in the process of aligning with the triple HIM. However, only a few universities have completed the alignment process and are in the development phase. According to the dimension-based competency analysis, the low rates of collaboration and interaction, as well as economic contribution and commercialization, indicate that the transformation of the knowledge economy, society, and democracy is not yet complete.

The quadruple and quintuple HIMs, which center on civil society, art, media, culture, and social ecology, are new approaches to the triple HIM. They are proposed as a solution to create synergy among actors through the Mod 3 knowledge production system and to increase socio-economic contributions. However, in Türkiye, the legal and conceptual infrastructure is based on a linear innovation system, which hinders the pluralism and diversity of knowledge and innovation paradigms. This situation delays the production, utilization, dissemination, capitalization, and commercialization of knowledge (Kiper, 2010, p. 92).

CONCLUSION

The triple HIM is a hybrid organizational structure used to accelerate the evolution of the knowledge-based socioeconomic structure from an evolutionary and institutional perspective. The three arms of the helix, representing the university, industry, and government, collaborate and undergo role changes to enable knowledge-based economic growth and development. The triple HIM, using both linear and nonlinear knowledge production systems and facilitating mutual and interactive relationships among actors, promotes the production, dissemination, capitalization, and commercialization of knowledge. The actors of the triple helix structure come together under the umbrella of TDZs.

TDZs serve as institutional tools for the effectiveness of the NIS and the promotion of university-industry-government collaboration. The quadruple and quintuple HIMs, which are new approaches to the triple HIM, are collaboration models that focus on civil society and social ecology and enhance the plurality and diversity of knowledge and innovation paradigms through the Mod 3 knowledge production system. Developed countries that have entered the process of knowledge-based economic growth and development earlier than developing countries have expanded the framework of the knowledge production system and included the concepts of knowledge society and democracy beyond the knowledge economy. In this regard, they have presented examples of socio-parks and eco-parks to build a knowledge society and democracy.

In Türkiye, the Ministry of Technology and Industry, TUBITAK, KOSGEB, Development Agencies, and relevant local authorities provide services to sustain the development of the NIS in line with the objectives of science and technology strategies. It is possible to say that the NIS is designed within the framework of the triple HIM. The Ministry of Technology and Industry and the TUBITAK are institutions guiding the triple helix structure in Türkiye and conducting evaluations regarding the performance of TDZs, which are the institutional tools of this structure.

The contribution of TDZs in Türkiye to the NIS has been evaluated within the framework of the Entrepreneurial and Innovative University Index. The criteria used to determine the performance status of universities include scientific and technological research competence (15%), intellectual property pool (20%), collaboration and interaction (25%), and economic and social contribution (40%). Although the economic and social contribution dimension ranks first with a weight of 40%, when the sub-indicators are examined, it can be said that the impact of social contribution is limited. Furthermore, the second rank of the collaboration and interaction dimension with a weight of 25% supports the finding that the NIS is designed within the framework of the triple helix structure. Therefore, Türkiye does not benefit from the additional contributions of the quadruple and quintuple helix structures in economic growth and development.

When examining the dimension-based comparative graph of the top 10 EIUs and the top 50 universities in Türkiye, significant performance differences among dimensions can be observed based on the total and average dimension scores of the universities. The total dimension score of the top 10 universities is 70.31. The average dimension scores for these universities are as follows: Scientific and technological research competence 10.34, intellectual property pool 12.65, collaboration and interaction 19.58, economic and social contribution 27.75. The total dimension score of the top 50 universities is 50.75, with average dimension scores as follows: scientific and technological research competence 7.79, intellectual property pool 7.95, collaboration and interaction 14.16, economic and social contribution 20.85. Therefore, for the top 50 universities to approach the top 10 universities, performance improvements are needed in the dimensions of economic and social contribution, intellectual property pool, and collaboration and interaction. Evaluation of the performance status of 142 out of the existing 192 universities could not be reached.

Within the framework of technology development zone statistics, imposing time constraints on the benefits obtained by companies within the TDZs, employed personnel, and entrepreneur academics weakens the commitment between the university and industry sectors. The fact that entrepreneur academics cannot benefit from tax exemptions in projects that are not within the scope of TDZs can weaken collaboration among actors and lead to the emergence of informality. Therefore, it is recommended to reevaluate the tax incentives provided under the Law on Technology Development Zones No. 4691 in order to strengthen collaboration. On the other hand, TDZs have a strong infrastructure, broad capacity, and a high share of R&D, but the intellectual property performance of universities indicates that the commercialization rate of scientific outputs is not at the desired level.

The quadruple and quintuple HIMs can be utilized as tools to enhance the economic and social contribution, intellectual property performance, scientific and technological research competence of TDZs, strengthen university-industry collaboration, and introduce high-tech products or production methods to the NIS. In this context, the future perspectives of the quadruple and quintuple innovation system, which focuses on civil society and social ecology in Türkiye, should be outlined. Interfaces that enhance university-industry collaboration should be established, horizontal technology transfer methods should be employed, and the legal and conceptual infrastructure should be designed within the framework of both linear and evolutionary innovation systems. National and international network connections should be expanded, and knowledge, science, and technology strategies should be designed from a historical and cultural perspective. Principles of democracy, transparency, and openness should be adopted to improve the performance of institutions and organizations and promote the common ownership of knowledge.

AUTHOR STATEMENT / YAZAR BEYANI

Researchers have jointly contributed to the article. Researchers have not declared any conflict of interest.

Araştırmacı(lar) makaleye ortak olarak katkıda bulunduğunu bildirmiştir. Araştırmacılar herhangi bir çıkar çatışması bildirmemiştir.

REFERENCES

Akın, G. (2006). Küresel ısınma, nedenleri ve sonuçları. *Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Dergisi*, *46*(2), 29-43.

Akses, S. (2014). *Avrupa 2020 stratejisi* (İktisadi Kalkınma Vakfı Yayınları Publication No: 269). Dünya Yayıncılık.

Aycan, F. & Şeker, U. (2013). Kamu-üniversite-sanayi sarmalı ve teknoloji geliştirme bölgeleri. *T.C. Bilim, Sanayi ve Teknoloji Bakanlığı Anahtar Dergisi*, *25*(295), 15-18.

Ayyıldız, G. (27 October 2022). *Teknokentlerde muhasebe, vergi ve SGK uygulamaları*. (PowerPoint Slides). Retrieved from https://www.asmmmo.org.tr/Files/Videos/Files/Seminer-4112022094003.pdf .

Bilgiyi Ticarileştirme Merkezi. (9 May 2022). *Faydalı model nedir? Nasıl oluşturulur?* Retrieved from https://btm.istanbul/blog/faydali-model-nedir-nasil-olusturulur (Access date: 9.1.2023).

Calleja, I. & Delgado, L. (2008). European Environmental Technologies Action Plan (ETAP). *Journal of Cleaner Production*, *16*(1), 181-183. doi: 10.1016/j.jclepro.2007.10.005.

Campbell, D. F. J., Carayannis, E. G. & Rehman, S. S. (2015). Quadruple Helix structures of quality of democracy in innovation systems: The USA, OECD countries, and EU member countries in global comparison. *Journal of the Knowledge Economy*, *6*, 467-493. doi: 10.1007/s13132-015-0246-7.

Cansız, M. (2017). *2023'e doğru Türkiye teknoparkları* (Publication No: 2972). Ankara: T.C. Kalkınma Bakanlığı.

Carayannis, E. G. & Campbell, D. F. J. (2009). 'Mode 3' and 'Quadruple Helix': Toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management*, *46*(3-4), 201-234. doi: 10.1504/IJTM.2009.023374.

Carayannis, E. G. & Campbell, D. F. J. (2010). Triple Helix, Quadruple Helix and Quintuple Helix and how do knowledge, innovation and the environment relate to each other?: A proposed framework for a trans-disciplinary analysis of sustainable development and social ecology. *International Journal of Social Ecology and Sustainable Development, 1*(1), 41-69. doi: 10.4018/jsesd.2010010105.

Carayannis, E. G. & Campbell, D. F. J. (2011). Open innovation diplomacy and a 21st century Fractal Research, Education and Innovation (FREIE) Ecosystem: Building on the Quadruple and Quintuple Helix innovation concepts and the “Mode 3” knowledge production system. *Journal of the Knowledge Economy*, *2*, 327-372. doi: 10.1007/s13132-011-0058-3.

Carayannis, E. G. & Campbell, D. F. J. (2012). Mode 3 knowledge production in Quadruple Helix innovation systems. In *Mode 3 Knowledge Production In Quadruple Helix Innovation Systems (pp. 1-63)*. SpringerBriefs in Business, vol 7. New York: Springer. doi: 10.1007/978-1-4614-2062-0_1.

Carayannis, E. G., Barth, T. D. & Campbell, D. F. J. (2012). The Quintuple Helix innovation model: Global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship*, *1*, 1-12. doi: 10.1186/2192-5372-1-2.

Carayannis, E. G. & Campbell, D. F. J. (2014). Developed democracies versus emerging autocracies: Arts, democracy, and innovation in Quadruple Helix innovation systems. *Journal of Innovation and Entrepreneurship*, *3*(1), 1-23. doi: 10.1186/s13731-014-0012-2.

Carayannis, E. G., Grigoroudis, E., Campbell, D. F. J., Meissner, D. & Stamati, D. (2018). The ecosystem as helix: An exploratory theory-building study of regional co-opetitive entrepreneurial ecosystems as Quadruple/Quintuple Helix innovation models. *R&D Management*, *48*(1), 148-162. doi: 10.1007/978-1-4614-2062-0_1.

Carayannis, E. G. & Rakhmatullin, R. (2014). The Quadruple/Quintuple Innovation Helixes and smart specialisation strategies for sustainable and inclusive growth in Europe and beyond. *Journal of the Knowledge Economy*, *5*, 212-239. doi: 10.1007/s13132-014-0185-8.

Cardiff University. (2015a). *Social Science Research Park: About us*. https://www.cardiff.ac.uk/social-science-research-park/about-us (Access date: 15.6.2023).

Cardiff University. (2015b). *Social Science Research Park: Research topics*. Retrieved from https://www.cardiff.ac.uk/research/explore/research-topics. (Access date: 15.6.2023).

Cardiff University. (2017a). *Social Science Research Park: Facilities*. Retrieved from https://www.cardiff.ac.uk/social-science-research-park/facilities (Access date: 15.6.2023).

Cardiff University. (2017b). *Social Science Research Park: Research*. Retrieved from https://www.cardiff.ac.uk/social-science-research-park/research (Access date: 15.6.2023).

Çağıl, C. T. (2007). *Türkiye'de ulusal teknoloji politikaları ve teknoparkların bölgesel gelişmeye etkileri* (Unpublished doctoral thesis). İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

Çalıkoğlu, C. (2022). *Bölgesel kalkınma ve inovasyon sarmal modelleri ilişkisi: Türkiye örneği* (Unpublished master thesis). Pamukkale Üniversitesi Sosyal Bilimler Enstitüsü, Denizli.

Çalıkoğlu, C. & Güneş, S. (2022). Bölgesel kalkınma ve inovasyon sarmal modelleri ilişkisi: Türkiye örneği (2010-2019). *Pamukkale Üniversitesi İşletme Araştırmaları Dergisi*, *9*(2), 488-501.

Çelik, G. (2016). Sosyal işbirlikleri bölgesi (SOSYOPARK). *Yükseköğretim Dergisi*, (2), 39-43.

Çetindamar, D., Phaal, R. & Probert, D. (2017). *Teknoloji yönetimi.* (Trans. Ayşegül Çetin). Ankara: Efil Yayınevi.

Çınar, İ. (2009). Küreselleşme, eğitim ve gelecek. *Kuramsal Eğitimbilim Dergisi*, *2*(1), 14-30.

Çiçek, H. (2021). Türkiye'de teknoparklar ve iktisadi performanslarının artırılması. *İşletme Akademisi Dergisi*, *2*(2), 186-207. doi: 10.26677/TR1010.2021.786.

Dağlı, İ. & Oğuztürk, B. S. (2018). Planlı dönemden günümüze Türkiye'de ulusal bilim ve teknoloji politikalarının değişimi. *Süleyman Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *23*(4), 1479-1503.

Demir, Ö. (1996). *Kurumcu iktisat*. Ankara: Vadi Yayınları.

Demirli, Y. (2014). Türkiye'de teknoparklara yönelik teşvikler ve teknoparkların bilim ve teknoloji kapasitesinin gelişimine katkısı. *Maliye Dergisi*, *166*, 95-115.

Dubina, I. N., Carayannis, E. G. & Campbell, D. F. J. (2012). Creativity economy and a crisis of the economy? Coevolution of knowledge, ınnovation, and creativity, and of the knowledge economy and knowledge society. *Journal of the Knowledge Economy*, *3*, 1-24. doi: 10.1007/s13132-011-0042-y.

Durna, U. & Demirel, Y. (2008). Bilgi yönetiminde bilgiyi anlamak. *Erciyes Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, (30), 129-156.

Ecer, K., Güner, O. & Çetin, M. (2021). Avrupa yeşil mutabakatı ve Türkiye ekonomisinin uyum politikaları. *İşletme ve İktisat Çalışmaları Dergisi*, *9*(2), 125-144.

Eren, M. (2011). *Türkiye'nin teknolojik gelişiminde teknoparklar ve Ar-Ge desteği* (Unpublished doctoral dissertation). Marmara Üniversitesi Sosyal Bilimler Enstitüsü, İstanbul.

Ertekin, Ö. (8 October 2013). *Teknoloji yönetimi neden, nasıl?*. Fikirden Gerçeğe: Ar-Ge, Yenilik ve TÜBİTAK Destekleri Semineri, (PowerPoint Slides). Ankara: TÜBİTAK TEYDEB. Retrieved from https://www.tubitak.gov.tr/sites/default/files/omer_ertekin-tubitak_sunum.pdf.

Etzkowitz, H. (2002). *The Triple Helix of university-industry-government: Implications for policy and evaluation* (Working Paper No: 2002-11). Swedish Institute for Studies in Education and Research. Retrieved from https://www.donorth.co/appurtenancy/pdfs/etzkowitz_triple_helix.pdf.

Etzkowitz, H. & Leydesdorff, L. (2000). The dynamics of innovation: from national systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research Policy*, *29*(2), 109-123. doi: 10.1016/S0048-7333(99)00055-4.

Gevher, R. & Hakan, A. (2023). Avrupa Birliğinde sürdürülebilir kalkınma ve yeşil ekonominin gelişimi. *Anadolu Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *24*(1), 224-253.

Göker, A. (20 April 2000). Ulusal inovasyon sistemi ve üniversite-sanayi işbirliği. *Ankara Üniversitesi Fen Bilimleri Enstitüsü Geleneksel Bahar Paneli IV*. Ankara. Retrieved from https://inovasyon.gen.tr/images/makaleler/ayk/AYK.Ank.Uni.Nisan00.pdf.

Gümüştekin, G. E. (2004). Bilgi yönetiminin stratejik önemi. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi, 18*(3-4), 201-212.

Harmancı, M. & Önen, M. O. (1999). *Dünya'da ve Türkiye'de teknopark ve teknokent uygulamaları* (Report No: GA/99-2-4). Türkiye Kalkınma Bankası A.Ş. Araştırma Müdürlüğü. Ankara.

İncekara, A. & Hobikoğlu, E. H. (1-3 July 2014). *Sürdürülebilir ekonomik kalkınma belirleyicisi olarak eko-inovasyonun önemi: Dünya ve Türkiye örneği*. International Conference on Eurasian Economies, (Conference Presentation). Skopje, Macedonia. Retrieved from https://www.avekon.org/papers/1170.pdf.

İzmir Kalkınma Ajansı. (6 August 2020). *Eko tasarım*. Retrieved from https://kalkinmasozlugu.izka.org.tr/eko-tasarim-2/ (Access date: 24.6.2023).

Kalundborg Symbiosis. (5 October 2022). *50 years of circular production*. http://www.symbiosis.dk/en/50-years-of-circular-production/ (Access date: 24.6.2023).

Kanbak, A. (2021). Eko-endüstriyel parklar. A. Ateş (Ed.). In *Sosyal, Beşeri ve İdari Bilimler Alanında Uluslararası Araştırmalar VIII* (p. 49-66). Konya: Eğitim Yayınevi.

Kayalıdere, G. (2014). Türkiye'nin teknoloji politikalarında teknoparkların önemi ve teknoparklara yönelik vergi avantajları. *Gazi Üniversitesi Sosyal Bilimler Dergisi*, *1*(1), 75-96.

Keskin, H. & Ovalı, E. (2022). Dörtlü ve beşli sarmal üniversite-sanayi iş birliği modelleri. *Business & Management Studies: An International Journal*, *10*(1), 447-461. doi: 10.15295/bmij.v10i1.2031

Kevük, S. (2006). Bilgi ekonomisi. *Yaşar Üniversitesi E-Dergisi*, *1*(4), 319-350.

Kiper, M. (2010). *Dünyada ve Türkiye'de üniversite-sanayi işbirliği ve bu kapsamda Üniversite-Sanayi Ortak Araştırma Merkezleri Programı (ÜSAMP)*. Türkiye Teknoloji Geliştirme Vakfı Yayınları.

Koç, K. & Mente, A. (2007). İnovasyon kavramı ve üniversite-sanayi-devlet işbirliğinde üçlü sarmal modeli. *Hacettepe Üniversitesi Sosyolojik Araştırmalar E-Dergisi.* Retrieved from https://web.archive.org/web/20220123112036/http://www.sdergi.hacettepe.edu.tr/makaleler/kkahm.pdf.

Kuş, C. (2017). Yenilik ekosistemlerinin desteklenmesine yönelik kamu politikaları: Kamu-üniversite-sanayi iş birliğinde üçlü sarmal modeli incelemesi. *Girişimcilik ve İnovasyon Yönetimi Dergisi*, *6*(1), 91-113.

OECD. (2010). *Eco-Innovation in Industry: Enabling Green Growth.* Paris: OECD Publishing. doi: 10.1787/9789264077225-en.

Özbay, F. (2021). Schumpeter'in kapitalizm, kalkınma, girişimci ve kredi perspektifinde inovasyona bakışı. *Sağlık ve Sosyal Refah Araştırmaları Dergisi*, *3*(2), 93-101.

Özçuhadar, T. & Öncel, P. (2017). *Eko-Tasarım*. Sürdürülebilir Üretim ve Tüketim Yayınları IV. Retrieved from https://rec.org.tr/wp-content/uploads/2017/02/eko-tasarim.pdf.

Özsoy, T. (2018). Endüstriyel ekolojiyi anlamak adına endüstriyel ortakyaşarlık örneklerinin incelenmesi. *Artıbilim: Adana Bilim ve Teknoloji Üniversitesi Sosyal Bilimler Dergisi*, *1*(2), 22-34.

Price, A. & Delbridge, R. (2015). *Social Science Parks: Society's New Super-Labs*. Nesta. Retrieved from https://media.nesta.org.uk/documents/social_science_parks_paper.pdf

Sakınç, S. & Bursalıoğlu, S. A. (2012). Yükseköğretimde küresel bir değişim: Girişimci üniversite modeli. *Yükseköğretim ve Bilim Dergisi*, *2*(2), 92-99.

Saygılı, Ş. (2003). *Bilgi ekonomisine geçiş sürecinde Türkiye ekonomisinin dünyadaki konumu* (Publication No: DPT: 2675). T.C. Başbakanlık Devlet Planlama Teşkilatı.

Stanford Research Park. (17 January 2018). *About*. Retrieved from https://stanfordresearchpark.com/about. (Access date: 4.5.2023).

Şenlier, N. & Albayrak, A. N. (2003). Endüstriyel ekoloji: Planlamaya ekolojik yaklaşım. *Planlama Dergisi*, (1), 26-29.

Taymaz, E. (2004). *Türkiye imalat sanayiinde teknolojik yetenek*. Vizyon 2023 Ulusal Teknoloji Envanteri Projesi. Ankara. Retrieved from https://www.tubitak.gov.tr/tubitak_content_files/vizyon2023/teknolojikyetenek/Ulusal_Teknolojik_Yetenek_Raporu.pdf.

Teknoloji Geliştirme Bölgeleri Kanunu. (6 July 2001). *Resmi Gazete* (Sayı: 24454). Retrieved from https://www.resmigazete.gov.tr/eskiler/2001/07/20010706.htm.

Teknoloji Geliştirme Bölgeleri Uygulama Yönetmeliği. (10 August 2016). *Resmi Gazete* (Sayı: 29797). Retrieved from https://www.resmigazete.gov.tr/eskiler/2016/08/20160810-8.htm.

Tiryakioğlu, M. (2011). Teknoloji transferi, teknoloji yoksulluğu mu? *Ankara Üniversitesi SBF Dergisi*, *66*(02), 169-199. doi: 10.1501/SBFder_0000002207.

Türkiye-EU Business Dialogue. (2020). *Üniversite-sanayi iş birliği*. Retrieved from https://isotebd.com/wp-content/uploads/2020/12/Booklet-USI-TR-1.pdf.

TÜBİTAK. (2022a). *2022 yılı girişimci ve yenilikçi üniversite endeksi gösterge tanımları ve kaynakları*. Retrieved from https://www.tubitak.gov.tr/tr/kurumsal/politikalar/icerik-gosterge-seti-ve-agirliklandirma (Access date: 10.7.2023).

TÜBİTAK. (2022b). *Girişimci ve yenilikçi üniversite endeksi 2022 yılı analiz sonuçları*. Retrieved from https://www.tubitak.gov.tr/sites/default/files/2022_yili_sonuc_analizi.pdf (Access date: 10.7.2023).

TÜBİTAK. (2023a). *Girişimci ve yenilikçi üniversite endeksi*. Retrieved from https://www.tubitak.gov.tr/tr/icerik-girisimci-ve-yenilikci-universite-endeksi (Access date: 10.7.2023).

TÜBİTAK. (2023b). *Boyut bazlı karşılaştırmalı grafik*. Retrieved from https://www.tubitak.gov.tr/tr/icerik-boyut-bazli-karsilastirmali-grafik (Access date: 10.7.2023).

TÜBİTAK. (2023c). *Boyut bazlı sütun grafiği*. Retrieved from https://www.tubitak.gov.tr/tr/icerik-boyut-bazli-sutun-grafigi (Access date: 10.7.2023).

TÜBİTAK Bilim, Teknoloji ve Yenilik Politikaları Daire Başkanlığı (27 July 2018). *Sosyal ve beşeri bilimler çalıştayı*. Retrieved from https://www.tubitak.gov.tr/sites/default/files/1095/sosyal_ve_beseri_bilimler_calistayi_bilgi_notu_btypdb.pdf.

Türkiye Cumhuriyeti Bilim, Sanayi ve Teknoloji Bakanlığı. (2018). *2017 yılı faaliyet raporu*. Retrieved from https://www.sanayi.gov.tr/plan-program-raporlar-ve-yayinlar/faaliyet-raporlari/mu1303011616.

Türkiye Cumhuriyeti Kalkınma Bakanlığı. (2018). *On birinci kalkınma planı (2019-2023) girişimcilik, kobiler, esnaf ve sanatkarlar özel ihtisas komisyonu raporu* (Publication no. KB: 220- ÖİK: 812). Ankara.

Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı. (2019). *2018 yılı faaliyet raporu*. Retrieved from https://www.sanayi.gov.tr/plan-program-raporlar-ve-yayinlar/faaliyet-raporlari/mu1303011619.

Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı. (2020). *2019 yılı faaliyet raporu*. Retrieved from https://www.sanayi.gov.tr/plan-program-raporlar-ve-yayinlar/faaliyet-raporlari/mu0103011615.

Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı. (2021). *2020 yılı faaliyet raporu*. Retrieved from https://www.sanayi.gov.tr/plan-program-raporlar-ve-yayinlar/faaliyet-raporlari/mu2602011615.

Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı. (2022). *2021 yılı faaliyet raporu*. Retrieved from https://www.sanayi.gov.tr/plan-program-raporlar-ve-yayinlar/faaliyet-raporlari/mu2802011616.

Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı. (2023). *2022 yılı faaliyet raporu*. Retrieved from https://www.sanayi.gov.tr/plan-program-raporlar-ve-yayinlar/faaliyet-raporlari/mu2802011617.

Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü. (21-22 March 2019). *KUSİP KUSİ ile ilgili bilgilendirme* (PowerPoint Slides). 2023 Vizyonunda Üniversitelerin Araştırma Laboratuvarları Çalıştayı-V. Retrieved from http://mrkzlab2023calistay.amasya.edu.tr/sunumlar.aspx.

Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü. (2020). *Teknoloji geliştirme bölgeleri*. Retrieved from https://www.sanayi.gov.tr/assets/pdf/istatistik/TGB_MART_2020_İstatistiki_Bilgiler.pdf.

Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü. (2021). *Teknoloji geliştirme bölgeleri.* Retrieved from https://www.sanayi.gov.tr/assets/pdf/istatistik/TGB_2020_İstatistiki_Bilgiler.pdf.

Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü. (2023a). Teknoloji *geliştirme bölgeleri*. Retrieved from https://www.sanayi.gov.tr/istatistikler/istatistiki-bilgiler/mi0203011501.

Türkiye Cumhuriyeti Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü. (2023b). *Teknoloji geliştirme bölgeleri sunumu.* (PowerPoint Slides). Retrieved from https://ankaraka.org.tr/sites/default/files/article-documents/Sanayi%20ve%20Teknoloji%20Bakanl%C4%B1%C4%9F%C4%B1-%20Teknoloji%20Geli%C5%9Ftirme%20B%C3%B6lgeleri%20Sunumu_0.pdf.

Uçkan, Ö. (2006). Bilgi politikası ve bilgi ekonomisi: Verimlilik, istihdam, büyüme ve kalkınma. *Bilgi Dünyası*, 7(1), 23-48. doi: 10.15612/BD.2006.395.

Ulutaş, F. (2017). *Endüstriyel Ekoloji*. Sürdürülebilir Üretim ve Tüketim Yayınları VI. Retrieved from https://rec.org.tr/wp-content/uploads/2017/02/endc3bcstriyel_ekoloji.pdf .

United Nations Industrial Development Organization. (2017). *Implementation Handbook for Eco-Industrial Parks: Inclusive and Sustainable Industrial Development.* United Nations Industrial Development Organization.

World Bank. (2021). *International framework for eco-industrial parks v.2.* Washington: World Bank.

World Wildlife Fund. (2013). *İklim değişikliği*. Retrieved from https://www.wwf.org.tr/ne_yapiyoruz/iklim_degisikligi_ve_enerji/iklim_degisikligi/ (Access date: 22.6.2023).

Zuhal, M. (2017). Ulusal yenilik sistemlerinde teknoparkların önemi: Türkiye deneyimi. *The Journal of International Scientific Researches*, *2*(7), 52-66.