VIRTUAL TECHNOLOGY DEVELOPMENT ZONE MODEL PROPOSAL FOR TECHNOLOGY DEVELOPMENT ZONES IN THE INDUSTRY 5.0 PROCESS

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Abstract

The digital transformation process of enterprises, which accelerated with the Industry 4.0 process, has turned into a process that includes the issues of employees and society, environmental sustainability, and resilience of enterprises with the Industry 5.0 process. In this process, businesses apply their working models face-to-face in physical environments, online in virtual environments or by choosing one of the hybrid models where both models are applied. One of the places where different working models are applied and businesses are gathered together to carry out research and development (R&D) activities is Technology Development Zones (TDZ). TDZs were established in Turkey with the law numbered 4691. Some exemptions are granted to enterprises working in TDZs within the scope of R&D activities. In order to work in TDZs, enterprises must submit an R&D project to the TDZ management. TDZs are declared as physical area. For enterprises that want to work in TDZs, physical buildings with physical work offices are constructed. Within the scope of this study, a virtual TDZ model, which can be considered the digital twin of physical TDZs, will be proposed. This model proposes virtual work offices instead of physical TDZ buildings, and businesses can carry out their R&D activities wherever they want. In this context, the construction costs, water, carbon and energy footprints of TDZ buildings can be reduced, contributing to environmental sustainability.

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1. Introduction

The Industry 5.0 process is defined as a new industrial revolution that focuses on the technologies of the Industry 4.0 process and includes processes related to labour, environment and resilience of businesses. The essence of this revolution is to define the digital transformation process of businesses in the relationship between technology, human and environmental sustainability (Barata & Kayser, 2023; European Commission, 2022; Grabowska, Saniuk, & Gajdzik, 2022; Huang et al., 2022; Xu, Lu, Vogel-Heuser, & Wang, 2021). In the digital transformation of businesses, obtaining, storing, analysing and sharing data and information with all structures that need it is essential. This process can be referred to as the data and information cycle. The physical and virtual environments must be connected to ensure the data and information cycle. This association is defined as a cyber-physical system structure (Valette, Bril El-Haouzi, & Demesure, 2023; Weyer, Meyer, Ohmer, Gorecky, & Zühlke, 2016). In order to establish this structure, the necessary software, hardware and technologies need to be developed. One of the places where these software, hardware and technologies are intensively developed in our country is TDZ.

Technology Development Zones (TDZs) are special zones established in our country by Law No. 4691, which grants certain exemptions to businesses operating in the zone within the framework of research and development activities (Resmî Gazete, 2001). A managing company that manages these zones is called the Managing Company Co., whose partners are generally universities, organised industrial zones, and chambers of industry. There are many physically structured work offices in these zones where businesses operating in TDZs can work. Enterprises wishing to operate in TDZs apply to TDZs with a project that includes R&D functions (T.C. Teknoloji ve Sanayi Bakanlığı, 2016). Projects are usually submitted online to expert reviewers. Companies whose projects are accepted can start their activities if a vacant physical office is available in the TDZ. Incentives such as VAT, social security contributions, and income tax are provided to businesses that start their activities within the scope of R&D projects (Beydemir, Bakmaz, & Ateş, 2022).

The work offices within the TDZs are structured within a physical building. Each office has square metres of varying sizes. Enterprises wishing to operate in the TDZ and whose R&D project has been approved by the Managing Co. start their activities by renting an office of a size suitable for the number of employees they wish to receive incentives by signing a lease agreement with the Managing Co. (Kapadokya Teknopark, 2023; Kütahya Tasarım Teknokent

Yönetici A.Ş., 2021; Teknopark İstanbul, 2021). The employees of the business that started its activities are not within the scope of remote working, and the right to work remotely, which was provided at a specific rate to software developers in businesses working on software after the Covid-19 pandemic process, is now applied as 100 (T.C. Sanayi ve Teknoloji Bakanlığı, 2023). They have to work by coming to the physical work offices in TDZ. These employees can benefit from incentives within the scope of the time they spend in the physical work offices within the TDZ.

This study aims to present a virtual TDZ model proposal on how TDZs can be structured virtually rather than physically and what their working principles can be in order to provide benefits such as eliminating the construction costs of physical TDZ buildings, reducing water, carbon and energy footprints, recovering the time spent by employees to reach TDZs, and increasing the resilience of businesses in physical TDZs to threats such as pandemics and environmental disasters by not affecting their business continuity.

In the second part of the study, brief conceptual information about the Industry 5.0 process is given. In the third part, information about the physical working structures of TDZs is given. Then, in the analysis part of the study, a model proposal is presented on how the virtual TDZ model can be structured and operated.

2. Industry 5.0 Process

Businesses' digital transformation process has accelerated with the Industry 4.0 process. Issues such as employee-related situations and environmental sustainability, which were not fully described in the Industry 4.0 process, have been more clearly expressed in the Industry 5.0 process. A digital transformation process suitable for the Industry 5.0 process should address issues such as the businesses' employees and society, environmental sustainability and resilience to threats such as natural disasters, cyber threats and infectious diseases. This process takes data and information as a reference, with the cooperation of technology. Physical processes are modelled in a virtual environment. This modelling process is also called a digital twin. Each stage of this process becomes a structure that generates data, and after analysing the data, decisions can be made according to the information obtained. At the same time, the cooperation of the businesses' internal and external environment is ensured. (Adel, 2022; Barata & Kayser, 2023; Ben Youssef & Mejri, 2023; European Commission, 2022; Golovianko, Terziyan, Branytskyi, & Malyk, 2023; Grabowska, Saniuk, & Gajdzik, 2022; Huang et al., 2022; Valette, Bril El-Haouzi, & Demesure, 2023). In light of this information, the Industry 5.0 process can be formulated as "Industry 5.0 = Industry 4.0 + Employees and Society +

Environmental Sustainability + Resilience of Businesses". This formula is illustrated in Figure 1.
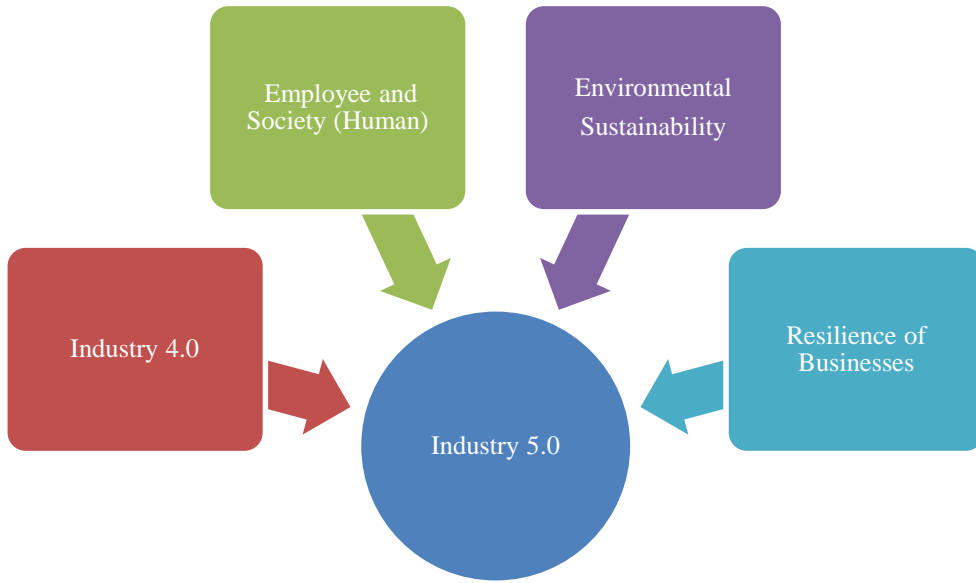
Figure 1.

Industry 5.0 Process

3. Technology Development Zones

Technology parks, or technoparks for short, are R&D structures that bring together R&D businesses to meet the technological needs of the private and public sectors in the country where they were established after the Second World War. The first example of a TDZ is Silicon Valley in the USA, founded in 1951. With the oil crisis in the 1970s, studies began around the world to mitigate its effects. As a result of the collaboration between universities, R&D institutions and the industrial sector, technological products started to emerge, and this collaboration led to the establishment of technology centres. The first TDZs were established in Europe in the 1980s and in Turkey in 2001 (Müsiad, 2012). As of 2023, 89 TDZs are actively operating in Turkey and 9951 businesses are carrying out R&D activities within these TDZs. The total number of employees is 105323, the export value is $10 billion and the total turnover is around TL 353 billion (Republic of Turkey Ministry of Industry and Technology General Directorate of R&D Incentives, 2023).

TDZs are defined in Article 3 of Law No. 4691 of 2001 as follows (Resmi Gazete, 2001):

"Technology Development Zone: An area where businesses using high/advanced technology or oriented towards new technologies produce/develop technology or software using the facilities of a specific university or high technology institute or R&D centre or

institute, where they operate to transform a technological invention into a commercial product, process or service, thus contributing to the development of the region; within or near the same university, high technology institute or R&D centre or institute area; where the academic, economic and social structure is integrated; or a technopark with these characteristics".

Entrepreneurs, businesses and academics wishing to carry out R&D activities in TDZs submit their R&D projects to the business established within the zone, called the managing company. Generally, its partners are universities, municipalities, special provincial administrations, chambers of industry and organised industrial zones. These projects are subject to a refereeing process, as set out in the operating rules of the managing company, and are accepted after approval by the referee. Projects can be accepted, revised or rejected (Kapadokya Teknopark, 2023; T.C. Teknoloji ve Sanayi Bakanlığı, 2016; Teknopark İstanbul, 2021).

Enterprises operating in TDZs within the framework of the project are obliged to submit reports requested by the managing company and the Ministry of Technology and Industry at specific intervals. At the same time, in order to benefit from the SSI (Social Security Institution) incentives offered by the Social Insurance Institution for the employees of these processes, the entry and exit times (tally) of these processes to and from the technological development zones within the framework of R&D activities are checked within the framework of the project periods (Kayalıdere, 2014; T.C. Teknoloji ve Sanayi Bakanlığı, 2016; Teknopark İstanbul, 2021).

In addition to the SSI exemption, processes operating in the TDIs can also benefit from tax exemptions on the income they earn from their R&D projects, VAT (Value-added Tax) and customs duty exemptions on the hardware, equipment and services they purchase for their R&D projects. In addition, with the approval of the Ministry of Finance, software produced in a TDZ can be invoiced VAT-free. Businesses operating in a TDZ are taxed on all types of income from non-R&D activities as if earned outside the TDZ. R&D processes are supported by this type of income from non-R&D activities (Çelik, 2019; T.C. Teknoloji ve Sanayi Bakanlığı, 2016).

Academics working at universities can set up businesses in TDZs. At the same time, in order to support the entrepreneurial activities of university students, academicians, and entrepreneurs in society, there is a structure called an incubation centre in TDZs, which is generally exempt from rental fees and provides free consultancy services. However, these businesses are not legally different from other processes. At the same time, these processes are expected to invest a certain part of the exemptions obtained by the processes with an exemption

amount of 1 million T.L. and above from the technological development zones into the capital of these processes, which is an obligation by means of a law enacted by Republic of Türkiye, thus strengthening the capital structures of these businesses (Hobikoğlu & Topak, 2022; T.C. Teknoloji ve Sanayi Bakanlığı, 2016).

The businesses in TDZs are obliged to provide the requested data on the R&D projects they carry out through the software infrastructure provided to them by the managing company. The requested data includes what is done within the scope of R&D projects, expenditures, and revenues generated. At the same time, the requested information also includes expenses and revenues other than R&D projects. The software provided by the managing company transfers this data collected in the TDZs to the Ministry of Industry and Technology's portal called TDZ Portal (commonly known as Biltek). Through this portal, certain reports are requested from the managing businesses at certain intervals. In this way, both the work of the processors in the work zone and the performance of the TDZs in Turkiye are monitored (T.C. Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü, 2023).

Today, the physical configuration of work zones can generate some problematic situations in terms of construction costs and provide a comfortable working environment for the processes in the TDZs. For example, the Kütahya Dumlupınar Design Technology Development Zone is located in Kütahya 30 August OSB. The distance of this TDZ from the university makes it difficult for students or academics to travel to the area. In addition, the construction of additional buildings for all TDZs may involve additional costs in terms of money, time and labour. The physical spaces of TDZ are heated in the winter months. The offices of businesses that do not come to the offices due to the right to work remotely are also heated. Thus, carbon, energy and water footprints are reduced. Virtual TDZs announced instead of physical TDZs can contribute to environmental sustainability by helping to reduce water, energy and carbon footprints.

4. Research

This study will try to explain the virtual TDZ model. In this context, the establishment of the infrastructure of the Virtual TDZ, the establishment of the managing company, the acceptance of R&D businesses to the virtual TDZ and the operation processes of the virtual TDZ infrastructure will be explained. Within the framework of the virtual TDZ model, a virtual TDZ infrastructure can be formed that contributes to environmental sustainability, increases the resilience of R&D businesses included in the virtual TDZ, and allows R&D employees to

choose their workspaces as they wish. Thanks to the infrastructure in the Virtual TDZ, R&D businesses can continue their activities in their own business centres or a location of their choice as if they were working in a physical TDZ.

This model should have an infrastructure that can be strengthened in the future with technologies such as metaverse, NFT, blockchain, and Digital Turkish Lira.

Within the framework of this study, after the announcement of the virtual TDZs, the businesses that want to work in this zone will work in their business centres or the location they determine, just as they work in the physical TDZ.

4.1. Purpose of the Research

The study aims to present a Virtual TDZ Reference Model.

4.2. Research Method

A qualitative method of analysis was preferred in the study.

4.3. Research Sample

The criterion case sampling was chosen from purposeful sampling methods in selecting the research sample. The criterion chosen was that of a managing company in the shadow of technology development. Kütahya Dumlupınar Design Technology Development Zone Managing Company was examined within the framework of the study.

4.4. Data Collection Method of the Research

Observation and document review were chosen as data collection methods.

a. Observation Process: The researcher (İsmail Yoşumaz) who conducted this study has been working as the Deputy General Manager of Kütahya Dumlupınar Design Technology Development Zone Yönetici A.Ş. since 2020. In this context, he has taken an active role in the preparation of many reports, in the construction of the additional building of Kütahya Dumlupınar Design Technology Development Zone, in the applications for new satellite incubation zones, and in conducting interviews with businesses coming to Kütahya Dumlupınar Design Technology Development Zone. During his work as a researcher, he had the opportunity to observe in detail the application and departure processes of the businesses in the TDZs, the work of the Ministry of Industry and Technology, the processes of the reports prepared by the businesses in the Kütahya Dumlupınar Design Technology Development Zone, the project processes and R&D activities.

b. Document review: Kütahya Dumlupınar Design Technology Development Zone, Teknopark Istanbul and Cappadocia Technopark Operating Directives, TDZ Implementing Regulation and Law No. 4691 were examined in the document review.

4.5. Research Questions

1. How can the existing infrastructure of TDZs be structured according to the Industry 5.0 process?

2. How can technoparks built for businesses operating in the technological development zone be structured in the virtual environment?

Within the scope of the research, some terms are tried to be explained below.

Technology Development Zone (TDZ): This refers to the existing physical TDZ where entrepreneurs such as academics, students, business owners or individuals in the community set up businesses (Resmi Gazete, 2001).

Virtual Technology Development Zone (Virtual TDZ): It refers to the virtual TDZ where entrepreneurs such as academics, students, business owners or individuals in the community establish businesses.

Virtual Office: It refers to the virtual office to be established within the virtual TDZ and defined for the R&D business.

R&D Business: It refers to the entrepreneur who wants to take place in the virtual or physical TDZ (Kapadokya Teknopark, 2023; Kütahya Tasarım Teknokent Yönetici A.Ş., 2021; T.C. Teknoloji ve Sanayi Bakanlığı, 2016; Teknopark İstanbul, 2021).

Employee: Within the scope of employees, it is used as a general expression used by the Ministry of Technology and Industry to define the employee working in the TDZ or virtual TDZ, such as R&D employees, researchers, software developers, support employees, and out-of-scope employees. This term can be expanded in software according to the employee characteristics specified by the Ministry of Technology and Industry (Kapadokya Teknopark, 2023; Kütahya Tasarım Teknokent Yönetici A.Ş., 2021; T.C. Teknoloji ve Sanayi Bakanlığı, 2016; Teknopark İstanbul, 2021).

TDZ Portal (Biltek): This term refers to the software used by the Ministry of Technology and Industry to monitor the status of the processes operating in the TDZ through the executive processes (T.C. Sanayi ve Teknoloji Bakanlığı Ar-Ge Teşvikleri Genel Müdürlüğü, 2023).

NFT: This concept is used to prove that the products developed in technology and industry development zones belong to the business operating in the virtual TDZ. It is defined as a "qualified intellectual deed" by Türkiye (T.C. Cumhurbaşkanlığı Dijital Dönüşüm Ofisi, 2022).

Metaverse: It refers to the infrastructure that enables the businesses within the TDZ to be represented in the virtual environment as if they shared the same physical environment in order to virtually cluster, cooperate and operate in the next stage after the implementation of the virtual TDZ (Lv, 2023; Young Lee, 2021).

Digital Turkish Lira: It refers to the digital money needed to sell the products produced in the Virtual Technology Development Zone to the region's people or internationally.

PDKS: It represents the infrastructure in which location-based overtime tracking can be carried out so businesses working in virtual TDZs can start R&D activities in their own centres as if they were working in the TDZ and calculate payrolls according to this overtime. This infrastructure should also be supported by the mobile application to be developed(Kapadokya Teknopark, 2023; Teknopark İstanbul, 2021).

Virtual Technology Development Zone Software: The Virtual TDZ software consists of two components and supports modern software development languages and infrastructures. The components (modules) that make up the Virtual Technology Development Zone software are as follows

a. Component 1: This component, which can be used by the Ministry of Industry and Technology, is the component that allows the software definition of the virtual TDZ with all its criteria and can exchange data with the second component. In this way, the definitions made in Component 2 can be analysed by Component 1. It can be modified if necessary. Only the Ministry of Industry and Technology can use this component.

b. Component 2: This is the component where the virtual offices, which can be used by the management businesses after the virtual TDZ has been defined in Component 1 and which will be owned by the businesses within the TDZ, are configured and managed according to the criteria of Component 1. In addition to virtual office management, this is the component that defines the employee and business information of the businesses that will be operating in the virtual TDZ.

Component 2 and Component 1 are integrated. All of the data, such as businesses, virtual offices, and employees defined in Component 2, are automatically transferred to Component 1

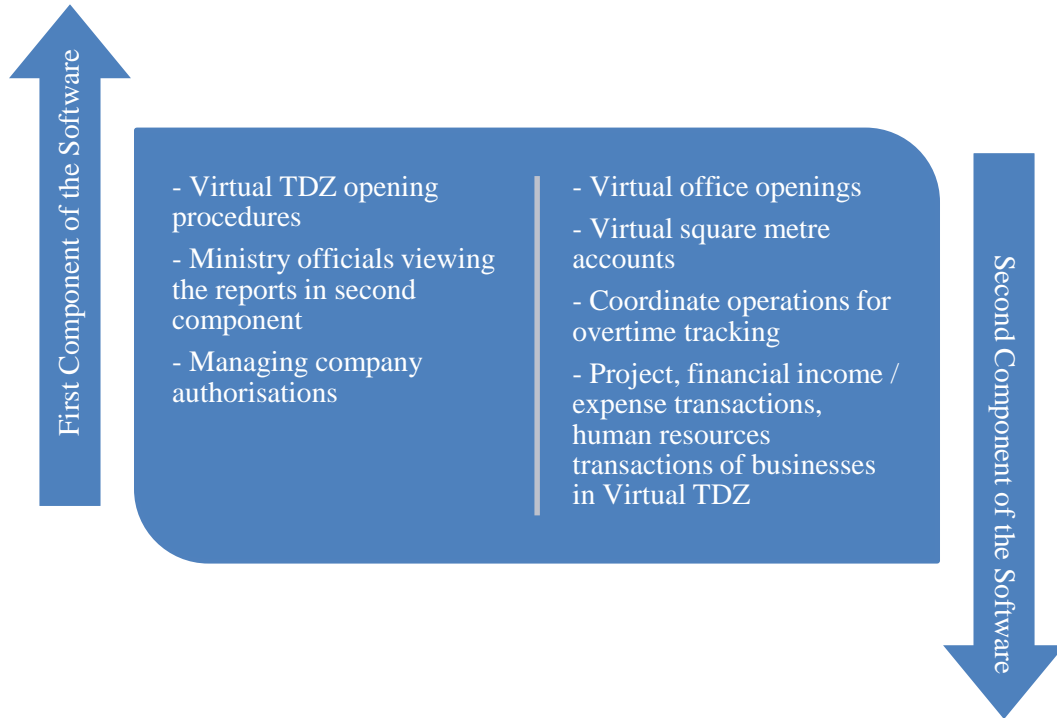The procedure for components 1 and 2 is shown in Figure 2.

First Component of the Software

- Virtual TDZ opening procedures
- Ministry officials viewing the reports in second component
- Managing company authorisations

- Virtual office openings
- Virtual square metre accounts
- Coordinate operations for overtime tracking
- Project, financial income / expense transactions, human resources transactions of businesses in Virtual TDZ

Second Component of the Software

Figure 2.

Components of Virtual TDZ software

Component 2 should also be made available to the businesses in the virtual TDZ. In this way, information such as income/expense, employee information, and project processes of the businesses can be collected from the businesses operating in the virtual TDZ.

The mobile software of the virtual TDZ software should also be developed. In this way, in the remote working structure offered in the virtual TDZ model, the R&D shifts of the employee can be monitored. Time tracking systems are called PDKS (Teknopark Istanbul, 2021). The attendance system in the mobile software to be developed should be developed in a structure suitable for GPS-supported location-based shift starting. At the same time, the mobile software to be developed should also include the management interfaces of Components 1 and 2. Figure 3 shows the structure of the mobile software.
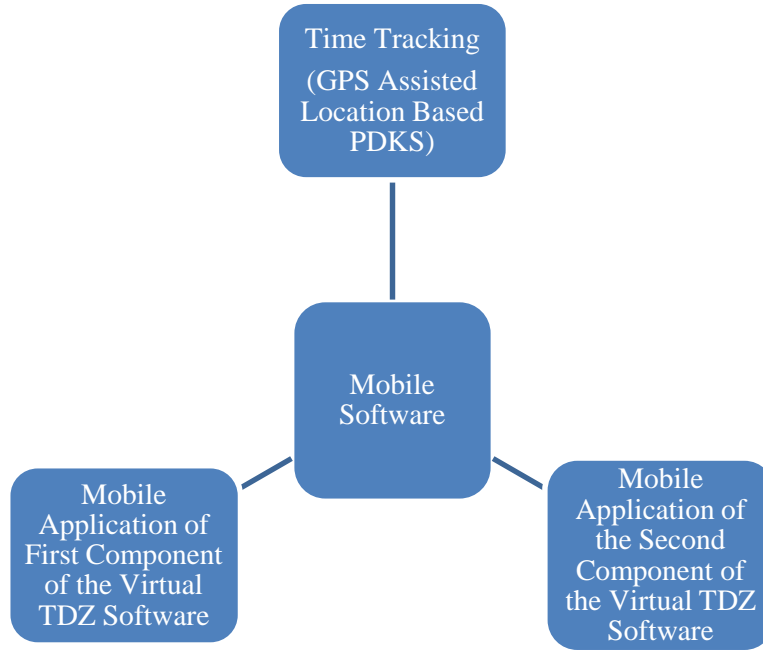
Figure 3

Virtual TDZ Mobile Software

The virtual TGZ software architecture should be designed to support the Metaverse infrastructure in various procedures. The Metaverse ecosystem could enable technology developers to promote their initiatives, resulting products and software at both national and international levels within the virtual space. Products produced in virtual TDZs can be presented to relevant individuals in the metaverse through representative offices abroad. Our businesses can facilitate meetings with these individuals. This enables the transfer of marketing processes from our businesses' products operating in TDZs to the digital environment. As a result, transparent monitoring of the revenues obtained and the expenses incurred during these processes can be maintained. All projects within the metaverse infrastructure must be registered with NFT and structured to facilitate the use of the digital Turkish lira infrastructure for transactions such as selling rental services and products from the metal environment. Immediate development of this software component is unnecessary.

The software's design must ensure that electronic signatures are employed for all software transactions, circumventing physical signatures and paper documentation.

5. Findings

In order to the TDZs mentioned in the first research question to be structured under the Industry 5.0 process, the physical structures of the TDZs should be transformed under the

Industry 5.0 process. In this transformation process, the technological transformation should be implemented in a way that includes the environment and people under the content of the Industry 5.0 process. At the same time, this transformation should enhance the resilience of businesses in TDZs against threats such as cyber threats and environmental disasters (Huang et al., 2022).

The virtual TDZ model can be defined as a model that represents a digital twin of physical TDZs and is managed by virtual TDZ software. Such a model does not exist in the literature. Therefore, it is considered as an original model. The objectives of this model can be listed as follows:

a. To save the labour and cost of building physical TDZs.

b. To contribute to environmental sustainability by aiming to minimise water, carbon and energy footprints thanks to the virtual environments to be used instead of these buildings, since the buildings and work offices in the physical TDZ have water, carbon and energy footprints.

c. Increasing the resilience of businesses to the threat of environmental disasters by enabling R&D businesses to develop R&D projects in the location of their choice.

The virtual TDZ model explains how the announcement and establishment of physical TDZs, the establishment of a managing company and the admission of R&D businesses to the physical TDZ will be carried out in the virtual TDZ model and how the process will operate.

Virtual TDZ Model

In order to establish a virtual TDZ, a virtual TDZ, like a physical TDZ, must first be declared by the Presidency of the Republic of Turkey (Resmi Gazete, 2001). After the declaration of the zone, the Ministry of Industry and Technology of the Republic of Turkey starts the studies to determine the managing company that will manage the virtual TDZ (T.C. Teknoloji ve Sanayi Bakanlığı, 2016). These studies can be carried out in the same way as in the physical TDZ. What is important here is not the shareholders or the structure of the managing company but the structuring of the virtual TDZ, which can be considered a digital twin of the physical TDZ with its software infrastructure.

After establishing the managing company, R&D businesses are admitted to the virtual TDZ. This acceptance takes place after the R&D businesses's project is submitted to the managing company and approved after going through the referee processes, just like in physical TDZs (Kapadokya Teknopark, 2023; Kütahya Tasarım Teknokent Yönetici A.Ş., 2021;

Teknopark İstanbul, 2021) A lease agreement is signed electronically with the accepted R&D business, and the R&D business and the criteria such as the number of employee, machinery and equipment requirements offered within the scope of the project are defined in the virtual TDZ software. After signing the lease agreement, the R&D business is provided with a physical working office in the physical TDZs. In the virtual TDZ, no physical office is provided. Instead, a virtual office is allocated in the virtual technology zone software. The size of this virtual space is determined by the number of people specified in the R&D project. It is also priced accordingly. In this way, the virtual office defined in the virtual TDZ software is transformed into a digital twin of the physical workspace of the physical R&D business or its employees.

R&D businesses wishing to operate in the virtual TDZ notify the managing company of the location where they will carry out their R&D processes. The location is defined by the coordinates of a physical area where the R&D business will carry out its activities, as determined by the R&D business. For example, when defining the location of an R&D business with its own working office, the coordinates of its current office are entered into the virtual TDZ software. The R&D business may wish for R&D employee to carry out R&D activities from their homes or individual work offices rather than gathering in a single location. In this case, a location definition is made for each of the R&D business employees. The reason for defining these locations is to track overtime and calculate R&D employee scorecards. In this way, the R&D business can benefit from the incentives provided by the government in the context of R&D processes. R&D employee scorecards and overtime tracking are carried out through turnstile and PDKS systems in physical TDZs. (Kapadokya Teknopark, 2023; Kütahya Tasarım Teknokent Yönetici A.Ş., 2021; Teknopark İstanbul, 2021).

In order to calculate the R&D employee payrolls and to calculate how much overtime is worked in R&D processes, a mobile time attendance system that can work integrated with the virtual TDZ software should be developed. This system is a mobile application that can run on Android or iOS operating systems (in short, smartphones) and allows location-based overtime tracking. For R&D employees who do not have smartphones, this need can be met by the R&D organisation where they are employed.

Virtual TDZs' incubation and pre-incubation units can be designed similarly to physical TDZs (T.C. Teknoloji ve Sanayi Bakanlığı, 2016). Moreover, current virtual TDZ firms can offer advisory services to these entrepreneurs in the forthcoming software. The management

firm can allocate various advisors to assist pre-incubation and incubation entrepreneurs using the software.

In the virtual TDZ model, the work carried out by R&D businesses and the follow-up of their employee can be carried out transparently using the virtual TDZ software. The differences and similarities between the virtual TDZ model and the physical TDZ model are shown in Table 1.

Table 1.

The differences and similarities between the virtual TDZ model and the physical TDZ model

Process	Virtual TDZ	Physical TDZ
Announcement of the TDZ	It shall be declared by a decree of the Presidency of the Republic of Turkey under the procedure in 5.1.	It shall be declared by a decree of the Presidency of the Republic of Turkey
Establishment of TDZ	After the announcement of the TDZ, the T.R. Ministry of Industry and Technology shall define the 1st component of the virtual TDZ software under the criteria specified in the announcement.	After the announcement of the TDZ, the TDZ is defined in the TDZ Portal (Biltek) software of the Ministry of Industry and Technology. The building construction process starts for the offices of the businesses that will operate in the TDZ in the physical location deemed appropriate in the announcement.
Establishment of the Managing Company	The managing company is structured as the management of the physical TDZ in the province where the virtual TDZ is announced or as a new managing company. If a new company is to be established, the shareholders of the managing company are also determined. The managing company is defined in the second component of the virtual TDZ software and authorised to send data to the first component.	The partners of the managing company are determined and established. After the establishment, the shareholders of the managing company are authorised to manage the TDZ announced in the TDZ Portal.

Admission of R&D Enterprises to TDZ	To accept R&D businesses to the virtual TDZ, the R&D business is asked to submit the R&D project. Companies submit the R&D project to the managing company using the 2nd component of the virtual TDZ software, and the R&D project is sent to the referees. If the response from the referees is in favour of acceptance, the identification of the R&D business and its employee is made in the 2nd component of the virtual TDZ software and automatically transferred to the 1st component. This way, the operations performed on the 2nd component can be monitored through the 1st component.	For the acceptance of R&D businesses, businesses are asked to submit an R&D project. The R&D project is sent to the referees through a software of the managing company's own choice. If the response from the referees is in the direction of acceptance, the identification of the business and its employees is made on the managing company's own choice software, and the necessary information is transferred to the TDZ Portal through this software.
Project Monitoring of R&D Businesses	Project tracking is done with the 2nd component of the virtual TDZ software and automatically transferred to the 1st component. This way, the operations performed on the 2nd component can be monitored via the 1st component.	Project follow-up is carried out through the software chosen by the managing company, and the results obtained are transferred to the TDZ Portal via this software.
Time Tracking of R&D Employee	The employee's overtime tracking and payroll calculations are made through the location-based overtime tracking mobile application to be developed, and the data is transferred to the 2nd component in the virtual TDZ software. The data transferred to the 2nd component is automatically transferred to the 1st component after the control of the managing company.	The overtime tracking of the employee is made under the entry/exit from the turnstile systems in the physical building. The time difference between the entry and exit of R&D employees is also calculated according to the time difference. All transactions are carried out through the software chosen by the managing company, and the results obtained are transferred to the TDZ Portal via this software.

Referance: Kütahya Tasarım Teknokent Yönetici A.Ş., 2021: Teknopark İstanbul, 2021

This model and the process required for its implementation are designed as shown in Figure 4.
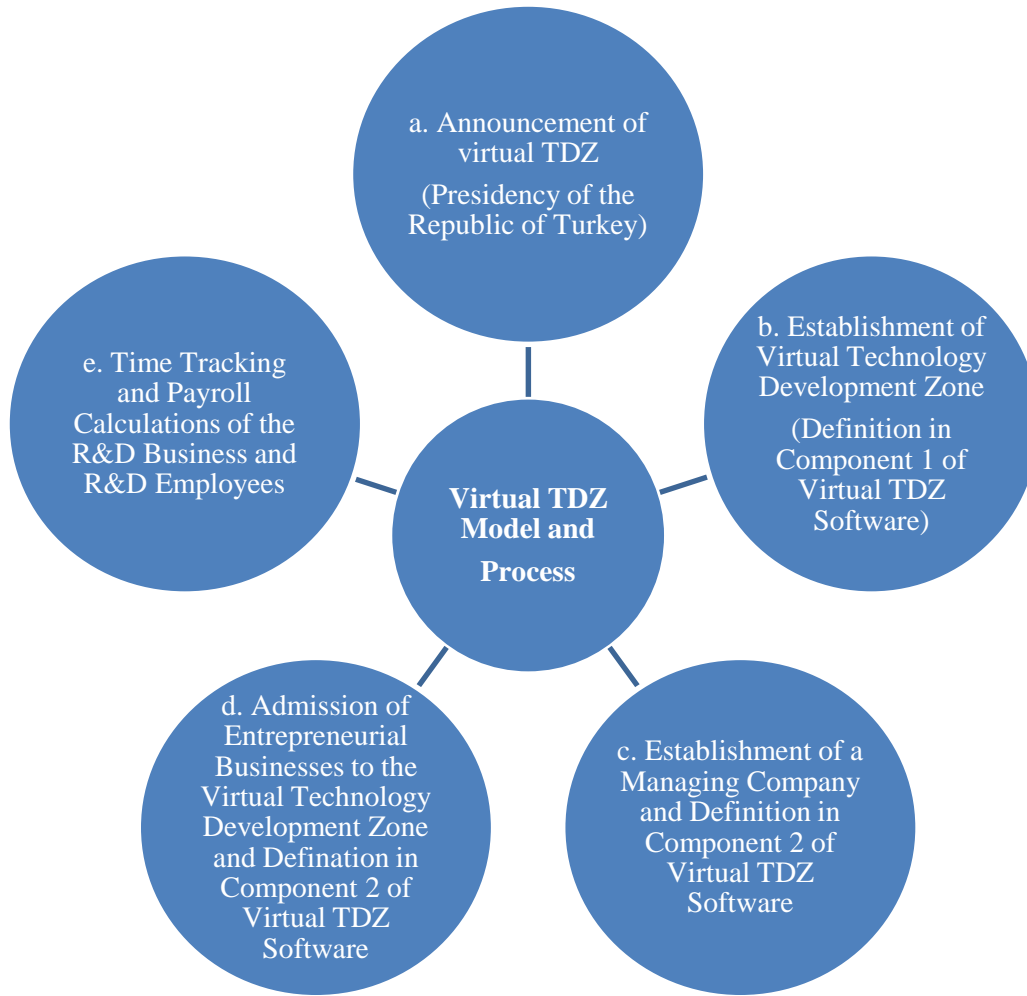

Figure 4.

Virtual TDZ Model and Processes

5.1. Process of Virtual TDZ

The process of how the Virtual TDZs mentioned in the 2nd research question can be structured is shown in Figure 4.

a. Announcement of Virtual Technology Development Zone

Law No. 4691 states that a physical TDZ can be declared by a presidential decree (Official Gazette, 2001). The announcement of a virtual TDZ can be just like the announcement of a physical TDZ. A virtual TDZ is announced by the Presidency in the desired criteria and provinces. The criteria for the announced virtual TDZ may be as follows

1. Maximum number of businesses that can be established,

2. The dimensions of the virtual TDZ in square metres and the square metres of the offices within the virtual TDZ,

3. Minimum and maximum square metre unit price of offices in the Virtual TDZ

4. Minimum and maximum number of R&D employees who can work in offices within the Virtual TDZ (These numbers can be calculated according to the number of employees per square metre in virtual TDZs as in physical TDZs. For example, a business that wants to employ ten employees, where the criterion of 1 employee per 4 square metres is introduced, must rent a minimum area of 40 square metres from the Virtual TDZ).

5. The maximum amount of incentives that the state can utilise for Virtual TDZs.

b. Establishment of Virtual Technology Development Zone (Definition in Software)

Establishing virtual TDZs means defining them in the virtual TDZ management software. In this context, virtual TDZs are defined in Component 1 of the virtual TDZ management software under the control of the Ministry of Industry and Technology, together with the criteria defined when the virtual TDZs are announced.

The Ministry of Industry and Technology's process of defining the virtual TDZ in component 1 of the software is shown in Figure 5.
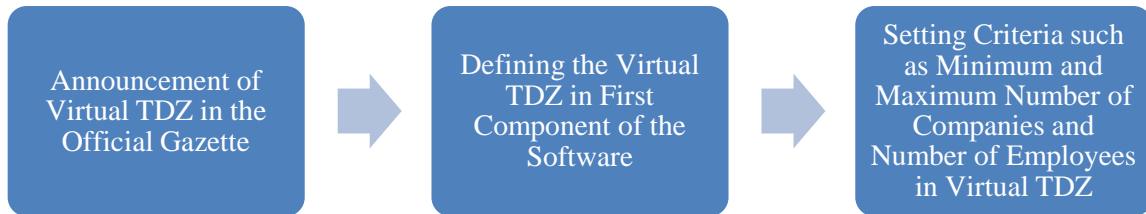

Figure 5.

Establishment Process of Virtual TDZ

c. Establishment of a Managing Company or Authorisation of an Existing Business in the Province where the Virtual TDZ is opened:

After the virtual TDZ is announced and defined in Component 1 of the virtual TDZ software, a new managing company is established by determining the company's shareholders that will manage the virtual TDZ. This company may be a new managing company specific to the virtual TDZ or one that manages the physical TDZ in the province where the virtual TDZ is announced.

Assigning the virtual TDZ and the physical TDZ to the same managing company may be beneficial. When R&D businesses working in the physical TDZ want to move to the virtual TDZ, they can be controlled by a single managing company. The establishment process of a managing company is shown in Figure 6.
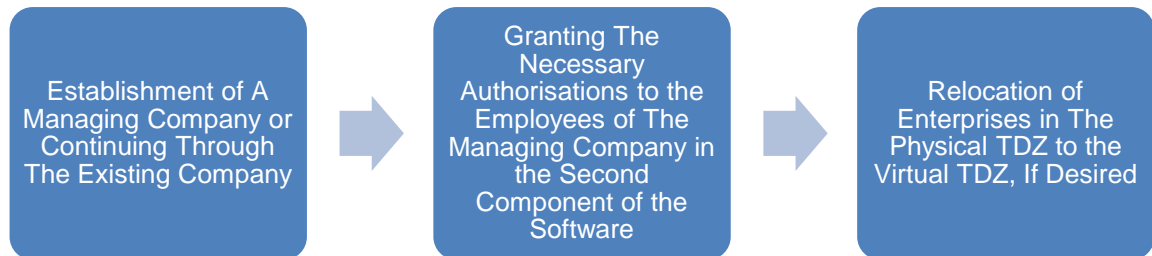

Figure 6.

The *Establishment of a managing company*

d. Admission of Entrepreneurial Enterprises to the Virtual Technology Development Zone

Virtual TDZs function in a manner akin to their physical counterparts. Once the referees have approved the project, the virtual TDZ software incorporates information related to employees, equipment, and services required to execute the project. To gain access to the virtual TDZ, businesses must submit their R&D project proposals for referees to review via the virtual TDZ software. Once the referees have approved the project, the virtual TDZ software incorporates information related to employees, equipment, and services required to execute the project. After the project is approved by the referees, information on the employees, equipment and services needed within the project's scope is added to the virtual TDZ software. Later, the managing company inaugurates establishing a business that will operate within the virtual TDZ from a virtual office. The employees who will work for this business are specified accordingly. This process is shown in Figure 7.
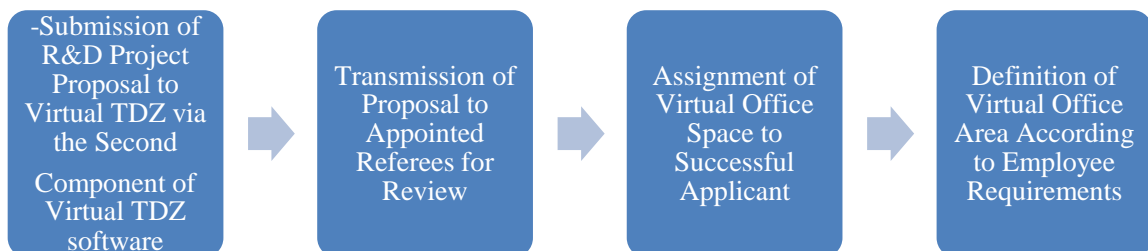

Figure 7.

Acceptance of the entrepreneur in the virtual TDZ

e. Time Tracking and Payroll Calculations of the R&D Business and R&D Employees

The tracking of overtime for employees working on the virtual R&D project for the business starting operations in the virtual TDZ is defined by the mobile overtime tracking system via mobile employee tracking. The business' coordinates are defined in the system under its physical location to enable the start and end of overtime for specified locations. Tracking overtime in this manner can also aid in calculating premium incentives that the business will receive from the SSI (Social Security Institution) for the tally work. This process is shown in Figure 8.
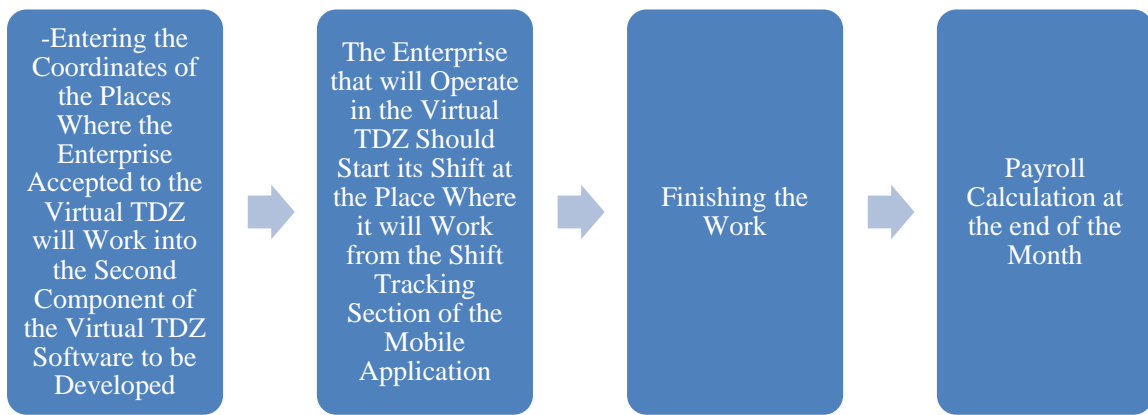
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┌──────────────┐    ┌──────────────┐    ┌──────────────┐    ┌──────────────┐
│ -Entering the│    │ The Enterprise│   │              │    │              │
│ Coordinates of│   │ that will Operate│ │              │    │   Payroll    │
│ the Places    │   │ in the Virtual│    │ Finishing the│    │ Calculation at│
│ Where the     │──▶│ TDZ Should    │──▶ │     Work     │──▶ │ the end of the│
│ Enterprise    │   │ Start its Shift at│               │    │     Month    │
│ Accepted to the│  │ the Place Where│   │              │    │              │
│ Virtual TDZ   │   │ it will Work  │    │              │    │              │
│ will Work into│   │ from the Shift│    │              │    │              │
│ the Second    │   │ Tracking      │    │              │    │              │
│ Component of  │   │ Section of the│    │              │    │              │
│ the Virtual TDZ│  │ Mobile        │    │              │    │              │
│ Software to be│   │ Application   │    │              │    │              │
│ Developed     │   │              │     │              │    │              │
└──────────────┘    └──────────────┘    └──────────────┘    └──────────────┘
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Figure 8.

Overtime tracking and payroll calculation in Virtual TDZ

6. Conclusion and Evaluation

The Industry 5.0 process deals with the digital transformation process of businesses, environmental sustainability, the ability of employees to work in cooperation with technology and increasing the resilience of businesses against threats such as environmental disasters or cyber threats. The studies that can be carried out in this context should be structured to address the whole of the businesses, employees, and society.

One of the places where studies on the Industry 5.0 process can be carried out is Technology Development Zones. R&D studies are carried out in TDZs, and valuable technologies that can be used for humanity are revealed. For this reason, it is thought that these regions need to be structured under this process.

Within the scope of this study has tried to explain how physically structured TDZs can be structured virtually. A virtual TDZ model has been put forward in this context. The Industry 5.0 process is a process that explains the employees and society, environmental sustainability, and the resilience of businesses against threats through technological cooperation. In this context, the virtual TDZ model enables businesses and their employees to develop R&D processes from wherever they want. It contributes to environmental sustainability by trying to reduce the carbon, water and energy footprints that arise during the construction and operation of physical buildings. In addition, it is thought that structuring the digital twins of these structures in the virtual environment instead of physical structures affected by environmental disasters will contribute to the resilience of businesses.

Thanks to adding a metaverse environment to the virtual TDZ software infrastructure, the products developed by R&D businesses can be promoted more effectively. At the same time, an R&D fair can be organised in the Metaverse environment in which all virtual development zones can participate together, and efforts can be made for the virtual participation of various participants from all over the world in this fair.

Since the virtual TDZ software to be developed can run on the national operating system Pardus, the usage area of the Pardus operating system will also be expanded.

In today's world, where studies on digital transformation and environmental sustainability, employee-technology cooperation and increasing the resilience of businesses are growing, it is thought that creating a virtual TDZ infrastructure can benefit entrepreneurs, administrative processes and the public and increase participation in TDZs.

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