LOGISTICS TECHNOLOGIES AND SUSTAINABILITY

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CEMAL ATAKAN PARLAK

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submitted by **CEMAL ATAKAN PARLAK** in partial fulfillment of the requirements for the degree of **Master of Science in Science and Technology Policy Studies, the Graduate School of Social Sciences of Middle East Technical University** by,

Prof. Dr. Sadettin KİRAZCI
Dean
Graduate School of Social Sciences _____

Prof. Dr. Mehmet Teoman PAMUKÇU
Head of Department
Science and Technology Policy Studies _____

Assoc. Prof. Dr. Adil ORAN
Supervisor
Department of Business Administration _____

Examining Committee Members:

Assist. Prof. Dr. Arsev Umur AYDINOĞLU (Head of the Examining Committee)
Middle East Technical University
Science and Technology Policy Studies _____

Assoc. Prof. Dr. Adil Oran (Supervisor)
Middle East Technical University
Department of Business Administration _____

Prof. Dr. Nihat GÜLTEKİN
Harran University
Department of Business Administration _____

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: Cemal Atakan PARLAK

Signature:

ABSTRACT

LOGISTICS TECHNOLOGIES AND SUSTAINABILITY

PARLAK, Cemal Atakan
M.S., The Department of Science and Technology Policy Studies
Supervisor: Assoc. Prof. Dr. Adil ORAN

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The aim of this thesis is to identify the barriers hindering the adoption of electric commercial vehicles for sustainable last-mile logistics operations within the post & parcel sector in Turkiye. With the rapid expansion of the e-commerce industry, last-mile logistics operations contribute significantly to environmental degradation due to harmful gas emissions. However, the utilization of electric commercial vehicles offers an opportunity to mitigate these environmental impacts.

This study employs the seven functions model to examine the relevant technological innovation system in Turkiye. The data generated from semi-structured interviews with diverse stakeholders are analyzed employing a deductive approach. Through this analysis, the barriers impeding the integration of electric commercial vehicles into last-mile operations for post & parcel companies are identified and categorized within the framework. Evidence-based policy recommendations are subsequently formulated to effectively address these barriers.

Facilitating environmentally friendly last-mile operations with electric commercial vehicles in the post & parcel sector in Turkiye necessitates several key factors. These

factors include the establishment of a national policy on electric commercial vehicles and sustainability, implementation of incentives to encourage the purchase and utilization of electric vehicles, increased research and development efforts focused on electric vehicles within academic institutions, the cultivation of a skilled workforce, and the enhancement of electric vehicle charging infrastructure.

Keywords: Electric commercial vehicles, post & parcel, last-mile delivery, sustainability, logistics

ÖZ

LOJİSTİK TEKNOLOJİLERİ VE SÜRDÜRÜLEBİLİRLİK

Parlak, Cemal Atakan
Yüksek Lisans, Bilim ve Teknoloji Politikası Çalışmaları Bölümü
Tez Yöneticisi: Doç. Dr. Adil ORAN

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Bu tezin amacı Turkiye'de posta & kargo sektörü tarafından gerçekleştirilen son kilometre lojistik operasyonlarının sürdürülebilir olması adına elektrikli ticari araç kullanımının önündeki bariyerleri tanımlamaktır. E-ticaret hacmine paralel olarak hızla büyüyen son kilometre lojistik operasyonları, sebep olduğu zararlı gaz emisyonu ile çevresel sürdürülebilirliğe en fazla zarar veren aktiviteler arasındadır. Son kilometre lojistik operasyonlarının çevresel zararını minimize etmek adına elektrikli ticari araçlar kullanılabilmektedir.

Çalışma kapsamında Turkiye'deki ilgili teknolojik inovasyon sistemi, Hekkert et al. tarafından önerilen yedi fonksiyon modeli kullanılarak ele alınmıştır. Yarı yapılandırılmış mülakatlar ile farklı paydaşların görüşleri alınarak üretilen veriler, yedi fonksiyonu odak alan tümdengelim yaklaşımı ile analiz edilmiştir. Analiz sonunda posta & kargo firmalarının son kilometre operasyonlarında elektrik ticari araç kullanımının önündeki bariyerler, yedi fonksiyon ile ilişkilendirilerek tanımlanmıştır. Kanıta dayalı politika geliştirme yaklaşımı ile bulgularda yer alan bariyerlere ilişkin politika önerileri geliştirilmiştir.

Turkiye'de posta & kargo sektörünün elektrikli ticari araçlar kullanarak çevre dostu son kilometre operasyonları gerçekleştirmeleri öncelikle ulusal elektrikli ticari araç ve sürdürülebilirlik politikasının belirlenmesi, araç alım ve kullanımına yönelik teşviklerin yaygınlaştırılması, üniversitelerin konuya ilişkin akademik çalışmalarını artırmaları, nitelikli insan kaynağı ve elektrikli araç şarj altyapısının gelişmesine bağlıdır.

Anahtar Kelimeler: Elektrikli ticari araçlar, posta & kargo, son kilometre teslimatları, sürdürülebilirlik, lojistik

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UN	United Nations
SDG	Sustainable Development Goals
EU	European Union
WEF	World Economic Forum
IEA	International Energy Agency
CSR	Corporate social responsibility
IPCC	Intergovernmental Panel on Climate Change
EPA	U.S. Environmental Protection Agency
MoEU	Ministry of Environment and Urbanization
TZWP	Turkiye's Zero Waste Project
GHGs	Greenhouse Gases
ECV	Electric Commercial Vehicles
ELV	Electric Light Vehicles
UAV	Unmanned Aerial Vehicles
EFV	Electric Freight Vehicles
TCO	Total Cost of Ownership
TIS	Technological Innovation System
KPI	Key Performance Indicators
VAT	Value Added Tax (VAT)
SCT	Special Consumption Tax
TOGG	Turkish Automobile Joint Venture Group

CHAPTER 1

INTRODUCTION

Global warming and climate change are among the most crucial challenges currently facing the world. International Energy Agency (2021) argues that greenhouse gas emissions have reached 36.3 gigatons due to a 6% increase from the previous year's levels. The increasing emission of greenhouse gases is causing global warming and climate change. Transportation and logistics activities have a significant role in the causes of greenhouse gas emissions. Transportation is the second-largest source of energy-related CO_2 emissions globally, contributing 25% of total energy-related CO_2 emissions (IEA, 2021).

The reduction of greenhouse gas emissions is critical for mitigating the negative impacts of global warming and climate change. Measures taken to decrease greenhouse gas emissions resulting from transportation and logistics activities can substantially contribute to achieving environmental sustainability. Greene et al. (2011) state that the transportation sector can cost-effectively achieve a substantial reduction of greenhouse gas emissions by 2050 through various measures, which have the potential to decrease emissions by up to 65 percent below 2010 levels. In order to effectively address the challenges of environmental sustainability, it is essential to adopt technologies capable of reducing greenhouse gas emissions related to logistics. The ongoing threat of climate change and global warming, considered among the most significant environmental issues facing the world today, underscores the importance of addressing these challenges through the implementation of sustainable logistics technologies.

The logistics and transportation industries are vital for the movement and storage of goods and materials on a global scale. However, they also have a negative impact on

the environment through carbon emissions and other forms of pollution. Ritchie et al. (2020) found that road transportation is the primary source of greenhouse gas emissions, accounting for 73.4% of the total emissions from transportation activities. Road logistics operations include delivering goods from a warehouse or other point of origin to the final consumer, known as last-mile delivery operations. Last mile logistics operations are considered one of the most polluting stages of the entire logistics chain (Gevaers et al., 2014).

To meet the growing demand for online shopping and enhance the overall customer experience, the number of last-mile delivery vehicles is anticipated to increase by 36% by 2030 (World Economic Forum, 2020). Such an increase in last-mile delivery traffic is expected to lead to a corresponding rise in greenhouse gas emissions and congestion of more than 21%. According to World Economic Forum (2020), there is projected to be a 31.6% increase in carbon emissions resulting from last-mile delivery in the top 100 cities worldwide by 2030, compared to 2019. This increase in e-commerce worldwide has resulted in a significant growth in the last-mile delivery sector, which is a significant contributor to greenhouse gas emissions.

Given the growing urgency to decrease greenhouse gas emissions and implement sustainable practices, sustainable logistics technologies have become indispensable for promoting green logistics practices. Effective use of technology is considered one of the most crucial ways to attain sustainability objectives in logistics operations. Pepper et al. (2022) argue that innovative technologies can play a crucial role in reducing greenhouse gas emissions in last-mile logistics operations by promoting the decarbonization of last-mile delivery. Recent advancements in logistics technologies are revolutionizing the transportation and delivery of goods and their implementation can significantly enhance the sustainability of last-mile delivery or pickup operations.

Yilmaz et al. (2022) have identified key technology models for last-mile delivery in urban areas as crowdsourced delivery, click-and-collect, pickup points, parcel lockers, reception and delivery boxes, in-car delivery, cargo bikes, drone delivery, and autonomous ground vehicles. Among the most promising solutions for

enhancing sustainability in last-mile logistics operations are advanced logistics technologies, such as electric vehicles, autonomous robots or drones, route optimization, shared load transportation models, and vehicle-load matching platforms.

According to the World Economic Forum (2020), electric vehicles represent the most advantageous logistics technology solution for the environmental sustainability. The adoption of electric vehicles for last-mile delivery presents a feasible option to reduce CO2 emissions. Specifically, electric commercial vehicles have the potential to reduce emissions by 60% while lowering delivery costs by up to 2%. Previous research has shown that electric vehicles can contribute to environmental sustainability in last-mile delivery operations. Post & parcel firms are recognized as the key players in last-mile logistics and have the potential to significantly contribute to sustainability efforts by reducing their greenhouse gas emissions. In Turkiye, post & parcel firms operate more than 50,000 vehicles fleet in total (KARID, 2023).

This thesis aims to explore the barriers to adopting electric vehicles for sustainable last-mile parcel delivery operations in Turkiye. The study utilizes the seven functions framework proposed by Hekkert et al. (2007) to analyze the relationship between electric commercial vehicles, post & parcel last-mile operations and sustainability. The framework includes Entrepreneurial Activities, Knowledge Development, Knowledge Diffusion Through Networks, Guidance of Research, Market Formation, Mobilization of Resources, and Creation of Legitimacy functions.

The combination of the theoretical background and sub-research questions has led to the research question: “What are the barriers in terms of Hekkert's seven functions to the implementation of electric vehicles for sustainable last-mile parcel delivery operations in Turkiye?”

Semi-structured interviews were conducted with participants selected through the theoretical sampling method to generate data on the research question. The generated data were analyzed using a deductive approach in the QDA Miner software. Hekkert et al.’s (2007) seven functions were positioned as the main clusters in the coding

stage. The findings presented in the discussion section were reviewed to ensure accuracy and consistency with the research question and data analysis results. In the final section, evidence-based policymaking was carried out based on the research findings. Barriers and policy recommendations related to different functions were suggested for the adoption of electric commercial vehicles in last-mile delivery operations carried out by post & parcel firms.

1.1. Organization of the Thesis

This study is comprised of six chapters: Introduction, Literature Review, Theoretical Background and Methodology, Findings, Discussion, Conclusion, and Policy Recommendations. The introductory chapter presents a comprehensive overview of the research topic, outlining its rationale, theoretical contributions, the significance of the research, overall structure and organization of the thesis, and general background information related to the research topic. Additionally, the introduction section includes a clear and concise statement of the research question, elaborating on the problem the study aims to address.

The Literature Review chapter starts with a discussion of sustainability, including global and Turkish sustainability goals and different definitions of sustainability, such as economic, social, and environmental. The second part of the chapter focuses on the logistics sector, which is recognized as a major contributor to greenhouse gas emissions and climate change. The chapter reviews the different types of logistics and their relationship with sustainability as well as the various technologies used in last-mile logistics operations, with a particular emphasis on electric commercial vehicles. Studies on electric commercial vehicle adoption policies and barriers are included. Overall, the Literature Review chapter provides an overview of the current state of knowledge on sustainability and logistics, setting the stage for the subsequent investigation of barriers to implementing electric vehicles in last-mile parcel delivery operations in Turkiye.

The third chapter provides an overview of the theoretical background and methodology of the research. The Technological Innovation System and the seven-

function model proposed by Hekkert et al. (2007) are introduced and their relevance to the research topic is explained. Based on the research topic, the seven functions are restated to define sub-questions for the use of electric commercial vehicles in sustainable last-mile cargo operations. The last part of the chapter details the semi-structured interview questions, objectives, and the characteristics of the interview group. Data generation, data analysis, and interview process are also described in this three.

The findings chapter presents the research results generated through semi-structured interviews. The findings are organized into seven sections based on Hekkert's recommended framework. Direct quotations from interviewees are included to convey their views effectively. Furthermore, data obtained through secondary sources are used to validate interview comments.

In the discussion section, the research findings are compared with previous academic studies on the same topic and various perspectives from those studies are discussed. Interpretations and comments for each finding section were added. Lastly, the discussion chapter provides a critical evaluation of the study by identifying its limitations, including theoretical or practical challenges encountered during the research process.

The final chapter of the thesis is Conclusion and Policy Recommendations. The barriers generated by analysis have been grouped according to their relationships. Policy suggestions have been made based on an evidence-based policy-making approach and represented in a three-column format consisting of the main barriers/issues to consider, the aim of policy, and policy tools. Furthermore, the research question, literature, analysis, data generation, theoretical background, and conclusion sections have been reviewed overall.

1.2. Significance of the Thesis

In this study, barriers that hinders the adoption of electric commercial vehicles by post & parcel companies in Turkiye for sustainable last-mile delivery operations are

investigated using Hekkert's seven functions as a framework. The significance of the thesis can be approached from multiple perspectives.

Firstly, the topics covered in the thesis hold increasing importance in the current global context. As evidenced in the literature review, this study is situated at the intersection of three emerging areas, namely sustainability, last-mile delivery, and electric commercial vehicles. Sustainability, particularly environmental sustainability, has become a pressing issue due to concerns over climate change, global warming, and greenhouse gas emissions, which have become priorities on the global agenda. The last-mile delivery sector, which is among the major contributors of greenhouse gas emissions, has experienced significant growth due to the surge in e-commerce activity following COVID-19 pandemic. This development is expected to exacerbate environmental pollution. Lastly, the electric vehicle market is expanding rapidly. While independent studies are being conducted in the three aforementioned areas, this thesis situates itself at the intersection of these interrelated domains, thereby offering a unique and integrated perspective on the topic at hand.

The second key aspect of this study is the thorough evaluation of the adoption of electric vehicle from both manufacturer and user perspectives. The analysis of the interrelationships among actors involved in the innovation system provides a more comprehensive understanding of the results. The thesis simultaneously examines various crucial factors which are necessary for the common use of electric commercial vehicles in last-mile delivery operations in Turkiye. This study is inclusive and comprehensive in the sense that it covers a wide range of areas associated with the adoption of electric commercial vehicles by post & parcel companies for sustainable last-mile delivery operations in Turkiye. The research considers various factors, including battery technologies, charging infrastructure, research centers, expectations of post & parcel companies, government incentives, and non-governmental organizations, as well as their interrelationships. As a result, this study provides a comprehensive and in-depth analysis of the barriers hindering electric vehicle adoption for last-mile delivery operations in Turkiye.

However, despite the availability of studies on electric vehicles and sustainability, there is a noticeable gap in academic studies regarding implementing sustainable practices in last-mile delivery operations using electric commercial vehicles in Turkiye. Relevant academic studies found on this topic is by Imre et al. (2021), which examined the implementation of electric freight vehicles in post & parcel operations using a different framework. This thesis adds a sustainability perspective to the topic and uses a function framework that takes into account relationships. This study is expected to provide a foundation for future sustainability and electric vehicle policies in Turkiye.

CHAPTER 2

LITERATURE REVIEW

2.1. Sustainability

Sustainability is a complex and multidisciplinary concept that has been defined in various ways by different academic disciplines. A widely cited definition of sustainability comes from the United Nations Brundtland Commission (1987), which defines sustainability as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The Brundtland Report is a document that lays out the idea of sustainable development. The report is considered to be a significant and influential work in the field of sustainable development and had a significant impact on the global environmental policy framework.

In both academic and business settings, there are many different definitions of sustainability. The purpose of sustainability for companies may also be parallel with corporate social responsibility. Marrewijk (2003) states that corporate social responsibility (CSR) and sustainability are closely related concepts for companies. Marrewijk (2003) defines corporate social responsibility as "a corporation should act in a way that enhances society and its inhabitants and be held accountable for any of its actions that affect people, their communities, and their environment," while sustainability is defined as "for human society to survive over time it must operate sustainably, in a way that does not destroy or deplete these natural resources for future generations" (Lawrence & Weber, 2017, p.148)

Sustainability is not just limited to being an environmental concept; it encompasses multiple dimensions, such as economic and social sustainability. Urdan and Luoma

(2020) highlight different definitions of sustainability in academic and business settings. Different definitions of sustainability can impact the design and effectiveness of policies and studies. Arena et al. (2009) investigated the existence of different sustainability definitions in academic studies. There are three main definitions: economic sustainability, social sustainability, and environmental sustainability. Arena et al. (2009) state that environmental sustainability is the most frequently used sustainability definition in the literature.

Firstly, economic sustainability is defined as focusing on the natural resources that provide physical inputs, such as renewable and exhaustible resources, into the production process. It also stresses the importance of considering the physical inputs into production, particularly the environmental life-support systems vital for both production and human survival (Goodland, 1995). Secondly, Goodland (2009) defines social sustainability as the maintenance and replenishment of social capital, which includes factors such as community cohesion, cultural identity, and shared values. Lastly, the United Nations Brundtland Commission (1987) defines sustainability as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Nine sub-dimensions of environmental sustainability can be revealed: materials, energy, water, biodiversity, emissions, waste, product and services, compliance, and transport. Environmental sustainability is utilizing and preserving natural resources to guarantee the continuation of ecosystem services for the current and future generations. (Arena et al., 2009)

2.1.1. Environmental Sustainability and Climate Change

Tol (2016) states that the Intergovernmental Panel on Climate Change (IPCC) meets the demand for information on climate change and policy. According to the Intergovernmental Panel on Climate Change (IPCC, p.557, 2012), climate change is defined as "a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and the variability of its properties and that persists for an extended period, typically decades or longer."

IPCC Intergovernmental Panel on Climate Change (2022) argues that as a part of climate change, greenhouse gas emissions (GHGs) over the last decade are at the highest levels in human history. There is a proven cause–result relationship between climate change to greenhouse gas (GHG) emissions. Stern (2008) states that releasing greenhouse gas from human activities, such as production and consumption decisions, causes climate change. These gases accumulate in the atmosphere and trap heat, leading to global warming. Global warming can significantly impact the environment, including changes in water patterns and potential alterations to the planet's geography and ecosystems, affecting people, species, and plants.

2.1.1.1. Greenhouse Gas Emission

U.S. Environmental Protection Agency (2022) highlights that atmospheric concentrations of greenhouse gases carbon dioxide, methane, and nitrous oxide have significantly increased due to human activities since 1750. The most significant percentage of GHGs is carbon dioxide (79%), followed by methane (11%), nitrous oxide (7%), and other greenhouse gases (3%). According to the International Energy Agency (2021), global CO_2 emissions from energy combustion and industrial processes reached their highest annual level.

Transportation is the second-largest source of energy-related CO_2 emissions globally. According to Greene et al. (2011), achieving a significant reduction in greenhouse gas emissions from transportation by 2050 through various GHGs-effective measures with the potential to decrease emissions by up to 65 percent below the 2010 level is possible.

Carbon dioxide (CO2) is the most prevalent greenhouse gas, accounting for about 78% of total greenhouse gas emissions in the U.S. in 2019. The United States emitted nearly 6 billion metric tons of greenhouse gases (EPA, 2020). The increase in carbon dioxide is primarily caused by fossil fuel use, with land-use change also contributing. (IPCC, 2007). The United States Environmental Protection Agency (2020) states that the primary sources of greenhouse gas emissions in the United States are transportation (27%), electricity production (25%), industry (24%),

commercial and residential (13%), agriculture (11%), and land use and forestry (13%) in 2020. The European Union Green Deal (2019) states that transportation currently accounts for 25% of the European Union's GHG emissions, and a 90% reduction in transport emissions is needed by 2050 to achieve climate neutrality. Another study conducted by Delft et al. (2017) on global greenhouse gases and transportation states shipping/logistics emissions are projected to increase by 50% - 250% in 2050 compared to 2012. The majority of greenhouse gas emissions from transportation activities are carbon dioxide (CO2) which is produced from the combustion of petroleum-based fuels in internal combustion engines. Greenhouse gases emission from Indian road transport activities reached 105 Mt of CO2 in 2000, which was 27 Mt of CO2 in 1980 and accounts for nearly 35% of the total consumption in India. (Singh, 2008).

The emissions generated from transportation result from the operation of various types of vehicles, including both passenger and commercial vehicles. These vehicles can be categorized based on their weight, such as heavy-duty, middle-duty, and light-duty vehicles, and their operations contribute significantly to transportation-related emissions. The number of vehicle miles traveled by light-duty motor vehicles increased by 30% from 1990 to 2020 because of population and economic growth (EPA, 2020). Transportation accounts for a full third of CO2 emissions in the United States, and that share is growing as others shrink in comparison, rising from 31 percent in 1990 to 33% today. (Ewing et al., 2007). Le Quéré et al. (2020) suggest that Covid-19 pandemic-related government policies, such as lockdowns that reduce transportation activities, have resulted in a 17% decline in global daily CO2 emissions in April 2020 compared to levels observed in 2019. David and Steven (2010) on the US road transport state that it is possible to reduce greenhouse gas emissions from transportation by up to 65% below current levels by 2050 through public policies, technological advancements, and awareness.

Sustainability goals are targets set by organizations, governments, and international bodies to promote environmentally and socially responsible practices. These goals aim to reduce negative environmental impacts, promote economic development and social well-being, and ensure the responsible use of natural resources.

2.1.1.2. United Nations Sustainable Development Goals (UN SDGs)

The most widely recognized sustainability goals are the United Nations' Sustainable Development Goals (SDGs), which were adopted in 2015 and consisted of 17 goals and 169 targets covering a wide range of economic, social, and environmental issues. (United Nations, 2018) SDGs related to environmental sustainability are

SDG Goal 6: Clean Water and Sanitation. The goal of this SDG is to ensure that everyone has access to clean and safe drinking water and adequate sanitation facilities. This goal aligns with sustainability principles as it aims to improve the overall health and well-being of individuals and communities while reducing the environmental impact of poor sanitation and water management practices.

SDG Goal 7: Affordable and Clean Energy - The objective of this goal is to make sure that everyone has access to energy that is affordable, dependable, sustainable, and modern. the 7th goal is related to the concept of sustainability, especially environmental sustainability, as it aims to foster economic growth and reduce poverty while also reducing the environmental impact of energy production and consumption.

SDG Goal 11: Sustainable Cities and Communities - The objective of this goal is to create cities and human settlements that are inclusive, safe, resilient, and sustainable. Sustainable Cities and Communities' goal is linked to the concept of sustainability as it aims to design urban spaces that are livable and sustainable and support the well-being of residents by promoting social, economic, and environmental sustainability, less traffic and noise, etc.

SDG Goal 12: Responsible Consumption and Production - The objective of the 12th goal is to establish sustainable patterns of consumption and production by encouraging the use of environmentally friendly technologies, products, and services that are less polluting, more energy efficient, and less wasteful. The Responsible Consumption and Production goal is related to sustainability as it aims to promote the efficient use of resources and reduce the environmental impact of consumption

and production. The goal also seeks to foster a culture of sustainable consumption and production by raising awareness and changing behavior and by encouraging the development of economic policies, institutions, and strategies that support sustainable consumption and production.

SDG Goal 13: Climate Action - This goal addresses the urgent need to combat climate change by taking immediate action to reduce greenhouse gas and adapt to the impacts of climate change. The goal helps the world to achieve sustainability goals because the 13th goal aims to decrease the emissions of greenhouse gases by implementing mitigation strategies and technologies. The objective is to promote the adoption of renewable energy sources such as wind, solar, hydro, geothermal, and bioenergy, along with encouraging energy efficiency in various sectors like buildings, transportation, and industry.

SDG Goal 14: Life Below Water: This goal aims to protect and sustainably use the oceans, seas, and marine resources for development. This goal aims to conserve and restore marine biodiversity and ecosystems and promote sustainable use of marine resources, including fisheries, aquaculture, and marine protected areas. It also aims to reduce marine pollution, including land-based activities, and prevent overfishing and illegal fishing.

SDG Goal 15: Life on Land - The objective of this goal is to protect, restore and promote sustainable use of terrestrial ecosystems, forests, wetlands, mountains, and other habitats and halt biodiversity loss. This goal is closely associated with sustainability as it aims to protect and conserve the biodiversity that supports human well-being and economic development while promoting sustainable use of natural resources.

2.1.1.3. EU Green Deal

The EU Green Deal is a package of measures proposed by the European Commission in 2019 aimed at making the European Union's economy climate-neutral by 2050 (European Commission, 2019). The European Green Deal aims to address the

significant dangers of climate change and environmental harm by transitioning the EU into a sustainable economy to achieve zero emissions by 2050. The EU Green Deal suggests a comprehensive methodology to accomplish this goal by reducing greenhouse gas emissions, increasing the share of renewable energy, and fostering a circular economy.

The EU Green Deal aims to reduce emissions from the transport sector and promote sustainable transportation modes. The EU Green Deal (2019) states that transport currently accounts for 25% of the EU's emissions and that a 90% reduction in transport emissions is needed by 2050 to achieve climate neutrality. The Green Deal motivates member countries to increase the use of low-emission vehicles and alternative fuels, improve the energy efficiency of vehicles, and develop sustainable and smart logistics systems. (European Commission, 2019) European Green Deal is expected to lead to essential changes in the logistics industry. Green supply chain management and logistics are likely to play a significant role in the planning and management of freight transportation across European borders. (Tas, 2022).

According to the European Regulators Group for Postal Services (2022), no member countries have established environmental sustainability objectives or assigned responsibilities related to environmental sustainability in the context of post & parcel activities within the logistics industry. The reason for the need for precise environmental sustainability policies among national postal organizations is attributed to the low priority given to sustainability issues during the time when postal legislation was being regulated in Europe.

2.1.1.4. Turkiye in Context of Environmental Sustainability

Turkiye has implemented several United Nations Sustainable Development Goals-related projects throughout the country. Turkiye established a National Sustainable Development Commission to achieve United Nations Sustainable Development Goals by coordinating all relevant organizations. Turkiye also focuses on the engagement of non-governmental stakeholders and aims to make SDG action a shared responsibility among all relevant stakeholders (UN DESA, 2016).

As an application of the SDG goals, the Ministry of Environment and Urbanization launched Turkiye's Zero Waste Project (TZWP) (MoEU, 2017). The project aims to achieve sustainable development by controlling and reducing waste for a cleaner and more habitable world. The TZWP focuses on increasing efficiency and raising sustainability awareness while decreasing environmental risks. The project is based on the principles of sustainable development and is in line with the United Nations Sustainable Development Goals, particularly Goal 12, which focuses on responsible consumption and production.

The Ministry of Transport and Infrastructure of Turkiye released its National Transport and Logistics Master Plan in 2022 and committed to acting within the framework of international agreements such as the EU White Paper, the Paris Climate Agreement, the European Green Agreement, and the European Climate Law.

In 2022, the Ministry of Transport and Infrastructure of Turkiye announced its National Transport and Logistics Master Plan, which commits to international agreements such as the EU White Paper, Paris Climate Agreement, European Green Deal, and European Climate Law regarding environmental sustainability. (Ministry of Transport and Infrastructure, 2022). The 2053 plan of Turkiye includes promoting and maintaining green transportation and logistics investments and applications by using renewable energy in the transportation and logistics sector.

2.2. Sustainability Transition

Sustainable transition theories refer to frameworks that describe moving towards a more sustainable society. These theories typically focus on the complex interactions between various social, economic, and technological systems and how they can be transformed over time. To understand the concept of sustainability transitions, it is first necessary to define the term. Markard et al. (2012, p.956) define concept as "sustainability transitions are long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption." The definition highlights

that sustainability transitions are long-term processes that involve transforming established socio-technical systems, such as economic and technological systems, towards more sustainable modes of production and consumption.

Geels (2004) defines socio-technical systems as systems that comprise elements such as technology, markets, supply and maintenance and repair networks, infrastructure, regulation, user practices, and cultural meaning. The socio-technical approach emphasizes that the interrelations between key actors are essential. Sustainability transitions must be an evolving process, and it may change over time as the framework of sustainability changes. The sustainability transition studies focus on understanding the complex interactions between different actors and the role of governance in shaping the transition process. (Markard et al., p.975) It is believed that an improvement in the logistics sector, which is one of the biggest causes of greenhouse gas emissions, will effectively achieve environmental sustainability goals. Incorporating electric commercial vehicles into transportation operations to achieve environmental sustainability goals is viewed as a facet of the broader "sustainability transition" process. The Technological Innovation System is the framework used to achieve this.

2.2.1. Technological Innovation System (TIS)

The innovation system approach is a comprehensive method that considers the complete process of technology, from its creation to its dissemination. It examines the interactions between institutions in the public and private sectors, forming a network that influences the dissemination of new technologies. (Freeman, 1987) Hanush and Pyka (2007) state innovation systems (IS) approach clearly defines all system components and considers the relationships & interactions between different members. Innovation systems can be categorized under four levels: National Innovation Systems (Lundvall, 1992), Regional Innovation Systems, Sectoral Innovation Systems (Malerba, 2022), and Technological Innovation Systems.

Carlsson and Stankiewicz (1991, p.93) define a technological system as “technological system is defined as a dynamic network of agents interacting in a

specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion, and utilization of technology." Nygaard and Hansen (2015) state that a technological innovation system can be described by three main components related to creating and spreading new technologies: actors, institutions, and networks. Actors comprise organizations dealing with education, research and development, industrial operations, and end-users. Institutions refer to laws and regulations that support technology and technology standards. Networks may be the connections between organizations in collaborative research and groups that support a particular cause.

2.3. Logistics

The word "logistics" is derived from the Greek word "logisticos," which means the science of accounting or the skill of calculation. Additionally, it is stated that the term logistics also means logical calculation, which is derived from the combination of the Latin words "Logic" (logic) and "Statics" (Koban and Keser, 2007, p. 35). Logistics, as defined by Christopher (2011, p.2), "is the process of strategically managing the procurement, movement, and storage of materials, parts and finished inventory (and the related information flows) through the organization and its marketing channels in such a way that current and future profitability are maximized through the cost-effective fulfillment of orders."

Logistics operations can take various forms, such as reverse logistics, supply chain management, maritime logistics, air freight, land, express, green, e-commerce, and city logistics (Tseng et al., 2005). Transportation and storage activities are major logistics components, with transportation costs generally being the most significant single component (Bureau of Transport Economics, 2001). Land logistics is essential in logistics activities, extending delivery services from airports and seaports. Land transportation activates cause problems like traffic jams, traffic crashes, and different type of pollution. (Tseng, Taylor & Yue, 2005).

2.3.1. Last-Mile Logistics

Road logistics refers to the planning, organizing, and managing the movement of goods and materials by road. (Demir, Bektaş, & Laporte, 2014). This includes the transportation of goods and materials by truck, trailer, and other road vehicles, as well as the management of the associated logistics activities such as loading and unloading, warehousing, distribution, and delivery. Demir et al. (2014) state that road freight transportation negatively impacts the environment and health.

As a part of road logistics, last-mile operations refer to the final leg of the delivery process, where goods are transported from a transportation hub to an end-consumer. The last step of delivering goods, the last-mile operation, is frequently acknowledged as one of the most difficult and costly aspects of logistics operations. Last mile delivery services account for 41% of overall supply chain costs. (Jacobs et al., 2019) Gevaers et al. (2014) state that business-to-customer last-mile logistics operations is currently considered one of the chain's costliest, least efficient, and most polluting stages. Despite the considerable effect on environmental sustainability, Olson et al. (2019) state that academic studies on sustainability and last-mile delivery primarily focus on economic sustainability. Research on environmental and social sustainability in last-mile logistics is less, and research opportunities exist for future studies.

2.3.1.1. Last-Mile Logistics Technologies in the Context of Environmental Sustainability

The future of last-mile delivery is heavily influenced by sustainability, as this stage of the delivery process significantly contributes to greenhouse gas emissions from transportation. Therefore, ensuring sustainable practices in last-mile delivery operations is crucial. According to Ignat and Chankov (2020), informing customers about the environmental and social effects impacts their preferred delivery choice. It encourages them to select a more sustainable option. The increasing importance of green logistics has also led to sustainability becoming increasingly crucial for last-mile logistics.

Peppel et al. (2022) state that one of the major factors shaping last-mile delivery is "decarbonization in last-mile delivery by investing in electric delivery fleets, cargo bikes or premium services. Considering the use of environment-friendly logistics practices and objectives for sustainability, technology is perceived as positively impacting reaching sustainability targets. Arena et al. (2009) state that technology can assist in promoting sustainability by maximizing the efficient usage of resources throughout the entire lifecycle of a product or service while maintaining the same level of quality.

Several logistics technologies can be used for last-mile delivery operations to decrease Greenhouse Gases (GHGs) and help environmental sustainability goals. Yilmaz et al. (2022) defined leading last-mile delivery technologies that can transform last-mile delivery for sustainable urban logistics as crowdsourced delivery, click-and-collect delivery, pick-up point, parcel locker, reception and delivery box, in-car delivery, cargo bike, drone delivery, autonomous ground vehicles. The Future of the Last mile Ecosystem (2020) report by the World Economic Forum investigated the environmental sustainability impact from the CO2 emission perspective of different last-mile delivery technologies like electric vehicles, delivery drones, and autonomous vehicles. The table below shows that using electric vehicles in last-mile delivery operations has the most significant positive environmental effect. Future of the Last mile Ecosystem (2020) states that using electric vehicles can help to decrease CO_2 emissions by 60% while decreasing delivery costs by 2%.

Table 1. Effect of different logistics technologies on sustainability

Last-mile technology / Model	**CO2 emissions**	**Delivery Costs**	**Traffic Congestion**
Electric Vehicles	- 60 %	- 2%	0%
Autonomous Vehicles	0%	-4%	-4%
Drone Delivery	-1%	-1%	0%

Source: Adapted from the Future of the Last-Mile Ecosystem (2020), The World Economic Forum.

Using logistics technologies like drones and autonomous vehicles in last-mile operations also can contribute to environmental sustainability. Chiang et al. (2019) highlight that under optimal conditions (optimized routes) unmanned aerial vehicles (UAV) would help logistics service providers to reduce greenhouse gases and decrease transportation-oriented costs. In the experiment with 200 customers, there is a sixteen percent decrease in total carbon emissions thanks to drone delivery. (Chiang et al., p.1170, 2019). Autonomous unmanned ground vehicles also have a positive environmental impact as they are emission-free. (*Technological disruption and innovation in last-mile delivery*, 2016). Sonnenberg et al. (2019) state that like drones and other novel last-mile delivery technologies, autonomous unmanned ground vehicles' contribution in the context of sustainability heavily depends on the nature of logistics operation like the number of stops, weight, and volume.

Electric commercial vehicles are considered a sustainable alternative to diesel vehicles for last-mile delivery operations to reduce the carbon footprint of logistics operations. Siragusa et al. (2020) showed that electric commercial vehicles could significantly reduce greenhouse gas emissions with a decrease of 17% for a daily mileage of 20 kilometers and up to 54% for a daily mileage of 120 kilometers. The emissions reduction increases with higher daily mileage. Iwan et al. (2022) state that the most important factor to consider when planning routes for electric freight vehicles is the number of deliveries per vehicle. The total environmental impact of battery electric vehicles (BEVs) is closely tied to the sources of electricity used to power them. Costa et al. (2021) state that if electricity to charge BEVs is generated from fossil fuels, implementing BEVs in last-mile delivery operations will not significantly impact the environment.

2.4. Electric Commercial Vehicles in Last-Mile Operations

It is possible to categorize electric vehicles for road transportation into two main groups: electric passenger vehicles and electric commercial vehicles. The International Energy Agency (2022) states that global sales of electric light commercial vehicles increased by 70% in 2021. Numerous studies have been conducted on using electric freight vehicles / electric commercial vehicles in last-

mile delivery operations. Mirhedayatian and Yan (2018) argue that the main challenges for electric commercial vehicles in real-life urban freight transport are their high acquisition cost, long recharging time, low capacity, and limited driving range. The authors propose that offering various incentives, such as purchase subsidies, zone fees, and vehicle tax exemptions, can increase the adoption of electric commercial vehicles in urban freight transport. Blanco (2019) argues that last-mile delivery fleets need incentives to switch to zero-emission vehicles and emphasizes the importance of pilot programs to understand the needs of last-mile delivery companies in the United States. Each country or region faces different challenges when transitioning to electric commercial vehicle use in post & parcel operations. Anosike et al. (2021) define the challenges facing United Kingdom courier companies in adopting electric vehicles in five barriers: Battery challenges, cost issues, general obstacles, operational issues, and infrastructure barriers.

As a pilot study, Bandeiraa et al. (2019) investigated the use of electric tricycles for last-mile postal delivery in Rio de Janeiro, Brazil. They revealed that the EV-oriented model resulted in a 27.9% reduction in total delivery cost per route and decreased atmospheric pollutants and greenhouse gas emissions. The researchers concluded that adopting electric tricycles for last-mile postal distribution in Rio de Janeiro would be economically, environmentally, and socially beneficial while maintaining the level of service. Other pilot studies to understand the nature of the adoption of electric vehicles in last-mile delivery operations are the FREVUE - Validating Freight Electric Vehicles in Urban Europe (Quak et al., 2015) and EUFAL - Electric Urban Freight and Logistics (Iwan et al., 2018) projects. FREVUE was conducted in eight European cities, including Amsterdam, Lisbon, London, Madrid, Milan, Oslo, Rotterdam, and Stockholm, over more than three years. The project involved the use of 127 electric commercial vehicles. Quak et al. (2015) conducted a SWOT analysis based on FREVUE - Cargohopper in Amsterdam to reveal strengths, weaknesses, threats, and opportunities for implementing EVs in last-mile freight operations.

Quak et al. (2015) conducted a SWOT analysis of using electric freight vehicles in urban freight operations. The study identified several strengths, such as low fuel

costs, good environmental performance, no noise pollution, and positive public acceptance, primarily if government support exists. The opportunities presented included higher ranges for newer vehicles, availability of public charging points, innovative leasing schemes for batteries and vehicles, and decreased battery prices. However, the study also identified several areas for improvement: high procurement costs, limited loading capacity, unreliable and expensive after-sales support, and grid issues with large fleets. Furthermore, the revenue generated from electric vehicle deliveries was not found to be better than that of traditional vehicles due to a limited number of customers willing to pay more. The study also highlighted some potential threats, including unclear regulations regarding certification, the increasing environmental performance of vehicles running on alternative fuels, low oil prices, and rising energy prices.

Imre et al. (2021) organized a workshop involving stakeholders such as local authorities, central government, vehicle manufacturers, fuel providers, shippers, carriers, consumers, and NGOs of Turkiye. Imre et al. (2021) argue that various barriers hinder using electric vehicles (EVs) in cargo operations. These include incompatible energy infrastructure systems, short driving ranges, and a need for charging stations. In addition, there is a lack of standardization for charging networks, and the high costs of batteries, procurement, and long payback periods for electric freight vehicles (EFVs) also pose a challenge. Furthermore, insufficient information or tools to calculate the total cost of ownership (TCO) for electric vehicles and the need for incentives to cover the cost difference between electric and diesel vehicles contribute to this problem. Economic fluctuations and insufficient government support are additional uncertainties that hinder the widespread use of EFVs in post & parcel operations. There is also a risk of foreign dependency in supporting industries and political difficulty enforcing non-monetary measures. To overcome these barriers, long-term framework conditions with steady policies are needed, along with cooperation among stakeholders for collaborative planning. Institutional resistance, a need for more information for decision-making, immature maintenance and repair service, and decreased vehicle capacities are other factors that impede the adoption of EVs in cargo operations. (Imre et al., 2021)

Özenir and Nakiboğlu (2020) assert that electric vehicles are perceived as the future mode of transportation for logistics operations. However, to gain acceptance in Turkiye, there is a need to improve charging infrastructure, battery technology, renewable energy production, and electricity grids. Imre et al. (2019) also state that Turkiye's effort on national automotive may affect the electric commercial vehicles niche. In a study conducted by Wesseling (2016), the national electric vehicle policies of 13 different countries, including Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, the UK, and the US, were analyzed and revealed that all policymakers justified their expenditures by emphasizing the environmental benefits of electric vehicle policies. Green et al. (2014) argue that policies should focus on post & parcel firms and carsharing firms as potential early adopters of electric commercial vehicles and try to eliminate efficiency and effectiveness barriers.

The core theory employed in this thesis is the Technological Innovation System (TIS), which examines the adoption of electric commercial vehicles to reduce greenhouse gas emissions. TIS was chosen due to its comprehensive and integrated approach to comprehending technology creation, dissemination, and utilization. Technological innovation systems approach an examination of the interactions between actors, institutions, and technological change, which are crucial for understanding how electric vehicle technologies can be adopted and integrated into existing systems to achieve the goal of reducing greenhouse gas emission.

There are academic studies that examine countries' sustainability policies, cargo policies, and electric vehicle policies. This thesis aims to identify the barriers to adopting electric freight vehicles in last-mile parcel delivery operations in Turkiye from Hekkert’s seven function perspectives to understand the relationship between dynamics to suggest a comprehensive and applicable policy set.

CHAPTER 3

THEORETICAL BACKGROUND AND METHODOLOGY

3.1. Theoretical Background

This chapter overviews the research question, related theoretical background, and methodology utilized in the thesis. The research question of the thesis is “What are the barriers in terms of Hekkert's seven functions to the implementation of electric vehicles for sustainable last-mile parcel delivery operations in Turkiye? “. The literature review section explores the concept of sustainability transition, technological innovation system approach and its related functions. These functions have been redesigned to fit the context of the thesis, and each function and its utilization in the research are discussed in detail. The methodology section details data generation, analysis, and interview process. Additional information is available regarding the interview questions, the connection between these questions, and individuals who participated in the interviews. Overall, this chapter provides a comprehensive understanding of the theoretical framework and research methods utilized in the study.

Technological innovation systems (TIS) center on the concept of transition inherent to innovation and technology. It is essential to recognize that technological innovation systems are not static but dynamic. Therefore, Bergek et al. (2005) and Hekkert et al. (2007) suggested a functional approach to capture the system's dynamics and provide measurable policy recommendations. Structural and static analysis of the innovation system needs to be more robust for performance measurement, as it needs to provide more information about root causes and dynamics. Suurs et al. (2009) state that a functional analysis in the context of a TIS involves tracing the evolution of the various activities within the system over time.

The functions of the technological innovation systems approach focus on the flow of information, resources, and knowledge within the system rather than on the system's current state or structure. Bergek et al. (2007) define a function used in technological innovation systems as "That directly influences the development, diffusion, and use of new technology and, thus, the performance of the innovation system."

The seven functions proposed by Hekkert (2007) have been used to analyze the technological innovation system in this study for inclusiveness and up-to-dateness. Suurs (2009, p.53) states that Hekkert's Seven Functions Model has been empirically validated through testing in many sustainability innovation and transition studies. Hekkert et al. (2007) proposed seven functions: Entrepreneurial activities, knowledge development, knowledge diffusion and networking, guidance of the search, market formation, resource mobilization, and creation of legitimacy.

Function 1: Entrepreneurial Activities

Schumpeter (1965) defines entrepreneurs as "individuals who exploit market opportunity through technical and organizational innovation." Entrepreneurs and entrepreneurial activities can lead to creating, testing, and commercializing sustainable new technologies. Entrepreneurial activities may detect or create a need in the market and conduct independent research and development activities to develop new technological products, models, or services. Hekkert et al. (2007) argue that entrepreneurs can also actively create new knowledge through risky experiments.

The presence of entrepreneurs can be seen as an early indicator of an innovation system. Entrepreneurial activity indicates a successful technological innovation system, and a functional design is characterized by an increase in the number of firms and entrepreneurial experiments (Hekkert et al., 2007). There are two ways in which entrepreneurial activities can increase: firstly, existing companies may broaden their services and venture into emerging technology fields, and secondly, new startups may be established. Hekkert and Suurs (2009) argue that incumbent firms are more successful than startups due to their existing infrastructure, know-

how, and resources. Indicators of entrepreneurial activities are the number of new startups, the difficulty of market entry barriers, the number and volume of interest from existing companies, and the number of experiments conducted.

The primary purpose of this thesis is to investigate the barriers to using electric commercial vehicles in post & parcel last-mile operations in Turkiye. In this context, the: Entrepreneurial Activities function is among the areas where data will be generated. The goals of F1 function-related research are to understand the electric commercial vehicle ecosystem in Turkiye, evaluate the adequacy of entrepreneurial activities, and identify the barriers to entrepreneurial activities. Within the scope of the research, entrepreneurial activities will be examined from the customer perspective (post & parcel firms) and the manufacturer perspective (electric commercial vehicle manufacturers: incumbent firms and startups).

Function 2: Knowledge Development

Knowledge development is a critical function for innovation activities. Knowledge development activities may occur from research & development or entrepreneurial activities. Hekkert et al. (2007) state that two main methods are essential for knowledge development as learning by searching and learning by doing. The assessment of the knowledge development function can involve examining indicators such as research and development investments and patents.

In this study, knowledge development activities have been investigated by considering the presence of different stakeholders. Activities of ecosystem actors such as universities, research centers, electric vehicle manufacturers, post & parcel companies, or civil organizations can contribute to knowledge development. The research aims to evaluate whether there are sufficient activities related to the topic in Turkiye, identify the barriers to developing knowledge, define the barriers in the existing knowledge development mechanisms, and propose policy recommendations for solutions.

Function 3: Knowledge Diffusion through Networks

In the context of Innovation Systems (IS), which focus on the relationships rather than the structure, it is crucial to check knowledge flows to determine innovation systems performance. Hekkert et al. (2007) argue that it is vital to have various activities that prevent asymmetric knowledge between academia, entrepreneurs, policymakers, and other stakeholders. Topic-related conferences, seminars, summits, digital information exchange platforms established to promote a specific technology, awards, hackathons, and competitions can also be used to evaluate knowledge development function.

Knowledge diffusion between the two main stakeholders, post & parcel companies and electric vehicle manufacturers, is critical for successful electric commercial vehicle adaptation by post & parcel firms. Also, the contributions of organizations like universities and research centers may improve knowledge diffusion activities. Activities such as fairs, conferences, seminars, etc., carried out in Turkiye on sustainability, electric vehicles, and post & parcels will be researched. The effectiveness of the events, barriers to knowledge diffusion, and good practice examples will be investigated.

Function 4: Guidance of the Search

Guidance of the search function is essential for directing the knowledge created by the public/market/others. Hekkert et al. (2007) suggest that guidance is necessary for the knowledge developed by entrepreneurs or other actors to have a specific impact. In other words, a particular direction or instruction is needed to ensure that the knowledge generated is used beneficially.

Guidance must be conveyed by the state or a technology authority and fed by the interactions and dynamics among the components of the innovation system. Successful experiments in entrepreneurial activities can bring out specific success stories, which can also be a factor guiding the searches. Academic studies can provide a deeper understanding of technology and its potential impacts on society

and the economy. Positive approaches in research may indicate a promising future for the technology, while negative approaches may indicate potential challenges or drawbacks that must be addressed. It is essential to have a clear, comprehensive, effective game plan to adapt to emerging technologies. To evaluate the guidance of the search function in this study, the existence and efficiency of goals at national or firm-level strategy documents related to electric vehicles, sustainability, and logistics, especially post & parcel last-mile operations, will be researched.

Function 5: Market Formation

Market formation refers to protecting emerging technologies against traditional methods or the disadvantages of being a new entrant. Creating protected areas (niches) for emerging technologies is crucial to building a sustainable innovation system. (Hekkert et al., 2007, p.424)

Various tools are available to regulators, primarily the state, to protect emerging technologies. If these tools perform well, emerging technologies can replace existing ones. This study will examine market formation activities for electric commercial vehicle manufacturers in Turkiye and post & parcel companies who are potential customers. The research will include topics such as incentives (electric commercial vehicle production, purchase of electric commercial vehicles, and electricity generation), limitations (GHG emission limit), and regulations (minimum electric vehicle obligation for post & parcel operations).

Function 6: Resource Mobilization

Resource mobilization means providing the necessary human and financial resources for new technology areas (Hekkert et al., 2007). Every technological innovation system has different needs in terms of resources. The perspective of sector actors regarding the availability of sufficient resources is an essential indicator of whether a technological innovation system is performing well. The required resources may belong to different categories. This study will examine the adaptation of electric vehicles to achieve sustainability goals in post & parcel last-mile delivery operations

in Turkiye. Financial resources, human resources, and physical infrastructure for electric commercial vehicles in Turkiye will be analyzed. Barriers to accessing resources will be identified, and solutions will be proposed.

Function 7: Legitimation

Creating legitimacy is integral to the survival of emerging technologies, as it enables the formation of coalitions or lobby groups that advocate for and support emerging technologies. Hekkert et al. (2007) state existence of lobby groups or non-governmental organizations can empower other functions like Market formation. Lobby groups can exert pressure on governments or ecosystems to create incentives, share the knowledge developed, and support the survival of emerging technology. This study will examine the presence and effectiveness of lobby groups operating at the intersection of electric vehicles, post & parcel, and sustainability in Turkiye. In addition, barriers to forming and using such coalitions will be investigated.

3.2. Methodology

3.2.1. Data Generation

Qualitative research methods were employed to generate data to answer the research question: "What are the barriers in terms of Hekkert's seven functions to the implementation of electric vehicles for sustainable last-mile parcel delivery operations in Turkiye?". The rationale for selecting qualitative research lies in the need to identify the dynamics, deep insights, and barriers among innovation system stakeholders to suggest a comprehensive policy set. Patton (2002) argues that using open-ended questions allows the researcher's perspective to merge with real life. The data collected isn't solely reliant on statistics or generated within the confines of a lab. Semi-structured interviews, employed as part of qualitative research methodology, provide profound and valuable insights at a personal level. The qualitative analysis of this data can unveil the profound emotions and thoughts of participants, ultimately leading to political actions that surpass a mere comprehension of the issue.

The study employed a dynamic approach to the Technological Innovation System (TIS), focusing on its dynamic functions rather than static actors. Hekkert's seven-function model highlights relationships between actors in a technological innovation system. Relying solely on quantitative methods may not provide sufficient and comprehensive insight into the dynamic relationship between actors. Qualitative data generation allows for a better understanding of the problems and needs of different stakeholders, including academia, incumbent automotive firms, electric commercial vehicle manufacturer startups, and lobby groups. A comprehensive understanding of Turkiye's electric commercial vehicle innovation system requires insight into sectoral problems, actors' relationships, and their perceptions and attitudes towards sustainability, electric vehicles, and competition. Therefore, this study adopted a qualitative method to generate data.

In summary, the literature review reveals that numerous studies have been conducted on sustainability, electric vehicles, policies, logistics, and other related areas. This study aims to identify barriers to using electric vehicles in last-mile operations regarding sustainability in Turkiye based on Hekkert's (2007) seven functions. These functions include Entrepreneurial Activities (F1), Knowledge Development and Diffusion (F2), Knowledge Diffusion through Network (F3), Guidance of Research (F4), Market Formation (F5), Mobilization of Resources (F6), and Creation of Legitimacy (F7). Furthermore, secondary data sources were searched for each function, and the data obtained from reliable sources was added to the discussion section as supplementary information. The following questions were prepared for semi-structured interviews to understand the relevant TIS. The interview questions, categories, and aim/related function of the question are listed below:

Table 2. Interview questions

CATEGORY	QUESTION	AIM /RELATED FUNCTION
Personal Information	Can you please introduce yourself?	To obtain categorizing and descriptive information about the interviewees,
	How many years have you been in this industry?	
	What is your current role in your organization?	
Organizational Information	Can you provide information about the positioning of your organization?	To position and categorize the organization
	What activities do you conduct as an organization?	
Organizational Information	How do you manage your daily logistics operations?	To understand the type and size of operations
Sustainability	What sustainable practices do you implement in your last-mile operations?	To understand their perspective on sustainability and logistics technologies
	How do you interpret the relationship between electric vehicles and sustainability?	
Electric Commercial Vehicles in Post & parcel Last-mile Operations	How do you think the barriers to implementing electric vehicles in the last-mile post & parcel delivery operations can be overcome?	To identify barriers to the use of electric vehicles in general
	What is your opinion on the commercial activities in the electric commercial vehicle sector in Turkiye?	F1
	What do you think about research and development activities conducted by universities or firms?	F1, F2, F3, F6
	How do you think research and development activities affect the ECV transformation in cargo operations?	F2, F4

Table 2. (continued)

How do you interpret events such as fairs, seminars, and conferences for sharing generated information?	F3, F2
How do you evaluate strategy documents or goals announced in the context of EV transformation in last-mile operations?	F5, F3
How do you interpret events such as fairs, seminars, and conferences for sharing generated information?	F2, F3
How do you evaluate strategy documents or goals announced at the international, national, or company level in the context of EV transformation in last-mile operations?	F4
How important are incentives/sanctions for you when producing/using a technology?	F1, F2, F5
Do you think that the necessary infrastructure exists in Turkiye to use electric vehicles? How do you perceive the current infrastructure situation?	F5, F6
How do you evaluate the impact of lobby groups in the technology transformations in the sector or technology vertical?	F7

Source: Author

3.2.2. Sampling Approach

Patton (2002) notes that participant selection is a crucial step in qualitative research, as the insights gained from the data primarily rely on the richness and depth of the information provided by the participants. When conducting qualitative analysis, purposeful sampling can be used to select interviewees, which emphasizes choosing individuals who are information-rich rather than selecting a statistically representative sample. Strauss and Corbin (1998, p. 201) define theoretical sampling,

which is a type of purposeful sampling as a means to “maximize opportunities to discover variations among concepts and to densify categories in terms of their properties and dimensions.” Kathy (2006) notes that theoretical sampling in qualitative research differs from sampling techniques utilized in traditional quantitative research designs. The primary objective of theoretical sampling is to generate data that will aid in clarifying the research categories. Theoretical sampling is concerned with conceptual and theoretical development, rather than representing a population or enhancing the statistical generalizability of the findings.

In this study, the theoretical sampling method was employed to select participants for the interviews. After positioning the seven functions suggested by Hekkert et al. (2007), relevant people in Turkiye were interviewed using a semi-structured approach to explore the scope of these functions. By combining Hekkert's seven areas with the research question, the organizational category/personal characteristics deemed important for conducting interviews were identified. The selection of interviewees was based on their experience and job titles. C-level executives and founding partners were chosen mainly because they possess a supra-departmental perspective, which is vital for making high-budget decisions, such as purchasing electric commercial vehicles. In general, C-level executives or co-founders were selected as interviewees as they have in-depth knowledge of various company processes.

As electric commercial vehicles are the subject of research on last-mile parcel delivery operations, eight out of thirteen interviews were conducted with representatives from post & parcel companies due to their potential or current use of such vehicles. The companies that were interviewed can be divided into three segments:

- Large international post & parcel companies operating across Turkiye (countrywide operation)
- Turkish post & parcel companies operating across Turkiye (countrywide operation)
- New-generation delivery startups (local operation)

The purpose of this categorization was to gather diverse perspectives on the topic. In addition to these interviews, the research also aimed to gather insights from other stakeholders in the technological innovation system. Thus, interviews were also conducted with traditional and new-generation commercial electric vehicle manufacturers, NGOs, and academics.

Table 3. List of interviewees

No. of Interview	**Organization**	**Segment**	**Title**
Interviewee 1 (i1)	Post & parcel Company	Countrywide Operation	Specialist
Interviewee 2 (i2)	Post & parcel Company	Countrywide Operation	C-Level Manager
Interviewee 3 (i3)	Post & parcel Company	Countrywide Operation	Operations Manager
Interviewee 4 (i4)	Post & parcel Company	Local Operation	Product Manager
Interviewee 5 (i5)	Post & parcel Company	Local Operation	Co-Founder & CEO
Interviewee 6 (i6)	Post & parcel Company	Local Operation	C-Level Manager
Interviewee 7 (i7)	Post & parcel Company	Local Operation	Co-Founder & CEO
Interviewee 8 (i8)	Post & parcel Company	Local Operation	Co-Founder & CEO
Interviewee 9 (i9)	Post & parcel Company	Local Operation	C-Level Manager
Interviewee 10 (i10)	University	NA	Academician
Interviewee 11 (i11)	Non-Governmental Agency	NA	General Secretary
Interviewee 12 (i12)	Electric Commercial Vehicle Manufacturer	NA	Specialist
Interviewee 13 (i13)	Electric Commercial Vehicle Manufacturer	NA	C-Level Manager

Source: Author

3.2.3. Interview Process

Within the scope of the research, thirteen semi-structured interviews were conducted. Pilot interviews were initially conducted with representatives of two companies whose technologies were complementary to electric commercial vehicle technology to test the accuracy and flow of the questions in the study and to improve them with revisions if necessary. Semi-structured pilot interviews were conducted remotely using Google Meet. The technical infrastructure was tested, and feedback was solicited regarding the interview questions as well as suggestions for improving the interview process.

As the second step, planning began for the actual interviews. Twenty potential interviewees contacts reached through email invitations, LinkedIn messages, and phone calls. Thirteen of the twenty potential interviewees, who lived in different cities, accepted the invitation and due to logistical challenges, the sessions were held remotely on the Google Meet platform. Before the meetings, the participants were informed about voluntary participation and use interview materials. During the interviews, notes were also taken and later converted into memos for analysis.

The duration of the interviews varied between 23 and 43 minutes. A few minutes of technical issues were experienced during one of the interviews, while the remaining interviews were conducted without any technical problems.

3.2.4. Data Analysis

Gale et al. (2013) suggest that researchers pre-select themes and codes based on previous literature, theories, or frameworks when using the deductive approach. In contrast, the inductive approach involves generating themes from the data through open coding and refining them. The raw data for this research generated from the semi-structured interviews formed the basis for data analysis, which followed a deductive approach. Azungah (2018, p.392) propose a six-stage process for data analysis using a deductive approach in qualitative research, including organizing

data, digesting data, defining clusters, collapsing overlapping categories into one category, integrating data, and cross-tabulation if needed.

This study employed a deductive approach to explore barriers to the implementation of electric vehicles for sustainable last-mile parcel delivery operations in Turkiye using Hekkert's seven functions. After transcribing and documenting the interviews, I analyzed the data by positioning Hekkert's seven functions: Entrepreneurial Activities (F1), Knowledge Development and Diffusion (F2), Knowledge Diffusion through Network (F3), Guidance of Research (F4), Market Formation (F5), Mobilization of Resources (F6), and Creation of Legitimacy (F7) as clusters/categories for coding. I utilized QDA Miner version 6.0 software for analysis, which was used to code the interviews. We conducted the analysis using the deductive approach, positioning the suggested functions from the theory as clusters.

CHAPTER 4

FINDINGS

Data was generated through semi-structured interviews as part of the research. As mentioned in the theoretical background, in semi-structured interviews, the researcher acted as an active instrument in the data generation process. The deductive approach was utilized in data analysis since the research question incorporated the functions proposed by Hekkert et al. (2007). The outputs of the interviews were analyzed using the QDA Miner software.

In the findings chapter, the primary focus was on the coded transcripts and notes taken during the data generation process. I validated the findings in the discussion section by combining various academic studies and personal observations. The findings section includes analyses of the seven functions suggested by Hekkert et al. (2007) to comprehend the dynamics within technological innovation systems. I utilized verbatim quotes to enhance the clarity and efficient transmission of the subject matter.

4.1. Entrepreneurial Activities (F1)

The current study examined the roles of two key stakeholders involved in entrepreneurial activities related to electric commercial vehicles: manufacturers and post & parcel companies. Specifically, electric commercial vehicle manufacturers were identified as entrepreneurs and service providers, while post & parcel companies were viewed as customers and users. Within the category of electric commercial vehicle manufacturers, two subgroups were identified: incumbent companies and startups. Incumbent firms referred to traditional automotive manufacturers transitioning to producing electric commercial vehicles, whereas

startups were defined as companies that exclusively develop electric commercial vehicles for use in post & parcel operations.

The results of the analysis of the semi-structured interviews indicated that both vehicle manufacturers and post & parcel companies find the level of entrepreneurial activities in Turkiye insufficient regarding the subject. Specifically, the analysis of the interviews conducted with electric commercial vehicle manufacturers in Turkiye revealed the qualitative and quantitative deficiency of entrepreneurial activities in the field of electric commercial vehicles in Turkiye. Respondents reported that electric commercial vehicle manufacturers are risk-averse and that the sector is characterized by a low level of maturity. Furthermore, the importance of having a clear vision was emphasized. From the perspective of an electric vehicle manufacturer i12:

> *When it comes to electric vehicles in the wider automotive industry in Turkiye, there are only a handful of companies that have a clear vision for it. It's a new field that's just starting to gain traction, and while many are trying to get involved, I think the sector as a whole is still in its infancy.*

I noticed that there exists a relatively low level of maturity among customers of electric commercial vehicles, as evidenced by their rudimentary and unsophisticated inquiries about electric vehicle technology. The interviews revealed that electric commercial vehicle manufacturers are starting to take sustainability concerns into account, along with commercial considerations while making investment decisions. It was also noted that incumbent vehicle manufacturers have the potential to use sustainability as a public relations tool to gain a competitive edge in the market. Environmental sustainability goals have an increasing impact on shaping the entrepreneurial activities of companies. Regarding this i12 stated:

> *Our company's sustainability goals have a significant impact our on decision-making processes. Therefore, when we evaluate a business decision, we also take into account whether it aligns with our sustainability goals and business objectives.*

My observations indicated that both customer and regulator demand for sustainability has the potential to shape the quantity and quality of entrepreneurial activities in the electric commercial vehicle ecosystem. Additionally, it was noted that such demands influence the agenda of electric vehicle manufacturers. The

importance of end customers' sustainability demands from post & parcel companies were identified as another motivation to increase the number of entrepreneurial activities in the field of electric commercial vehicle production for last-mile delivery operations in Turkiye. The presence of environmentally conscious end consumers is accelerating the transition toward electric vehicles in the delivery industry.

It was observed that post & parcel companies are increasingly preferring to collaborate with Turkish electric vehicle manufacturers rather than global ones. This preference increases demand for electric commercial vehicles in the Turkish market, as these companies prioritize supporting local manufacturers. Furthermore, it was noted that post & parcel companies exhibit a greater level of tolerance in their evaluation of Turkish companies. Thus, it is imperative for Turkiye to prioritize the development of domestic software and hardware for electric vehicles, given the rapid growth of the electric vehicle industry and the influx of foreign companies in the market. This measure will help Turkiye attain self-sufficiency in both aspects, ultimately preventing dependence on foreign technology.

It may be useful to evaluate entrepreneurial activities not only based on quantitative measures such as the number of companies or the number of risky experiments performed but also based on the qualitative feedback of target customers. As highlighted earlier, the perceived insufficiency of entrepreneurial activities related to the use of electric commercial vehicles in last-mile post & parcel operations is also attributed to the shortcomings and inadequacies in the business processes of electric vehicle manufacturers. Post & parcel firms expressed dissatisfaction with the performance of electric vehicle manufacturers in various areas such as technical performance of the vehicles, marketing activities, pilot area selection, vehicle design, and pricing models.

The post & parcel industry has a perception that electric vehicle manufacturers lack a good understanding of their specific needs and preferences, which often leads to the development of products and services that are not tailored to the industry's requirements. This mismatch in understanding is a source of concern for companies within the sector. As an example of the impact of choosing the wrong location during the pilot process i9 stated:

> *I can't name the specific companies, but around four or five different firms approached my previous employer to sell electric vehicles. Unfortunately, they chose the worst location in Istanbul for testing purposes, which resulted in the test being unsuccessful.*

In the above case, the post & parcel company collaborated with an electric commercial vehicle manufacturer to conduct a pilot project. However, the electric vehicle manufacturer solely provided the hardware (vehicle) and did not actively participate in the pilot process. However, the electric vehicle manufacturer's limited involvement in the pilot process resulted in its failure. Inefficient communication between the two parties and an incorrect initial decision about the pilot region selection were cited as reasons for the unsuccessful project. This highlights the importance of properly demonstrating the product's value to the customer through a well-planned pilot process, rather than solely manufacturing the vehicle. Post & parcel companies criticized electric vehicle manufacturers for their inadequate business capacities. It was highlighted that there is a lack of electric vehicle manufacturers who understand the target customer base well, work with them, and solve the real problems of post & parcel companies.

To assess the performance of entrepreneurial activities, the findings from post & parcel interviewees in Turkiye regarding the electric post & parcel delivery vehicles can be categorized into technical issues, financial perspectives, operational efficiency, and sales & marketing activities.

Barriers to the adoption of electric vehicles in the industry include the limited range of vehicles on a single charge, uphill performance, vehicle volume, charging duration, instability of range according to the user, safety, and speed. The perceived inadequacy of entrepreneurship activities in addressing these issues underscored the importance of resolving them. Many of the technical issues raised in interviews relate to the range and charging time of the vehicles. As an example, i8 stated:

> *Our biggest concern with electric commercial vehicles is the range. We typically travel around 150 kilometers per day, so if we had an electric vehicle with a range of 150 km or more, our problem would be solved. We could charge it overnight and have it ready for use the next morning. I mean, if you say it has a range of 150 km, it should really be 150 km - even if we have to drive uphill or if there's a 100-kilo man riding in it, you know what I mean?*

The range issue is the most common technical barrier encountered in using electric vehicles in cargo operations. There are two opposing views on the range issue. While some participants argue that there will be no range-related problems for last-mile delivery operations because cargo vehicles will distribute in a limited area in terms of mileage, the predominant view is that the current range of electric vehicles on the market is insufficient for delivering cargo. The fact that the range of electric commercial vehicles varies according to the driver also creates another concern. Factors, such as air conditioning, inclines, and load weight, reduce the range. The range variation, which causes electric commercial vehicles to be perceived as an unstable technology, is seen as a more significant problem as the company's geographical distribution area expands.

In addition, it was said that due to the limited range, electric vehicles can only be used by big cargo companies with high drop density in a narrow region. Moreover, the range is further impacted by the vehicle's speed, which raises concerns for delivery companies that prioritize fast and same-day deliveries. Such companies fear that using electric vehicles will result in even shorter ranges and potential loss of business volume.

Another critical factor affecting the adoption of electric vehicles is the charging duration of electric vehicles, which varies depending on the type of current used and the characteristics of the vehicle. In the context of electric commercial vehicles, it was observed that the charging time is less critical than in electric passenger cars. Whether or not the non-working hours are sufficient for charging electric vehicles in last-mile delivery operations was considered important. This is because electric commercial vehicles are mainly used during working hours, and they can potentially charge during the remaining time.

Moreover, from a financial perspective, stakeholders raised concerns over the high prices of electric vehicles. Participants focused on the purchase price rather than considering the total ownership cost when evaluating the cost of electric commercial vehicles. These vehicles are currently being purchased at prices two to three times higher than conventional cargo vehicles used in last-mile operations. i9 also

mentioned that they would experience a loss of business volume due to speed and performance and added:

> *Right now, an electric vehicle costs about 500,000 Turkish Lira. So, are you really going to buy a 500,000 TL electric vehicle and only deliver 100 packages a day? Or would you rather use a Doblo, which costs around 350,000 TL and can deliver at least 150 packages per day? From an economic standpoint, it just doesn't make sense to use an electric vehicle.*

After the analysis, I realized that the high purchase cost of electric vehicles and the concern that their low performance may result in a loss of business volume had put electric vehicles at a disadvantage compared to internal combustion engine vehicles. Furthermore, the low number of electric commercial vehicles, infrastructure issues, and the market's low maturity level also contribute to the increase in vehicle prices.

In addition to the high cost of purchasing vehicles, there are other barriers hindering the adoption of electric commercial vehicles by post & parcel companies. Uncertainty regarding the availability and cost of spare parts and battery replacements, the absence of a second-hand market for electric commercial vehicles, and the prevailing economic conditions of Turkiye are factors that negatively affect the adoption of electric vehicles by delivery companies. There may be a sunk cost effect in great post & parcel companies that have been operating for many years. It was stated that these companies, which have invested heavily in diesel and gasoline vehicles may face higher switching costs. I noted that observed that the application of conventional sales and marketing strategies in the automotive industry for electric vehicles proves ineffective due to the presence of high switching costs and the sunk cost effect.

My observations suggested that innovative sales and marketing strategies are required for the electric commercial vehicle sector. To this end, one proposal is for vehicle manufacturers to introduce alternative payment models, such as leasing, subscription plans, and rent-the-battery schemes, which could directly influence the effectiveness of entrepreneurial activities in promoting electric vehicle adoption.

Another significant organizational and operational barrier involves the fact that big post & parcel and logistics firms do not manage their operations with dedicated

fleets. Rather, these companies collaborate with local contractors, including agents, dealers, and partners, to manage their operations. These local companies are the actual owners of the vehicles used in the operation, resulting in a high rate of subcontractor vehicle usage in large fleets in Turkiye. Therefore, subcontractors are the customers, not the primary company for electric commercial vehicles. While it is unlikely that the employer company will be compelled to require its contractors to use electric vehicles shortly, incentives could be an effective means of promoting the adoption of electric commercial vehicles.

Cargo agents, who operate under the umbrella of parent companies, are characterized by their limited financial resources and higher sensitivity to costs. In addition, they have a strong inclination toward achieving a high return on investment. Similarly, drivers who use electric vehicles also face challenges. Given that the connection between the driver and the vehicle extends beyond working hours, many drivers rely on company vehicles to meet their personal transportation needs. As such, it was observed that the adoption of electric vehicles will require drivers to modify their habits to align with the new standards. On this part i7:

> *Drivers often use the same car they use for work to go on family picnics during their free time. If they were to go on a picnic to Beykoz and then think about going back home to Sultangazi, the vehicle's range would not be enough. You see, it's not practical for a driver to use an electric vehicle for both work and personal life because it can't handle cargo and leisure at the same time, and waiting for charging time is just not feasible.*

Entrepreneurs/companies need to strategically plan and manage the task of convincing drivers, as it was suggested that no innovation can succeed if the operation does not accept it. Electric vehicles designed for post & parcel operations aim to offer significant differences in terms of fuel type/engine type as well as the driver experience. In this respect, it aimed to provide drivers with an experience and benefit with new vehicles. It was also mentioned that advanced driver experience can lead to increased adoption of electric commercial vehicles.

Within the context of entrepreneurship activities, findings were presented from the perspectives of electric commercial vehicle manufacturers and users in Turkiye. Electric commercial vehicle manufacturers drew attention to the insufficient quantity

and quality of entrepreneurship experiments in the country, which they associated with a lack of financial and human resources for research and development. They also highlighted the low maturity level of the industry, the desire to work with Turkish firms, and the impact of sustainability on decision-making. On the other hand, post & parcel companies, who are users of electric commercial vehicles, do not consider electric vehicle manufacturers' sales and marketing processes to be sufficient. The study identified a range of barriers, including technical factors, such as range, charging time, hill performance, and carrying capacity, as well as business-related issues such as high vehicle costs, reduced business volume, the need for changes in driver habits, and working with subcontractors.

4.2. Knowledge Development (F2)

In this section, we will investigate activities related to knowledge growth and discuss the discoveries regarding the challenges that impede the adoption of electric vehicles in last-mile delivery operations for sustainable post & parcel services. The first research finding was that sector stakeholders consider universities as the primary responsible and authorized party for research and development. Additionally, the importance of conducting research and development activities to overcome technical problems and increase electric commercial vehicle adoption in post & parcel last-mile delivery operations were emphasized.

I observed that participants identified universities as essential stakeholders in this process and underscored that universities can act as a catalyst for transformation. The participants suggested that universities hold responsibility and authority in research and development. Universities are expected to engage in research and development activities due to their competence, trustworthiness, impartiality, and possession of necessary physical and human resources infrastructure. Another reason why the sector views universities as critical was that the outputs of research and development activities in universities set the standards for the sector.

It was mentioned that universities are responsible for defining base standards for regulations and acquiring essential knowledge through academic studies.

Furthermore, inadequate quantity and quality of research and development activities on electric commercial vehicles conducted by universities or research centers in Turkiye was emphasized. The stakeholders recommended that increasing incentive and support mechanisms, which will be examined in subsequent sections, can assist in enhancing knowledge development activities in universities. i12 stated:

> *It's essential to support university startups and research centers. Large and established companies responsible for significant operations lack the necessary financial resources and time to conduct extensive research and development. On the other hand, universities, whose primary focus is research and development, are better equipped to handle these activities. By strengthening their capabilities, the quality of their research can be improved.*

Research and development activities conducted by universities have an impact on the adoption of electric vehicles by post & parcel companies. It was asserted that technical concerns related to performance by post & parcel companies can be resolved by analyzing an impartial academic study, rather than relying on a case study from an electric vehicle manufacturer. Knowledge development activities at universities also affect electric vehicle manufacturers. Electric vehicle manufacturers can benefit from research and development activities conducted by universities or research centers on technical production standards, battery technologies, charging technologies, and fuel technologies, which can have performance-enhancing and cost-reducing effects. Moreover, the lack of academic studies on the adoption of electric vehicles could have negative implications for the conversion of Turkiye's electric commercial vehicle sector. The interviewees highlighted that universities in Europe conduct not only technical academic studies but also a significant number of social science studies on the adoption of electric commercial vehicles. However, they pointed out that Turkiye faces a problem in this area.

It was generated that companies expect universities and research centers to develop cost-effective new technologies, raise public awareness, and present the contribution of electric vehicles to environmental sustainability in an impartial manner through their research and development activities. Additionally, emphasis has been placed on the critical role of the university-industry collaboration model in conducting research and development activities. Some universities in Turkiye have a more favorable

position to conduct knowledge development within the university-industry collaboration due to their location or organizational structure such as:

> *Universities that maintain close relationships with the industry and are in constant contact with the sector are better positioned to engage in research and development activities. For instance, universities located in regions where automotive production is a major industry can conduct more effective studies because they have frequent interactions with the automotive industry.*

Both electric commercial vehicle manufacturers and post & parcel companies can also engage in knowledge development activities, yet the findings indicated that such activities are considered insufficient. However, it was noted that startups and traditional automotive manufacturers in Turkiye are making notable progress in the development of electric commercial vehicles. Regarding knowledge development activities carried out by firms in Turkiye, in the previous section, we noted that the majority of the companies we interviewed identified universities as the primary responsible party for research and development and knowledge development activities. Nevertheless, it was also emphasized that large post & parcel companies must conduct their own research and development activities. Investing in research and development can help these companies find solutions to their needs and even create a separate business based on research and development efforts. While resource and time constraints are mentioned as obstacles to companies carrying out research and development activities in-house, it was argued that the environmental sustainability contribution of electric vehicles can eliminate financial resource constraints.

4.3. Knowledge Diffusion Through Networks (F3)

Interviewees attributed the insufficient adoption of electric commercial vehicles in Turkiye not only to low level of research and development activities or poor technical performance of the vehicles but also to barriers in knowledge sharing, marketing, and sales processes. This section identifies the barriers to knowledge diffusion. The focus is on the barriers and the impacts of knowledge diffusion activities, rather than the number of activities conducted.

The interviewees identified trade shows, seminars, workshops, and industry-specific events as the most effective channels for knowledge diffusion. These events are perceived as indicative of industry maturity and offer networking opportunities, direct relationships, exposure to the latest technologies, updates, and sales opportunities. Inviting industry experts to give seminars at industry-specific trade shows is considered a particularly effective agenda. Furthermore, it was stated that events can elevate the knowledge level of participants about industry applications. it was also noted that in areas where emerging technology areas are surrounded by uncertainties, fairs can serve as a tool to demonstrate their potential. i1 said:

> *A few months ago, I attended a logistics technology event where experts from various industries shared their knowledge. It was an eye-opening experience for me, and I realized that many things that I thought were impossible could be achieved. I have been working in the industry for about two years, and at times I doubted the feasibility of some projects. However, after attending the event, I witnessed that these projects were already being accomplished. The event gave me the confidence to adopt new technologies in our post & parcel operations.*

Thanks to previous research, the significance of involving multiple stakeholders in organized events was revealed. According to the interviewees, it is recommended that electric vehicle manufacturers participate in postal and parcel fairs, where postal and parcel companies usually attend, instead of electric vehicle fairs, to achieve more effective outcomes. Moreover, to enhance knowledge diffusion and encourage the adoption of electric vehicles, it was suggested to provide special discounts and incentives for events and to organize fairs in smaller cities.

Another obstacle to knowledge diffusion activities is related to the attendee list. It was pointed out that events that only involve top-level executives or C-level managers, without including drivers, may not be efficient. Regarding the importance of involving implementers/drivers in all processes i8 stated:

> *I am a boss, yes. I attended the fair, but did my driver attend it? He will be the one who will be directly affected by the electric vehicle, not me as the boss. Therefore, instead of seminars, it is necessary to join platforms where drivers gather. Electric vehicle manufacturers should be a part of WhatsApp, Facebook, and Telegram groups for drivers and share information there.*

Another output of the data generation process is the importance of involving implementers, such as drivers, in all processes. There is a shortage of experienced drivers in logistics industry. In addition, conservative attitudes towards sharing information among firms were identified as another issue. Due to intense competition and cultural practices, companies in Turkiye are hesitant to share their data with others. Furthermore, the lack of trust in the global patent system could be another factor hindering information diffusion.

4.4. Guidance of Research (F4)

This section examines the impact of strategy documents, policy papers, and other mechanisms that affect companies' decision-making processes. Research on the adoption of electric commercial vehicles in post & parcel last-mile operations is conducted at the intersection of three major ecosystems: sustainability, logistics, and electric vehicles. These ecosystems interact in various ways depending on different contexts. In some cases, sustainability concerns facilitate the transition to electric vehicles, while in others, resistance from drivers to electric commercial vehicles leads to increased carbon emissions.

The research emphasizes the importance of having a clear strategy and vision. It was highlighted that without a specific goal or standard, stakeholders may head in different directions, causing chaos. To avoid this, it is suggested that the government should play an active role by setting targets, incentives, and restrictions. Collaborating with stakeholders to establish goals is the first step in initiating the transition to electric vehicles in cargo operations. Policies and strategies that exclude stakeholders during the development phase are unlikely to be feasible for implementation. In regard to developing policies on electric vehicle usage in post & parcel last-mile delivery operations in Turkiye with stakeholders. On that i11 stated:

> *All stakeholders need to be brought together, but it's not an easy task. If we don't do this, the policies and documents that we produce may not be practical in the market. For example, if we prepare a strategy, we need to make sure that academia, manufacturers, and distributors are all on board. These are collaborative efforts that need to be carried out jointly."*

According to research in Turkiye, it was emphasized that the government needs to establish a clear target for conversion to electric vehicles. Transforming infrastructure and financial concerns is only possible through a planned transition process. Achieving transformation goals will take many years, and constant communication among all stakeholders will increase the likelihood of success. Limitations, sanctions, and incentive motivations should be included when setting these targets under state coordination. Presenting targets or goals as mere intentions will be ineffective. After setting the goals, monitoring progress, providing encouragement, and imposing prohibitions will be effective.

The presence of sustainability targets is crucial to support the transition to electric vehicles in cargo operations. Recent interviews revealed that sustainability goals are becoming more important than operational concerns and that electric commercial vehicles are being preferred even if they are not feasible. Sustainable development goals can be established at the international, national, or corporate level. It was noted that the transition towards eco-friendly engines in the automotive industry became possible due to the Paris Climate Agreement and that the European Union's Green Deal could have similar transformative effects.

Furthermore, it was suggested that these goals can be established not only at the international or national level but also at the corporate level. The research indicates that targets set by a firm's headquarters also play a crucial role in its local operations. It was noted that firms conduct internal audits toward their goals using specific Key Performance Indicators (KPIs). A similar approach could be effective regarding electric vehicles and sustainability. Major players in the post & parcel sector set ambitious targets that can reshape the technology. The sustainability goals of large post & parcel players can drive transformation in the automotive sector, as well as in government and international policies. i2 stated:

> *We have set a zero-emission goal for our operations, which might sound amusing, but it could encourage vehicle manufacturers to develop carbon-neutral vehicles within the next decade. Although cost is an important consideration, I understand that electric vehicles will be pricier than gasoline-powered vehicles. However, for the sake of sustainability, we find it acceptable to pay more for electric vehicles in the short term.*

In terms of monitoring the established sustainability goals, it was emphasized that, employing specialized personnel to track progress and making it mandatory for companies above a certain size to employ a sustainability expert would be beneficial, in addition to the incentive-penalty mechanism.

4.5. Market Formation (F5)

In the analysis of the market formation function, it was found that the outputs can be grouped under two primary categories: incentives and limitations/regulations. In the previous chapter, we highlighted that cost concerns pose significant obstacles to the adoption of electric vehicles in Turkiye's last-mile operations of post & parcel companies. Companies expressed that incentives are crucial to encouraging the use of electric vehicles in their last-mile operation fleet, particularly in the context of financial concerns. The primary expected benefit of incentives for companies is related to the purchase of vehicles.

To eliminate high-cost barriers, zeroing or reducing the Value Added Tax (VAT) and Special Consumption Tax (SCT) rates in purchasing electric vehicles could be an effective strategy. Facilitating the adoption of electric vehicles can be achieved by offering incentives that reduce vehicle taxes during the purchasing process. Companies also expressed the need for government incentives even after purchasing electric vehicles, such as insurance discounts for personnel and charging incentives. Since there are differences in the unit electricity price between charging with external charging stations and charging at home, electric commercial vehicle charging incentives are required to reduce the overall ownership cost. i5 stated:

> *Having the government's support is crucial for the transition to electric vehicles. One way the government can facilitate this change is by offering tax incentives such as discounts on Special Consumption Tax (SCT) or Value Added Tax (VAT) for electric vehicle purchases. For instance, the government could offer a 1% VAT discount to those who use electric vehicles as an incentive.*

The demand for incentives was not limited to the purchase and maintenance of electric commercial vehicles. Requests were raised for incentives for the production of electricity to be used in electric vehicle charging. In order to achieve sustainability

goals and reduce harmful gas emissions, the electricity consumed by electric vehicles must be generated using environmentally friendly methods. The source of electricity production becomes important when the life cycle assessment of electric vehicles is conducted from an environmental sustainability perspective. Therefore, companies that want to produce electricity for use in vehicles require support.

Including sustainability criteria in the incentive conditions could encourage the adoption of electric vehicles. If sustainability is given a high weight in the incentives provided to electric commercial vehicle manufacturers or post & parcel companies in Turkiye, an environmentally friendly transformation can begin in their operations.

Data analysis also revealed that using electric vehicles in the operations of public institutions, ministries, and municipalities can have a significant positive impact. The government can support the electric commercial vehicle ecosystem by being the first users of the technology. However, cost issues have emerged as a barrier to public usage.

> *For the government, it's essential to lead by example and support the industry by being a customer themselves. By using electric vehicles, the government can help reduce market insecurity and provide a sense of reassurance to potential buyers.*

Regulations imposed by the European Union on carbon emissions, like the Green Deal, could be effective. In order to support the conversion of cargo companies to electric vehicles, it was recommended to implement a "harmful gas emission limit" for each company and halt the activities of firms that exceed the emission limit. Another way to protect the niche could be to impose restrictions on the use of existing technologies that are in competition and disrupted. This approach could create a space for emerging technologies to flourish. Taking actions that disadvantage existing technology could have a positive impact on emerging technologies. When combined with incentives for electric vehicles, this anti-incentive mechanism could accelerate the transformation in the sector even further.

4.6. Mobilization of Resources (F6)

The survival of emerging technologies becomes challenging when there is a lack of sufficient resources. Sometimes, the lack of necessary resources or misallocation of resources causes failure. This section includes the opinions of key stakeholders regarding the availability of resources in the use of electric vehicles in last-mile delivery operations of Turkish post & parcel. The barriers that stakeholders see in terms of resources are mentioned.

The necessary resources for using electric vehicles in cargo operations in Turkiye were expressed in four main categories: financial resources, charging station and electrical infrastructure, maintenance and repair network, and human resources. The charging station and maintenance and repair infrastructure can also be evaluated as a single category as physical infrastructure, yet they are given as two separate categories to demonstrate details.

The first category is financial resources. The high unit cost of vehicles and performance inadequacies make electric vehicle use economically unsustainable for postal and parcel companies. In terms of access to financing, the concept of electric vehicles and environmental sustainability is seen as key to accessing financing. Therefore, there is no barrier regarding the availability of financial resources in Turkiye. Although the transition to electric commercial vehicles may not seem like it could be more economically efficient, it was stated that sufficient financial resources exist in Turkiye. The growth of newly established startups can be facilitated by the positive impact of electric vehicles and sustainability concepts, particularly in their investor relations. Easy access to financial resources for an electric commercial vehicle manufacturer or a newly established last-mile delivery company can strengthen the niche.

Additionally, it is widely recognized that banks operating in Turkiye have established special credit packages for individual electric passenger car purchases, installation of electric vehicle charging stations, and initiatives aimed at developing electric vehicle technology.

The preference for non-electric vehicles in post & parcel last-mile delivery operations in Turkiye is largely attributed to the issues related to charging infrastructure. The primary barrier to charging electric commercial vehicles is the shortage of charging stations. This issue was emphasized by stakeholders who have highlighted the lack of electric vehicle charging stations in small cities across the country. Interviews with key stakeholders also revealed that there are insufficient companies in Turkiye that produce or install charging stations. However, developments in the electric passenger vehicle ecosystem have had a positive impact on charging infrastructure. The impact of Turkish Automobile Joint Venture Group (TOGG) on the commercial and passenger vehicle ecosystem in Turkiye can be exemplified by i2's statement:

> *We expect a breakthrough with the TOGG. In fact, we're planning on converting a large portion of our fleet to electric vehicles, and we're optimistic that the TOGG project will have a positive impact. It's fantastic that Turkiye's first passenger car production will be electric.*

TOGG plays an important role in various aspects of the electric vehicle industry, including assessing the current state of the sector, facilitating the provision of necessary resources (financial, human, and infrastructure), promoting market maturity, and increasing awareness about electric vehicles.

An alternative perspective on the charging issue was that post & parcel operations typically occur during business hours; thus, these vehicles can be charged at the cargo depot outside of these hours. Unlike passenger vehicles, electric commercial vehicles have a clear daily range requirement, making them more suitable for cargo operations with predictable range needs. Conversely, some argued that all the required infrastructure for electric commercial vehicles is already available in Turkiye, and no further development is necessary. It was claimed that electric vehicles are highly compatible with post & parcel operations concerning charging. With adequate planning in last-mile delivery operations, there should be no impediments to using electric vehicles. About that i10 stated "*It may sound surprising, but there's no requirement for any extra physical infrastructure to operate electric commercial vehicles. We don't have to invest in any expensive infrastructure, we just need to carefully plan our usage habits.*"

Another perspective on charging was to utilize the physical environment and infrastructure of post & parcel companies to charge vehicles. These companies operate through branches located throughout the country or in local areas. However, some concerns were expressed about their ability to charge vehicles using their own physical infrastructure, such as offices of cargo company branches that may not be large enough to charge a vehicle. Furthermore, it was noted that the electric power demand for electric commercial vehicles is higher compared to electric passenger vehicles, which could pose additional challenges.

Another finding from the semi-structured interviews regarding resources and infrastructure was the maintenance and repair of infrastructure barriers. Electric vehicles have a different motor mechanism than internal combustion engine vehicles, which creates uncertainty about maintenance and repair needs that may arise during use. Post & parcel companies nationwide currently work with traditional automotive repair shops and anticipate an increase in service costs if they switch to electric vehicles. Authorized maintenance and repair centers will be needed for electric commercial vehicles, which are more expensive than traditional counterparts. Additionally, uncertainties about the availability and cost of spare parts create additional barriers to the adoption of electric commercial vehicles in the post & parcel industry. On maintenance and repair i4 stated:

> *Let's say you are a national post & parcel company that has transitioned to electric commercial vehicles. In this case, it's essential to provide top-notch maintenance and repair support, as well as collaborate with reliable tow truck companies. Imagine if your vehicle breaks down, runs out of battery, and is stranded in the mountains. You need to have a plan in place to resolve this situation quickly and efficiently.*

It was highlighted that the inadequate maintenance and repair infrastructure can also result in a loss of business volume. In particular, if an electric vehicle located in a small city of Turkiye requires repair in another city, this situation could lead to significant profit loss for post & parcel companies.

Another aspect to consider with regards to maintenance and repair of electric vehicles is the use of new-generation technologies that enable the detection of malfunctions and maintenance needs in advance. One perspective regarding repairs

was that since electric vehicles use simple electric motors, they can be easily repaired and any non-electric vehicle technician can do so with ease. On the other hand, another viewpoint from i10 suggested that certified technicians must perform maintenance and repair work on electric commercial vehicles.

> *Electric vehicles have a high-voltage section that is not present in traditional vehicles, which makes it difficult to repair for everyone. If someone touches it, it could be fatal. That's why our workforce is not yet prepared for electric vehicles when it comes to repair and maintenance.*

The statement highlights the issues related to the maintenance and repair of electric commercial vehicles, including absence of qualified technical personnel, inadequate knowledge of aftermarket repair services regarding electric vehicles, and the high costs associated with professional maintenance services.

The last resource examined in the context of resource mobilization is human resources. When investigating the use of electric vehicles for sustainable post & parcel last-mile operations in Turkiye, it was found that the topic involves many different people from various functions, such as drivers, fleet managers, sustainability managers, maintenance and repair technicians, academics, vehicle manufacturer engineers, and customers. Regarding the drivers who will use the vehicles, it was stated that they can use electric vehicles without requiring additional licenses or training. After a short training period, drivers can easily use these vehicles. In Turkiye, there is a good motivation for electric vehicles and environmental sustainability.

4.7. Creation of Legitimacy (F7)

Emerging technologies have the potential to disrupt existing technologies. As noted in the F5: Market Formation section, certain measures can be taken to protect the niche. Tax incentives and financial support may not be sufficient to achieve success. There is a need for groups to defend developing technology and engage in lobbying activities. Individual efforts may be insufficient to sustain the emerging technology. The activities of coalitions to create legitimacy can have a positive effect on other functions.

Interviewees frequently associated post & parcel last-mile delivery operations and electric commercial vehicles with TOGG. Some of the post & parcel and electric commercial vehicle manufacturers interviewed pointed out that TOGG produces vehicles for the passenger vehicle sector, which differs from electric commercial vehicles. This statement suggests that Turkiye has developed its own electric passenger vehicle, which is produced locally and is expected to accelerate the shift to electric transportation in the delivery industry. i1 stated:

> *We are all eagerly waiting for the release of TOGG for electric vehicles to become more widespread in Turkiye. In my view, we need to wait for TOGG to be launched before we can increase sales, establish infrastructure, and for other vehicle manufacturers to start producing electric vehicles. Post & parcel companies are currently hesitant to choose electric vehicles because the electric vehicle ecosystem will not be fully established until after TOGG's launch.*

Formal or informal groups can engage in lobbying activities mentioned above. In Turkiye, various civil society organizations operate in the field of electric vehicles, including automotive manufacturers, post & parcel associations, and sustainability groups. These civil society organizations were established to provide solutions to sectoral problems and they are critical in Turkiye's electric vehicle conversion process in the last-mile delivery sector. It was noted that they can have a positive impact on the process.

It was suggested that government relations will be the first contribution of legitimacy activities, which bring together stakeholders in the technological innovation system. Through lobby groups, companies can come together and contribute particularly to F5 Market formation activities. Key concepts in lobbying are objectivity, competition in collaboration, and a results-oriented approach. All stakeholders should be invited to participate in lobby groups to increase their power and create legitimacy.

Moreover, lobby groups can also play a crucial role in promoting the adoption of electric vehicles in the Turkish post & parcel sector. Coalitions of industry representatives can also facilitate benchmarking. In coalitions bringing competing firms within the same industry together, the importance of "coopetition" is emphasized. When other firms see one company investing in electric commercial

vehicles, their likelihood of making the same investment increases. Therefore, activities carried out under the function of F7 Creation of Legitimacy can also support F3: knowledge diffusion activities. Moreover, the participation of industry stakeholders with a collaborative perspective can actively shape expectations (F4: Guidance of search) for emerging technologies.

The research findings indicate that coalitions are responsible for identifying sectoral shortcomings and areas. Within the scope of the study, the lack of qualified human resources and certification processes in the field of electric vehicles in Turkiye was identified as a particular concern. To address this issue, practical training programs should be implemented in addition to university education. Related the topic I4 stated:

> *If we could establish an association focused on training technicians for electric vehicles and organizing training programs for technical personnel, it would be a great initiative. It would also be beneficial if they could organize more awareness-raising activities. However, in Turkiye, we mostly see lobby groups that exist only for the sake of PR and rarely do more than make statements at events.*

It was suggested that lobby groups should organize various activities, such as education and events to foster the development of the ecosystem and create legitimacy. It was also emphasized that establishing lobby groups or NGOs exclusively for public relations can be detrimental to the transformation process.

CHAPTER 5

DISCUSSION

This chapter addresses the review of the findings, feedback from various academic studies on the same topic, and the researcher's perspective by drawing upon existing literature. The chapter begins by discussing Hekkert's seven functions which constitute the backbone of the research. Each function's findings are presented and scrutinized based on feedback from other academic studies on the subject. Finally, the chapter identifies the limitations within the scope of the study.

5.1. Entrepreneurial Activities (F1)

This section examines entrepreneurship activities as one of the functions of a technological innovation system, which are critical for its healthy functioning. Entrepreneurs who develop sustainable, repeatable, and scalable business models to address various needs play a pivotal role in creating an ecosystem. In uncertain environments, they use their limited resources to conduct experiments that enhance knowledge and experience in the relevant field. The entrepreneurship activities of firms serve as a research and development function. These activities are not limited to newly established startup firms but are also undertaken by incumbent firms when they venture into new areas and modify their business models. Suurs and Hekkert (2007) assert that incumbent firms are more successful than startups, which may be attributed to their strong know-how, financial resources, or networks.

The findings related to entrepreneurial activities are presented in the findings section. The first finding indicates that incumbent automotive companies, startups, or even post & parcel firms engage in entrepreneurial activities related to electric commercial vehicles in Turkiye. For example, a Turkish logistics company called Netlog, has

developed electric commercial vehicles for its own last-mile delivery operations. After a successful pilot project in their operation, the company introduced vehicles as a new business model. (musoshi.com, 2023)

However, like any entrepreneurial activity, achieving a product-market fit for use of electric freight vehicles in post & parcel last-mile delivery operations is essential. One obstacle that has emerged is the lack of knowledge about the post & parcel sector among manufacturers of electric commercial vehicles in Turkiye. Based on the analysis, increasing the use of electric vehicles in cargo operations depends on manufacturing electric commercial vehicles that can be used efficiently in last-mile delivery operations and making them sustainable.

According to a report by the International Energy Agency (IEA, 2022), sales of electric light commercial vehicles (LCVs) saw a significant increase of more than 70% worldwide in 2021. Even in developed electric vehicle (EV) markets, the market share of electric LCVs barely exceeds 12%. Electrifying LCVs makes more economic sense than doing so for passenger cars, especially for urban last-mile delivery. This is because LCV fleets typically follow predictable routes and can be charged at commercial depots.

The Turkish post & parcel sector aims to support the manufacturing of electric commercial vehicles by Turkish companies. The demand from post & parcel companies for solutions developed by Turkish companies within Turkiye leads to an increase in demand in the market, resulting in cheaper lead generation, pilot, and production processes for Turkish vehicle manufacturers. However, the number of experiments conducted by incumbent firms or startups regarding the use of electric commercial vehicles in post & parcel last-mile operations is considered insufficient. The perceived lack of entrepreneurial activities in Turkiye concerning the use of electric commercial vehicles in post & parcel last-mile operations may be due to either the low quantity of entrepreneurial activities or the low success rate of the activities being conducted.

In Turkiye, it is difficult to obtain quantitative metrics such as the number of experiments and firms related to electric commercial vehicles. Perception of post & parcel companies and electric vehicle manufacturers towards entrepreneurial activities in Turkiye have been identified through interviews. From the manufacturers' perspective, the reason why sufficient entrepreneurial activity cannot be conducted is due to the high level of research and development activities required for the production of electric commercial vehicles. Incumbent automotive companies have expressed that they do not have sufficient budgets for research and development. The variety of electric commercial vehicles in the market in Turkiye is limited and vehicle costs are high. On the other hand, electric vehicle startups can easily access financial resources through their innovative business models. Startups believe that electric commercial vehicle customers in Turkiye have a low level of maturity and until the market reaches maturity, startups will go bankrupt.

Sustainability concerns of the customers served by post & parcel companies have prompted these firms to search for more environmentally friendly delivery models. This can be considered as one of the factors that could accelerate the transformation in Turkiye. According to Ignat and Chankov's research (2021), customers are willing to endure longer wait times, pay extra fees, or select a less convenient delivery location if it leads to a more sustainable and socially responsible delivery option. In other words, customers prioritize sustainability and social responsibility when it comes to their last-mile delivery preferences.

The comments of post & parcel companies on entrepreneurial activities in Turkiye regarding the use of electric vehicles are divided into two categories. Younger firms at the startup level have interpreted entrepreneurship activities in Turkiye as quite sufficient. However, incumbent post & parcel companies have pointed out many deficiencies in the processes. The fact that technically efficient vehicles have not yet been produced may be a major reason for the perception of inadequate entrepreneurial activities. Many prospective users have complained that vehicle manufacturers have not yet produced vehicles with enough technical performance.

One of the main technical barriers hindering the utilization of electric commercial vehicles in cargo operations is range limitations and driver resistance. The current

vehicles fail to meet the requirements of post & parcel operations, thereby adversely affecting the well-being of drivers. The rationale behind driver resistance is that they also use the vehicles in their personal lives. Consequently, vehicles with inadequate range are likely to diminish the overall quality of life for drivers. Measures can be implemented to address driver concerns and alleviate their anxieties pertaining to the limited range of electric vehicles. To eliminate the "range anxiety" among users of electric vehicles (EVs), it is possible to develop visual aids such as interactive maps. These maps can effectively outline the coverage area of EVs, providing a display of the potential range based on the current charge level of the battery pack. (Varga, Sagoian, & Mariasiu, 2019).

Another crucial aspect is enhancing speed and uphill performance. Low vehicle speeds can have a detrimental impact on the volume of business activities. The last technical expectation is related to charging time. Participants have noted that charging time holds relatively less significance for cargo operations. The key point of concern lies in the ability to complete the charging process during non-working hours.

An in-depth analysis of the non-technical barriers preventing post & parcel companies in Turkiye from adopting electric vehicles reveals that these barriers primarily stem from the quality rather than the quantity of entrepreneurial activities. These companies perceive the vehicles produced by entrepreneurs as inefficient in terms of performance and economically unfeasible. The primary factor behind this perception is the substantial expense of acquiring electric vehicles. This obstacle is further compounded by the elevated costs of spare parts, prolonged return on investment, and sunk cost effect resulting from prior investments made in petrol or diesel vehicles. Decision makers know that electric vehicles have comparatively lower fuel expenses per kilometer and reduced overall ownership costs in the long run. However, their focus tends to be more oriented towards short-term concerns.

The existing sales and marketing processes are inefficient, and companies have expressed their reluctance to adopt electric vehicles through conventional buying methods. In order to address the cost pressures involved, experts propose the

provision of electric vehicles to shipping companies via leasing or subscription models. Failure to do so may result in shipping companies persisting in their preference for diesel vehicles, which are more affordable and enable them to handle greater business volume.

5.2. Knowledge Development (F2)

Hekkert et al. (2007) have emphasized the critical importance of knowledge development and research & development activities within technological innovation systems. Research findings indicate that there is insufficient knowledge development activity regarding electric commercial vehicles in Turkiye. The lack of research and development activities, inadequate education, and a low number of academic studies specific to Turkiye are indicators of the problem. However, it is believed that electric vehicles are a popular subject for both universities and research centers in Turkiye, and an increase in research and development activities and expenditures related to electric vehicles is anticipated in the near future based on research.

The capacity of a country to develop knowledge or adapt existing knowledge within the function of knowledge development is indicated by the ratio of research and development expenditures to GDP. According to the World Bank (2021) Turkiye's ratio of research and development expenditures to GDP has been increasing since 2013 which was 0.81% and reached 1.09% in 2020. As a top-level indicator, the ratio of research and development expenditures to GDP in 2020 was 5.04% in Israel and 4.81% in South Korea.

Knowledge development can be achieved by various organizations through methods such as knowledge acquisition through search and knowledge generation through experience. I understand that knowledge development and research development activities are generally carried out by two types of organizations, namely universities and electric commercial vehicle manufacturers. In certain cases, cargo companies also engage in research and development activities in the technological domain. In my research universities were primarily identified as the primary entities responsible for research and development activities. However, it has been noted that there exists

a lack of incentives to stimulate research and development activities within universities. To encourage research and development activities in universities, The Council of Higher Education in Turkiye (2019) mandated that private universities allocate a minimum research and development budget of 1% of their student income.

A web-based investigation on the topic of “electric vehicles and research and development centers" have revealed that several universities in Turkiye have research centers dedicated to electric vehicles. It has been observed that “electric commercial vehicles' ' and “electric passenger vehicles”, which typically pertain to distinct technological innovation systems, exhibit a significant convergence in terms of knowledge development and are generally encompassed under the overarching concept of “electric vehicles”. As of April 2023, the following centers can be cited as examples of academic institutions in Turkiye that operate research centers focused on electric vehicles.

Table 4. Electric Vehicle Research Centers in Turkiye

University / Institution	**Location**	**Research Center Name**
Düzce University	Düzce	Electric Vehicles and Digital Transformation Application and Research Center
Okan University	Istanbul	Transportation Technologies and Intelligent Automotive Systems Application and Research Center
Bursa Technical University	Bursa	Electric Vehicle Technologies Application and Research Center (ETAGEM)
Altinbas University	Istanbul	Electric, Autonomous and Unmanned Vehicles Application and Research Center
OTAM Automotive Technologies research and development Center)	Istanbul	Automotive Technologies research and development Center

The research centers that focus on electric vehicles conduct research and development activities, as well as provide services such as electric vehicle testing, validation, training, and certification activities, as evident from their interviews and stated goals on their respective websites. In addition to research centers established by universities in Turkiye, there are also specialized degree programs known as “Hybrid and Electric Vehicles Technology". The presence of these programs within universities, alongside the formation of research centers specifically focused on electric vehicles, underscores the pivotal role played by universities in fostering knowledge development within the country. The main objectives of these programs are to conduct research and development activities and to train technical human resources in order to meet the maintenance and repair requirements of the industry. According to the April 2023 data obtained from the Turkish Higher Education Atlas database, 12 different universities in Turkiye offer education in the field of Hybrid and Electric Vehicles Technology.

Table 5. Turkish Universities with Hybrid and Electric Vehicles Technology Programs

No	University Name	Capacity	University Type
1	Afyon Kocatepe University	40	State
2	Bilecik Şeyh Edebali University	45	State
3	Mehmet Akif Ersoy University	40	State
4	Bursa Uludağ University	30+50	State
5	Fırat University	30	State
6	İnönü University	40	State
7	İskenderun Technical University	40	State
8	Gelisim University	6+34	Private

Table 5. continued

9	Kocaeli Health & Technology	6+34	State
10	OSTIM Technical University	11+59	Private
11	Tokat Gaziosmanpaşa University	40	State
12	Trakya University	40	State

Source: Yükseköğretim Program Atlası, *2023, retrieved from yokatlas.yok.gov.tr*

The notion of university-industry collaboration has emerged as a pivotal factor in the knowledge development endeavors undertaken by universities. It can be assumed that universities situated in close proximity to industrial areas, technical universities, or those specializing in specific fields are more likely to achieve success in university-industry collaborations. The efforts of universities can yield fruitful outcomes in terms of individual academic research or training students. Scholars within research centers and university departments can conduct academic research on electric vehicles. The primary expectation from such academic studies is their ability to conduct cost-effective research, with a particular focus on battery or charging technologies.

Universities hold a distinguished reputation as independent and objective institutions, thereby enabling them to establish rules or standards for electric commercial vehicles. As emphasized in the research i8: *"It all starts with the university."*

Another key stakeholder in knowledge development through research and development activities is the vehicle manufacturing companies, whether they are incumbent players or startups. These companies encounter challenges related to limited research and development budgets, expressing a lack of adequate financial resources, time, and qualified human capital for research and development endeavors. Therefore, collaborating with universities on joint projects and establishing their own research and development centers may serve as effective solutions to address these challenges.

5.3. Knowledge Diffusion Through Networks (F3)

The diffusion of knowledge generated by universities and companies holds paramount importance for the effective functioning of the technological innovation system. Various events, such as fairs, workshops, seminars, and other gatherings in Turkiye focused on the adoption of electric commercial vehicles in post & parcel operations, play a vital role. These knowledge diffusion-oriented events bring together stakeholders from the sector, increase awareness, and offer informative opportunities. Some fairs even incorporate a seminar program alongside exhibition stands. While some participants find attending events highly effective, others perceive them as inefficient. The effectiveness of these events relies on factors such as the purpose of the fair, the delegation's participation goals, and the comprehensive program designed for the fair.

Numerous fairs are dedicated to specific sectors, such as logistics, technology, electric vehicles, and post & parcel services. The emergence of new integrated concepts like logistics + technology or post & parcel +electric vehicle fairs can increase knowledge diffusion and prevent asymmetric information among stakeholders. Moreover, it has been emphasized that limiting fair participation solely to top-level managers or business owners hampers the diffusion of knowledge. Inclusion of drivers or implementers, who directly benefit from the technology, is crucial. To prevent driver resistance from impeding the success of the technology, it is essential to organize fairs or social events where drivers can actively participate in the promotional process. Finally, the provision of special sales discounts at fairs can serve as a catalyst for accelerating the transition to electric commercial vehicles.

Academic seminars and workshops organized by universities make a valuable contribution to the industry. The findings section enumerates the events associated with electric vehicles that are predominantly organized by universities in Turkiye. Given the impartial and scientific nature of universities, these activities possess the potential to exert a more substantial impact on the industry.

Numerous events centered around sustainability, post & parcel, and electric vehicles are being organized in Turkiye. Through web searches, several instances of electric vehicle events believed to directly foster the diffusion of research and development activities as a result of F2: knowledge development function have been identified. The following list provides examples of such events:

Table 6. Electric vehicle events organized by universities in Turkiye

Organizing Institution	**Date**	**Event Detail**
OSTIM Teknik University and Automotive Engineers Association (OTOMDER)	Jan.23	Topics such as the concept of e-mobility in Turkiye, qualified human resources in the sector, electric vehicle drivetrains, charging infrastructure, and storage solutions were discussed.
Bursa Uludag University	Jun.22	A workshop was held for precautions in electric vehicles. The workshop discussed safe and appropriate charging infrastructure, safety standards and legal issues for electric vehicles.
Marmara University	Apr.22	Electric Vehicle Software and Artificial Intelligence Conference was organized. Information was provided on electric vehicle software and artificial intelligence technologies.
Sabancı University ICEC	Dec.21	Turkiye Electric Vehicles Outlook report presentation covered the future of electric vehicles, technological innovations, the automotive industry, climate and changes in the automotive sector topics.

Table 6. (continued)

eDriveTurkiye	Dec.21	Fair and conference includes 45 panelists across 9 sessions. The conference covered a broad perspective on the e-mobility sector, e-mobility, renewable energy, charging infrastructure and station networks in Turkiye.
Gazi University	Jan.21	The seminar organized by the Gazi University Automotive Engineering Department provided information about hybrid and electric vehicle technologies, future research opportunities
TEHAD and E&Y Turkiye	Apr.20	Turkiye 2030 Electric Transportation Roadmap Workshop by Ernst& Young and Turkiye Electric and Hybrid Vehicles Association. Addressed battery technologies, digitization, consumer usage habits, grid infrastructure, charging stations, and automotive industry.
Sakarya University SARGEM	Dec.16	The National Battery Workshop for Electric Vehicles was organized by Sakarya University Research, Development, and Application Center (SARGEM). Discussions were held on battery technologies, production, cost, and performance.

5.4. Guidance of Research (F4)

Both incumbent firms and startups conduct experiments (F1) to acquire experience. The knowledge development activities undertaken by universities or companies generate a diverse array of technological options within the market. In a technological innovation system, guidance of research is important for bringing emerging technology to the attention of its producer, users, beneficiaries. (Hekkert et al., 2007) This thesis operates at the intersection of three major ecosystems: sustainability, logistics, and electric vehicles. The interplay between these

ecosystems manifests in distinct ways across various contexts. Sometimes, sustainability concerns facilitate the transition to electric vehicles, while in other instances, resistance from drivers towards adopting electric commercial vehicles can result in increased carbon emissions.

The initial imperative lies in establishing clear targets or policies. The formulation of targets by international organizations, governments, or company top management is also important for the use of electric vehicles in the post & parcel sector in Turkiye. There is a strong demand for "participation" from all stakeholders in the target-setting process. It has been emphasized that the government needs to enact a "national electric commercial vehicle policy" to increase the use of electric commercial vehicles. There is a pressing need for collaborative efforts among regulators, electric commercial vehicle manufacturers, post & parcel companies, relevant civil society organizations, and academia to jointly establish a policy framework which is clear, measurable, and scalable.

The announcement of sustainability objectives by prominent corporations holds the potential to instigate industry-wide transformations. Major post & parcel companies are exerting pressure on their subcontractors, vehicle manufacturers, and spare parts suppliers to align with their own sustainability targets. Given their significant market influence, these large post & parcel companies can propel a comprehensive transformation in the value chain for electric commercial vehicles.

International agreements, such as the Paris Climate Agreement and the European Union Green Deal, also serve as guiding frameworks for the electric commercial vehicle and post & parcel industries. Monitoring mechanisms encompassing control, audit, penalty and incentive play a crucial role in achieving the purpose of the guidance of search activities. While the targets are important, their effectiveness relies on being supported by sanctions and/or incentives.

5.5. Market Formation (F5)

The presence of "niches" holds significance for the development of emerging technologies. Hekkert et al. (2007), states that protecting niches is important for the

survival of emerging technologies. It is important for regulators, especially the government, to protect new startups or incumbent firms to invest in new emerging areas. In this context, incentive and penalty mechanisms can be employed.

The adoption of electric vehicles for sustainable last-mile delivery operations in Turkiye involves multiple stakeholders. Key participants include manufacturers of commercial electric vehicles and organizations utilizing these vehicles for post and postal services. Additionally, there are other stakeholders, such as research and development centers, universities, and non-governmental organizations that operate within this ecosystem. Furthermore, there is a substantial overlap between the electric passenger vehicle industry and the electric commercial vehicle industry. Given that the majority of last-mile delivery vehicles comprises light commercial vehicles, this intersection assumes even greater importance.

To comprehend the dynamics of "market formation" and the associated challenges, we can initially analyze the size of the electric vehicle market over time. According to the International Energy Agency (2022) electric vehicle sales (both commercial and passenger vehicles) reached a record high in 2021, nearly doubling to 6.6 million and resulting in a total of 16.5 million electric vehicles on the road. The report further predicts that electric cars will constitute 60% of new vehicle sales, with over 300 million electric vehicles anticipated on the road by 2030. Recent market analysis by Statista (2023) indicates substantial growth prospects for the global electric commercial vehicle market in the upcoming years. The estimated number of electric commercial vehicles worldwide was approximately 257,000 in 2022, with projections indicating an increase to 1,018,000 by the end of 2026.

The primary obstacle to market formation in the rapidly growing electric commercial vehicle market lies in the realm of incentives. One of the foremost hindering the widespread adoption of electric commercial vehicles in Turkiye is the high cost associated with their acquisition. Post & parcel companies argue that this cost can be reduced through incentives. the provision of incentives. These companies have expressed their desire for exemptions from Special Consumption Tax / Value Added Tax when purchasing electric commercial vehicles, as well as discounts on these

taxes. The call for incentives extends beyond the purchase of vehicles alone. Companies have also requested long-term incentives encompassing benefits, such as reduced personnel insurance premiums and discounts on electricity consumed during the charging process.

There is currently a growing emphasis on extending incentives not only to electric vehicle manufacturers but also to end-customers or buyers. Ensuring that buyers have access to financial resources, which will be discussed in the F6 Mobilization of Resources section, is considered important for fostering a well-functioning innovation system.

A prime example of effective incentive implementation can be found in South Korea, where incentives have been instrumental in driving the adoption of electric commercial vehicles. South Korea's unique policy of incentivizing the usage of electric commercial vehicles has resulted in a remarkable surge in sales. In 2021, 28,000 units were sold, accounting for 12% of the total light commercial vehicle market (IEA, 2022). This represents a significant increase from a mere 1,500 units sold two years prior.

An additional incentivization strategy that the government can employ is becoming the first customer by incorporating these vehicles into their own operations. For startups, the proof-of-concept stage is critical, and electric vehicle manufacturers developing prototype or minimum viable product (MVP) vehicles for cargo operations require pilot users for testing. The use of electric commercial vehicles in public operations will not only contribute to breaking down the trust barrier but also create an encouraging effect. According to a press release from Anadolu Agency (2022), Turkish Post aims to make 40% of its vehicle fleet comprised of electric vehicles by 2030, aligning with their sustainable, environmentally friendly, cleaner, and greener Turkiye approach.

In order to attain sustainability objectives and mitigate the emission of harmful gases, it is imperative to generate electricity for electric vehicles using

environmentally friendly means. Consequently, there is a need to create opportunities for companies interested in producing eco-friendly electricity for vehicle charging.

In order to achieve sustainability goals and reduce harmful gas emissions, the electricity consumed by electric vehicles should be produced using environmentally friendly methods. Thus, it is necessary to encourage companies that are interested in generating electricity using environmentally friendly methods for charging electric vehicles. Therefore, regulators should approach this issue with a regulator-agnostic perspective. Depending on the country, electric vehicle production can be regulated by industry ministries, energy production by energy ministries, and post & parcel operations by transportation ministries. In this case, incentives should also be carried out in communication with relevant stakeholders.

Research has indicated that achieving sustainability goals and reducing harmful gas emissions requires the use of environmentally friendly electricity in electric vehicles. The source of electricity production plays a significant role in assessing the environmental sustainability of electric vehicles through a life cycle assessment. Companies interested in producing electricity for vehicle charging using environmentally friendly methods should be incentivized. Considering the varying regulatory frameworks across countries, electric vehicle production may be regulated by industry ministries, energy production by energy ministries, and post & parcel operations by transportation ministries. Thus, it is important for incentives to be designed and implemented with an inter-regulatory perspective in mind, fostering collaboration among different ministries and stakeholders.

Creating a niche or establishing a protected area for emerging technologies holds significant importance. Implementing restrictions and limitations can serve as an additional method to increase the adoption of electric vehicles in last-mile delivery operations within the post & parcel sector. Regulatory measures, including the enforcement of an annual greenhouse gas emission threshold for post & parcel companies or a mandatory minimum fleet size requirement for electric vehicles, can render electric vehicles more advantageous. In addition, pilot applications can be made using bans to support both the F3: Knowledge Diffusion and F4: Guidance of

Search functions. Within Turkiye, specific locations could be designated as "zero-emission zones," where the entry of diesel/gasoline vehicles into the region is prohibited. This will enable testing of various models such as electric vehicle and bicycle distribution, as well as drone delivery, thereby facilitating knowledge development.

5.6. Mobilization of Resources (F6)

Hekkert et al. (2007) define the method of resource mobilization of function analysis as the process of identifying whether inner core actors perceive access to sufficient resources as problematic. Securing the necessary resources is vital for a technology to strengthen, expand, and become operationally sustainable. Emerging technologies encounter greater challenges to survive if they lack the required and sufficient resources, either due to their unavailability or inadequate allocation. The section on the mobilization of resources function will be discussed under four main categories.

5.6.1. Financial Resources

The accessibility of financial resources has improved as environmental awareness and the prevalence of electric vehicles have grown. According to my research, electric vehicle startups in Turkiye face no difficulties in securing investment or finance. Additionally, Turkish banks offer favorable loan options for the acquisition of individual electric passenger vehicles. Specific banks also provide specialized credit packages to entrepreneurs interested in establishing charging stations to enhance the charging infrastructure for electric commercial vehicles. (Source: https://www.isbank.com.tr/is-ticari/elektrikli-sarj-istasyonu-kurulum-kredisi)

5.6.2. Charging Infrastructure

The research findings demonstrate that the evaluation of charging station infrastructure should consider prevalence and occupancy. Since cargo operations primarily occur during business hours, charging time does not pose a significant

barrier. However, post & parcel companies operating throughout Turkiye express concerns about the adequacy of charging stations in smaller cities.

Another approach to vehicle charging involves utilizing post & parcel offices. It has been noted that the physical layout of existing cargo branches and their electrical infrastructure may not be well-suited for vehicle charging. As indicated by research, the charging requirements of electric commercial vehicles differ from those of electric passenger vehicles.

According to Al-Hanahi et al. (2021), there are two main models for charging electric commercial vehicles: return-to-base model and the utilization of public charging infrastructure. The return-to-base model for charging commercial electric vehicles (CEVs) requires high-power charging infrastructure at commercial facilities, which can strain local electrical distribution networks significantly. Upgrading the electrical network of commercial facilities may be necessary to accommodate growing adoption of CEVs, but the high investment costs can be prohibitive. Decisions regarding infrastructure upgrades will be driven by cost-benefit analyses as the market for electric trucks expands.

According to Çakmak and Turan (2022), there are 0.036 charging stations per electric-hybrid vehicle in Turkiye, with a total of 1340 charging stations nationwide. The European Union's recommendation of having 1.0 charging station for every ten electric vehicles translates to 0.36 charging stations per ten EVs in Turkiye, including hybrid vehicles.

5.6.3. Maintenance and Repair Infrastructure

There is a prevalent notion within the post & parcel industry that maintenance of electric commercial vehicles is a simple process. Post & parcel companies have mostly assumed that no supplementary human resources, training, or equipment are required for maintenance or repair operations. However, electric vehicle manufacturers and universities hold a contrasting perspective. It has been proposed that the repair and maintenance of electric vehicles should be conducted by proficient

technicians, as errors could potentially result in fatalities due to high voltage. To reduce uncertainties in the repair process for electric commercial vehicles, it is imperative to enhance the repair and maintenance network.

5.6.4. Human Resources

There are multiple stakeholders involved in the electric commercial vehicle ecosystem, including drivers, technicians, fleet managers, and senior executives. Regulatory bodies in Turkiye have indicated that drivers holding a diesel, petrol vehicle or motorcycle license are also permitted to operate electric commercial vehicles without acquiring an additional license. However, vehicle manufacturers have emphasized the need for training related to the charging process.

Turkish Vocational Qualification Authority (2016) defined the job description of "Battery Electric Vehicle Service Technician (Level 3)" in 2016, which includes responsibilities, such as ensuring workplace safety and cleanliness, conducting maintenance and repairs on electric vehicles, and addressing electrical hazards during the charging process. In Turkiye, there are 12 distinct universities offering training programs in Hybrid and Electric Vehicle Technologies to educate requisite technical workforce for maintenance and repair. A significant increase in both electric passenger and commercial vehicles is anticipated in Turkiye in the forthcoming years. The Strategic Objectives and Roadmap Draft for Mobility Vehicles and Technologies (2021) state "electric vehicle sales to reach a market share of 35%, electric vehicle fleet to reach 2.5 million, and the number of publicly accessible charging sockets to reach 250,000 by 2030." Expanding the enrollment capacity of existing Hybrid and Electric Vehicle Technologies programs or establishing new programs at additional universities could serve as potential solutions to meet the demand for a substantial number of qualified human resources.

5.7. Creation of Legitimacy (F7)

Emerging technologies have the potential to disrupt existing technologies. Research indicates that implementing certain measures in F5: Market formation to protect

developing technologies may not be sufficient to achieve success through only tax incentives or subsidies. It is crucial to have advocacy groups that can defend and lobby for the advancement of emerging technologies. Individual efforts may not be adequate to sustain the technology, and activities falling under the "creation of legitimacy" function can directly impact other functions. Lobby groups, for instance, can exert pressure on governments to introduce new incentives.

It has been observed that some findings were related to a Turkish electric passenger vehicle named TOGG. The definition of the Technological Innovation System to be investigated in this thesis was determined as electric commercial vehicles/electric freight vehicles. Function analyses reveal disparities in terms of scope, operation, and stakeholders between electric passenger vehicles and electric commercial vehicles. However, during the data generation process, I have seen that TOGG, which is not directly involved in the selected innovation system, has a positive impact on the functions within the electric commercial vehicle TIS. The presence of TOGG in Turkiye offers various advantages to the electric commercial vehicle innovation system, including increased legitimacy, improved access to skilled labor, and reduced uncertainties. Theoretically, TOGG belongs to a separate technological innovation system because it manufactures electric passenger vehicles. The development of positive externalities is linked to the entry of new firms into the same technological innovation system.

There is a pressing need for an intermediary organization in Turkiye that can facilitate collaboration between two key sectors: vehicle manufacturers and Post & parcel. The activities related to the utilization of electric commercial vehicles in cargo operations can be examined within the coalition of post & parcel, electric vehicle manufacturers and sustainability groups. The establishment of organic structures that can serve as a bridge between the government and private companies is anticipated. The scarcity of lobby structures in Turkiye and the trust issue have been highlighted as barriers.

Furthermore, competition has been recognized as another factor that can impede lobbying activities. Collaborative efforts with competing cargo companies or electric

vehicle manufacturers are considered essential for advancing infrastructure and promoting environmentally friendly practices in Turkiye. Examples of non-governmental organizations in Turkiye include the Turkiye Electric and Hybrid Vehicles Association (TEHAD), the Turkiye Cargo-Courier and Logistics Operators Association (KARİD), the Intelligent Transportation Systems Association of Turkiye (AUS Turkiye), the Electric Storage and Electric Vehicle Industrialists Association (EDEAS), and the International Transport and Logistics Service Providers Association (UTİKAD)

These NGOs operating in Turkiye aim to raise awareness, provide educational opportunities, and serve as representatives of Turkiye in their specific areas of focus, in line with their mission and objectives.

5.8. Limitations of the Study

The study encompasses four main limitations. The first limitation pertains to the selection of the theoretical framework as it is challenging to determine the most suitable function set prior to commencing the study. After careful examination of the function sets, I have chosen the seven functions from Hekkert et al. (2007) that are deemed more appropriate, while also proposing a theoretical contribution to address gaps or shortcomings in Hekkert's model. The second limitation concerns the identification of suitable interviewees. Given the limited number of post & parcel companies and electric commercial vehicle manufacturers in Turkiye, it is challenging to find appropriate interviewees. Conducting online interviews is necessitated by the busy schedules of top-level executives. However, conducting in-person interviews could have provided additional valuable information. Thirdly, the introduction of TOGG in Turkiye coincided with the period when the research was conducted, which may have resulted in participants inadvertently intertwining their discussions on electric commercial vehicles and electric passenger vehicles due to the presence of TOGG in Turkiye. The final limitation is associated with the study's focus on three distinct ecosystems simultaneously: electric commercial vehicles, sustainability, and the post & parcel sector. Consequently, data is collected and interpreted from a broad spectrum.

CHAPTER 6

CONCLUSION AND POLICY RECOMMENDATIONS

As revealed in the literature review presented in the second chapter, sustainability stands as the crucial element in achieving harmonious equilibrium among ecology, society and economy on a global scale. The literature review addresses diverse definitions and facets of sustainability. It has been found that greenhouse gas emissions are a threat to environmental sustainability due to their contribution to global warming and climate change. Transportation activities have emerged as the primary source of such emissions. Moreover, the literature review has delved into the concept, definition, history, and typology of logistics while exploring the intricate relationship between environmental sustainability and logistics operations.

Post & parcel companies can adopt a range of technologies, strategies, and practices to realize their environmental sustainability objectives in last-mile delivery operations. The World Economic Forum's Future of Last mile Report (2020) has identified electric vehicles, autonomous delivery robots, route optimization, parcel lockers, and drone delivery technologies as notable technological solutions. Among these, electric commercial vehicles exhibit the highest potential in terms of fostering environmental sustainability within post & parcel companies.

This study centers on the integration of electric commercial vehicles into post & parcel operations as a topic of sustainability transition within the socio-technical systems approach described in the theoretical background section. The adoption of electric commercial vehicles involves multiple stakeholders, such as post & parcel companies, electric vehicle manufacturers, and universities, which can be identified as a Technological Innovation System (TIS). The research primarily focuses on how post & parcel companies operating in Turkiye have integrated electric commercial

vehicles into their sustainable last-mile parcel delivery operations, utilizing Hekkert's seven functions as a conceptual framework. The subsequent section presents the research findings and analysis, identifies the barriers impeding the use of electric vehicles for sustainable last-mile delivery operations of post & parcel companies in Turkiye, and formulates policy recommendations aimed at facilitating environmentally friendly last-mile delivery operations using electric vehicles in the country. These policy recommendations are presented in a four-column table, including main barriers, related function, policy aims and policy instruments.

Table 7. Policy suggestions

Related Function	**Main Barriers / Issues to Consider**	**Aim of Policy**	**Relevant Policy Instruments**
F1	The number of firms and experiments related to electric commercial vehicles is insufficient. Ineffective sales and marketing processes of ECV manufacturers	Increasing number and capacity of companies manufacturing electric commercial vehicles in Turkiye	New incentive package on factory establishment, land allocation, and insurance premium discounts for research and development personnel for ECV manufacturers. Offering basic entrepreneurship courses online for ECV manufacturers Establishment of an incubation center focused on electric vehicle technologies.

Table 7. (continued)

F1	Technical performance issues such as range, speed, traction, vehicle volume, and charging duration.	Overcoming technical performance barriers in electric commercial vehicles (ECVs).	Establishing an electric commercial vehicles research center focusing on technical improvements Providing project-based grants for firms, universities or freelancers to solve each defined technical barrier Organizing hackathons about pre-identified technical themes.
F1	ECVs are not economically feasible: high purchase cost, sunk costs, expensive spare parts, fluctuations in foreign exchange rates.	Making electric freight vehicles economically competitive with non-electric commercial vehicles.	Reducing special consumption tax (ÖTV) and value-added tax (KDV) for electric commercial vehicles.

Table 7. (continued)

F2	Lack of academic research in social sciences for electric commercial vehicles. Weak university-industry cooperation hinders practical knowledge development.	Improving the quantity and quality of academic research on electric vehicles in universities. Strengthening university-industry collaboration in the field of electric commercial vehicles.	Providing specific project calls for academic research in social and technical sciences related to ECVs Requiring students of Hybrid and Electric Vehicle Technology programs to complete a collaborative industry project as a graduation requirement Offering graduate and doctoral programs in the Department of Hybrid and Electric Vehicle Technologies. Strengthening the "Motor Vehicle Technology" departments in vocational high schools by adding electric commercial vehicle studies to the curriculum.

Table 7. (continued)

F2	Lack of budget and qualified human resources for firms to conduct research and development on ECV	Enhancing the quantity and efficacy of research and development activities by companies.	Tax incentives based on research and development efforts
F3	Ineffectiveness of fairs and events due to limited attendance of decision makers Lack of interest of universities in knowledge-diffusion activities. Lack of exhibitions or events on ECVs in small cities of TR Universities are perceived as objective and reliable by other parties.	Creating a reliable electric commercial vehicle ecosystem. Spreading awareness about electric commercial vehicles throughout the country.	Positioning selected universities as ecosystem leaders in ECV TIS Providing domestic fair participation & organization support in addition to the international fair support Organizing electric commercial vehicle events by local development agencies Supporting the existence of electric vehicle student clubs at universities

Table 7. (continued)

F3	Resistance to share know-how due to privacy concerns Distrust in the patent and intellectual property rights mechanisms Lack of know-how sharing platform about ECVs	Increasing knowledge diffusion on electric commercial vehicles between stakeholders	Creating an online platform that unites stakeholders involved in the electric vehicle ecosystem to share sectoral updates Providing intellectual property rights training to electric commercial vehicle manufacturer Removing the cost of patent application for manufacturers of electric commercial vehicles
F4	The absence of national policies concerning electric commercial vehicles, sustainability and the post & parcel industry.	Clarifying Turkiye's stance and objectives on ECV, post & parcel, and sustainability.	Organizing national conferences on sustainability and ECVs in the post & parcel sector to establish a unified national strategy.

Table 7. (continued)

F4	The government not widely using electric commercial vehicles in its own operations Lack of awareness about environmental sustainability	Encouraging and empowering the adoption of electric commercial vehicles through state power Creating awareness of environmental sustainability in logistics	Ensuring high levels of electric vehicle usage in Turkish Post operations and promoting ECVs Organizing sustainability in logistics awards and promoting best use cases
F5	Lack of incentives for post & parcel firms to adopt electric commercial vehicles.	Increasing the use of electric commercial vehicles by post & parcel companies	Reduction in Special Consumption Tax for post & parcel companies that purchase electric commercial vehicles. Discounted electric charging options to post & parcel companies
F5	There is no greenhouse gas emissions limit or penalty for logistics operations in Turkiye	Ensuring environmental sustainability Forcing logistics companies to adopt sustainable delivery methods	Introducing emission limits for each post & parcel company based on fleet and operational size. Suspending operations or imposing high tax charges for exceeding GHGs limits.

Table 7. (continued)

F6	Insufficient electric charging infrastructure coverage in Turkiye. The physical layout and electricity infrastructure of cargo offices not suitable for ECV charging	Establishing a robust charging infrastructure network for both passenger and commercial electric vehicles. Lowering the total cost of ownership for electric commercial vehicles. Addressing charging concerns and visual pollution, and ensuring safe and accessible charging	Revising and expanding charging station installation incentives to meet commercial vehicle infrastructure needs Establishing co-charging stations for post & parcel fleet vehicles by municipalities Enabling post & parcel companies to charge at lower rates than individual vehicles.

Table 7. (continued)

F6	Insufficient maintenance/repair infrastructure across the country Lack of sufficient and qualified human resources for electric commercial vehicle maintenance and repair	Ensuring the use of electric commercial vehicles throughout Turkiye Reducing maintenance and repair costs of ECVs	Increasing the number of universities with Hybrid and Electric Vehicle Technology programs and their quotas Electric commercial vehicle maintenance and repair training in universities or vocational high schools for non-students
F7	Absence of unified and extensive advocacy groups to promote the adoption of ECVs TOGG's significant effect on the electric commercial vehicle sector Doubts regarding the credibility of NGOs in Turkiye	Ensuring government-private sector coordination Strengthening communication among sector stakeholders. Designing applicable and effective policies	Making it mandatory to involve a non-governmental organization as a partner in ECV related incentive and grant applications.

Source: Author

The policy recommendations presented above have been formulated within the framework of Hekkert et al.'s (2007) seven functions model. Some policies intersect multiple functions and policy recommendations with multiple functions have been placed under the dominant function. The identification of policy areas has relied

solely on the findings derived from data generation, facilitating evidence-based policy making. In the policy recommendations section, the current situation in Turkiye, global best practice examples, and ongoing processes provided in the discussion section have been taken into account.

Overcoming the barriers to the widespread adoption of electric commercial vehicles in sustainable last-mile delivery operations in Turkiye necessitates a comprehensive and interdisciplinary approach. This entails simultaneous and coordinated improvements across multiple domains, including the implementation of tax incentives, the establishment of dedicated university research centers focused on electric vehicle technology, the provision of comprehensive driver training programs, advancements in enhancing the range and charging infrastructure of electric vehicles, the organization of local fairs to promote electric vehicle adoption and active involvement of civil society organizations in advocating for sustainable last-mile delivery solutions.

Moreover, the current trajectory of increasing environmental awareness and the introduction of TOGG into the Turkish market further reinforce the timeliness and relevance of integrating electric vehicles into last-mile delivery operations. By capitalizing on these developments and embracing a holistic, environmentally sustainable perspective, Turkiye can significantly expedite the adoption rate of electric commercial vehicles in its last-mile logistics operations, thereby contributing to emissions reduction and fostering a greener transportation ecosystem. It is essential to prevent the occurrence of asymmetric information among policymakers and stakeholders. By adopting a holistic and environmentally sustainable approach, the adoption rate of electric commercial vehicles in last-mile logistics operations in Turkiye will experience rapid growth.

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APPENDICES

A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

DUMLUPINAR BULVARI 06800
ÇANKAYA ANKARA/TURKEY
T: +90 312 210 22 91
F: +90 312 210 79 59
uygam@metu.edu.tr
www.uygam.metu.edu.tr

28 ŞUBAT 2023

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Doç. Dr. Adil Oran

Danışmanlığını yürüttüğünüz Cemal Atakan PARLAK'ın **"LOJİSTİK TEKNOLOJİLERİNİN SÜRDÜRÜLEBİLİRLİK AÇISINDAN ETKİNLİĞİNİN İNCELENMESİ"** başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek **0105-ODTUİAEK-2023** protokol numarası ile onaylanmıştır.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Sibel KAZAK BERUMENT
Başkan

Prof.Dr. İ.Semih AKÇOMAK
Üye

Doç. Dr. Ali Emre Turgut
Üye

Dr. Öğretim Üyesi Şerife SEVİNÇ
Üye

Dr. Öğretim Üyesi Murat Perit ÇAKIR
Üye

Dr. Öğretim Üyesi Süreyya ÖZCAN KABASAKAL
Üye

Dr. Öğretim Üyesi Müge GÜNDÜZ
Üye

B. CODEBOOK

Entrepreneurial Activities

- Logistics Technologies
  - Bicycle / Pedestrian Distribution
  - Drone Delivery
  - Request for face-to-face events
  - Lack of fairs in small cities
  - Seminar + fair association
  - Drones
  - Route Optimization
  - Autonomous vehicles
  - Electric Vehicles
  - Solar Warehouses
  - Cargo Lockers
  - Robotics
  - Order Consolidation

- EV Technical Barriers
  - Low carrying capacity
  - Speed problem
  - Lack of range
  - Charging Time
  - Charging time is insignificant in shipping
  - Range change according to the driver
  - Hill Climbing Problem
  - Range is sufficient

- Market Situation
  - Domestic National Support
  - Vehicle prices are high
  - Sunk Cost Effect
  - Demo process inefficiency - its importance
  - Creating an ecosystem
  - The number of companies producing EVs is low
  - decrease in business volume
  - Suitability for cargo operation
  - EV investment by courier
  - Lack of original vehicle / model
  - Willingness to gain competitive advantage
  - Only suitable for large companies
  - Industry-specific car needs
  - The need for conversion at the subcontractor
  - TOGG Effect

    - Turkish EV manufacturers are not mature
    - Manufacturers don't know courier well
    - Inability of manufacturers to take risks
    - Product variety is low
    - The necessity of transformation in the sub-industry
    - Not common
    - Poor performance of new ventures
    - The need for an innovative sales/marketing model

Knowledge Development

- Universities
    - Logistics importance and trend in academia
    - Establishment of Repair Departments
    - The importance of university - industry cooperation
    - University categorization (R&D, industry)
    - Battery development prospect
    - Undergraduate graduation projects

- Firms and R & D
    - Domestic battery production
    - Finding R&D funding when it comes to electricity
    - Lack of financial resources
    - The importance of company R&D centers
    - R&D problems of production companies
    - Adequate level of study

Knowledge Diffusion

- Information Diffusion Barriers
    - Saying I'll keep it to myself
    - Inadequacy of the patent system
    - Insufficient marketing activities
    - Training Needs
    - Re-learning requirement

- Events and Marketing
    - Prestige events are needed for EVs
    - Awareness raising and informing effect
    - Special discounts for the fair
    - Keeping the fairs at the PR level
    - Keeping the fairs in one vertical
    - It is a sign of industry maturity
    - Missing activities involving driver
    - PR lobbying activities
    - Triggering intra-industry transformation
    - Sign of industry maturity
    - Bringing experts together

Guidance Of the Search

- Setting Target
  - The impact of the global firm targets
  - Prevent chaos
  - Material benefits
  - Setting a clear electric vehicle transformation goal
  - Leading / shaping the industry
  - Developing the strategy with stakeholders
  - Enforcement should also include

- Measuring Mechanisms
  - Only the stressor/ineffectiveness of the target
  - Penalty + Incentive should be applied together
  - Incentive instead of punishment
  - Insist on the cost
  - Tracking Mechanism Requirement

Market Formation

- Incentives
  - Subcontracted EV requirement of adults
  - Electricity Production Incentive
  - EV Use Obligation
  - Global courier's transformation of manufacturers
  - Personnel Insurance discount
  - Incentives to continue
  - Influence of incentive decision
  - Having a sustainability criterion in incentives / investments
  - Lack of incentives in Turkey
  - Tax / VAT - SCT Reduction

- Limitations
  - Emission limit
  - Non-EV ban
  - Non-EV high tax

- Regulations
  - Maintenance and repair certification
  - Clarifying EV Vehicle Statuses
  - No need for change in human resources
  - EV incentive in min number of vehicles

Resource Mobilization

- Financial Resources
  - Easy access to funds specific to EV

    - Determination of financial resources
    - Credit Support Package
- Charging Infrastructure
    - Infrastructure problem in small cities
    - Insufficient charging station infrastructure
    - Charging station full
    - Electricity price by charging point
    - Adequate charging infrastructure
    - Lack of physical environment for charging in the branch
    - Charging costs are high

- Maintenance / Service Infrastructure
    - Maintenance uncertainties
    - Low maintenance
    - Frontal damage detection
    - Requires prevalence across the country
    - Adequate maintenance / service infrastructure
    - Insufficient service infrastructure

- Human Resources Infrastructure
    - No need for additional qualified human resources
    - Lack of qualified service/maintenance personnel
    - Operations manager to be visionary
    - Sustainability awareness among staff
    - Developing sustainability KPIs
    - Employment Specific to Sustainability
    - Need for driver training

Creation of Legitimacy

- Significance of NGOs
    - State-private bridge
    - The importance of ecosystem connectors
    - Institutional contact status
    - Discounted vehicle purchase for lobby member
    - The meaninglessness of the lobby

- NGO Responsibilities
    - Organizing training
    - Competing in cooperation
    - Inclusivity
    - Bringing stakeholders together
    - They should know the industry well

C. INTERVIEW QUESTIONS

1. Can you please introduce yourself?
2. How many years have you been in this industry?
3. What is your current role in your organization?
4. Can you provide information about the positioning of your organization?
5. What activities do you conduct as an organization?
6. How do you manage your daily logistics operations?
7. What sustainable practices do you implement in your last-mile operations?
8. How do you interpret the relationship between electric vehicles and sustainability?
9. How do you think the barriers to implementing electric vehicles in the last-mile post & parcel delivery operations can be overcome?
10. What is your opinion on the commercial activities in the electric commercial vehicle sector in Turkiye?
11. What do you think about research and development activities conducted by universities or firms?
12. How do you think research and development activities affect the ECV transformation in cargo operations?
13. How do you interpret events such as fairs, seminars, and conferences for sharing generated information?
14. How do you evaluate strategy documents or goals announced in the context of EV transformation in last-mile operations?
15. How do you interpret events such as fairs, seminars, and conferences for sharing generated information?
16. How do you evaluate strategy documents or goals announced at the international, national, or company level in the context of EV transformation in last-mile operations?
17. How important are incentives/sanctions for you when producing/using a technology?

18. Do you think that the necessary infrastructure exists in Turkiye to use electric vehicles? How do you perceive the current infrastructure situation?
19. How do you evaluate the impact of lobby groups in the technology transformations in the sector or technology vertical?

D. TURKISH SUMMARY / TÜRKÇE ÖZET

Sürdürülebilirlik kavramı son yıllarda önemini giderek artırmaktadır. Ekonomik, sosyal ve çevresel sürdürülebilirlik olmak üzere üç ana tanımı bulunan kavram özellikle çevresel sürdürülebilirlik ile ilişkilendirilmektedir. Çevresel sürdürülebilirliği etkileyen en önemli iki konsept iklim değişikliği ve sera gazı salınımıdır. Başta karbondioksit olmak üzere çeşitli aktiviteler sonucu atmosfere salınan zararlı gazlar, çevresel sürdürülebilirliğe zarar vermektedir. Birleşmiş Milletler Sürdürülebilir Kalkınma Amaçları, Avrupa Birliği Yeşil Mutabakat ve Türkiye'nin çevresel sürdürülebilirlik adına politikaları bulunmaktadır. Paris İklim Anlaşması ve Sıfır Atık projesi Türkiye'nin çevresel sürdürülebilirlik adına takip ettiği önemli çalışmalardır. Sera gazı emisyonları ve sebepleri incelendiğinde ulaştırma ve lojistik aktivitelerinin sera gazı emisyonu açısından en öndeki sektörler arasında oldu görülmektedir.

Lojistik aktiviteleri hava, kara, raylı lojistik gibi farklı şekillerde icra edilebilir. Lojistik aktiviteleri içerisinde karayolu taşımacılığı en yaygın ve en yüksek maliyete sahip kalemdir. Karayolu taşımacılığı aktiviteleri arasında ise son kilometre teslimatı olarak ifade edilen aktiviteler ön plana çıkmaktadır. Son kilometre operasyonları, ürünlerin genellikle şehir içinde son kullanıcılara teslimatını veya son kullanıcılardan toplanmasını ifade eder. Tüm tedarik zinciri süreçleri içerisinde çevreyi en çok kirletme potansiyeline sahip ve en maliyetli aktivitelerden olan son kilometre operasyonlarının hacmi, özellikle e-ticaretin pandemi sonrası hızlanması ile dramatik şekilde artmıştır.

Son kilometre operasyonları sürdürülebilirlik açısından ele alındığında; farklı teknolojilerin karbon sıfır operasyon hedefine katkı verebildiği görülmüştür. Rota optimizasyonu, otonom teslimat robotları, drone ile teslimat modelleri, kargo dolapları ve elektrikli araçlar ile teslimat modelleri öne çıkan teknolojiler arasındadır. Yenilikçi son kilometre teslimat teknolojileri içinden çevresel

sürdürülebilirliğe en çok katkı verme potansiyeline sahip olan teknoloji elektrikli araçlardır.

Elektrikli araçların son kilometre operasyonlarında en yaygın olarak kullanılabildiği yerler yer posta ve kargo operasyonlarıdır. Posta ve kargo firmaları, gerçekleştirdikleri şehir içi son kilometre operasyonlarında sürdürülebilirliğe katkı vermek için elektrikli araçlar kullanmaktadır. Farklı ülkelerde posta ve kargo operasyonlarında elektrikli ticari araç kullanımını ele alan çalışmalarda elektrikli araçların teslimat maliyetini düşürdüğü, zararlı gaz emisyonunu minimize ettiği ve şehir içi gürültüyü azalttığı görülmüştür. Çeşitli ülke ve şirketler, sürdürülebilirlik kaygısıyla operasyonlarını geleneksel araçlar yerine elektrikli araçlarla yürütmeye başlamıştır. Literatür araştırmasında posta & kargo operasyonlarında elektrikli ticari araç kullanımının önünde; menzil, satın alma maliyetinin yüksek olması, teknik performans sorunları ve alışkanlıklar gibi farklı bariyerler bulunduğu gözlemlenmiştir.

Bu tezin amacı Türkiye'de sürdürülebilir posta ve kargo son kilometre operasyonları yürütmek amacıyla elektrikli araç kullanımının önündeki bariyerleri tespit etmektir. Teori arka planı olarak kullanılan sürdürülebilirlik odaklı dönüşüm teorileri sosyo-teknik sistemler içerisinde daha sürdürülebilir yapılara geçişi ele almaktadır. Teknoloji, pazar, tedarik, altyapı, insan kaynağı, bakım ve tamir çalışmaları gibi farklı elementleri ve bunlar arasındaki ilişkileri ele alan sosyo-teknik sistemler yaklaşımı, sürdürülebilirlik adına olan dönüşümleri analiz etmekte kullanılmaktadır. Sürdürülebilirlik dönüşümü teorilerinden beslenen inovasyon sistemleri yaklaşımı ise teknolojinin yaratılması ve paydaşlar arasında yaygınlaşmasını ele alır. Ulusal inovasyon sistemleri, bölgesel inovasyon sistemleri, sektörel inovasyon sistemleri ve teknolojik inovasyon sistemleri yaklaşımı olmak üzere 4 farklı inovasyon sistemi yaklaşımı bulunmaktadır. Bu çalışmada elektrikli araçların post ve kargo operasyonlarında kullanılması bir teknolojiyi odak aldığı için teknolojik inovasyon sistemleri yaklaşımları ile ele alınmaktadır.

Teknolojik inovasyon sistemleri yaklaşımı, sistem içerisindeki belirli aktörleri tanımlamak ve bütüncül bir bakış açısı sunmayı hedefler. Sürdürülebilirlik, kargo ve

elektrikli araç olmak üzere üç büyük ekosistemin kesişim noktasında yürütülen bu tez çalışmasında statik bilgilerden ziyade aktörlerin birbirleriyle olan iletişimi daha büyük öneme sahiptir. Bu sebeple tezde Hekkert et al. (2007) tarafından inovasyon sistemlerinin dinamik etkileşimlerini analiz etmek üzere önerilen fonksiyon yaklaşımı kullanılmıştır. Araştırma sorusu önerilen yedi fonksiyon etrafındaki bariyerleri tanımlamak üzerine revize edilmiştir. Sunulan yedi fonksiyon: girişimcilik aktiviteleri, bilgi üretimi, bilginin yayılması, araştırmalara yön verme sektöre yön verme, pazar düzenlemeleri, kaynakların kullanımı ve meşruiyet olarak tanımlanmıştır. Çevresel sürdürülebilirliğe katkı vermek adına Türkiye'de kargo operasyonlarında elektrikli ticari araçların kullanımının önündeki analiz edilecektir.

Çalışmada veri üretimi aşamasında nitel araştırma yöntemleri kullanılmıştır. Nitel araştırma yöntemlerinin tercih edilmesinin sebebi politika önerisi sunmayı hedefleyen bu tezde daha derin iç görüleri, paydaşlar arası etkileşimleri ve sektörün problemlerini tanımlamaya olan ihtiyaçtır. Sadece nicel araştırma yöntemleri kullanılarak verilecek sayıların sektör ürün gerçek durumunu ve bariyerleri tanımlamada yeterli olmayabileceği düşünülmüştür. Bu sebeple yarı yapılandırılmış mülakatlar ile verilerin yaratılması sağlanmıştır. Mülakata katılacak isimler teoriye dayalı seçim yaklaşımıyla belirlenmiş, isimlerin üst düzey yönetici olmasına özen gösterilmiştir. Çalışma kapsamındaki mülakat soruları, fonksiyonlara yanıt verme potansiyeli olacak şekilde tasarlanmıştır. Bu kapsamda elektrikli ticari araç üreticileri, posta ve kargo firmaları, üniversitede görevli akademisyenler ve sivil toplum kuruluşları temsilcileri ile 13 farklı mülakat gerçekleştirilmiştir. Katılımcıların iş yoğunluğu sebebiyle görüşmeler online olarak gerçekleştirilmiş ve izin alınarak yapılan ses kaydı ve notlar çalışma analizinde kullanılmıştır.

Elde edilen verilerin analizi tümdengelimsel yaklaşım ile QDA Miner Lite isimli yazılım kullanılarak gerçekleştirilmiştir. Kullanılan yedi fonksiyon çatı kümeler olarak belirlenmiş ve deşifre edilen mülakatlar alt kodları fonksiyonlar ile ilişkilendirilmiştir. Analizler sonunda yedi farklı fonksiyonda bulgular elde edilmiştir.

Girişimcilik aktiviteleri fonksiyonu altında Türkiye'de yürütülen faaliyet ve deney sayısının yetersiz olduğu söylenebilir. Son dönemde geleneksel veya yeni nesil elektrikli ticari araç üreticileri, sürdürülebilirliği ticari kararlarını alırken bir etken olarak pozisyonlamaya başlamışlardır. Elektrikli araç üreticileri teşviklerin yetersizliğine dikkat çekmiştir. Diğer yandan elektrikli araçların kullanıcısı pozisyonda olan posta ve kargo firmaları ise Türkiye'deki elektrikli ticari araç üreticilerinin hem teknik hem iş kapasitelerine yetersiz görmüşlerdir. Mevcuttaki araçların performans yetersizliğine, pahalı olmasına, ikinci el pazarının oluşmamasına, menzil problemlerine dikkat çekmişlerdir. Ayrıca araç sahipliğinin ana posta ve kargo firmasına değil bireylere ait olduğu ve acente mantığı ile çalışıldığı ifade edilmiştir.

Bilgi üretilmesi kısmında ise üniversitelerin asıl sorumlu olduğu söylenmiş fakat çalışmaların yetersiz olduğuna da dikkat çekilmiştir. Üniversiteler Türkiye'de tarafsız ve objektif kurumlar olarak görülmektedir. Bu sebeple firmalar üniversitelerin daha çok aktif rol alması gerektiğini düşünmektedir. Ayrıca araç üreticileri veya kargo firmalarının araştırma ve geliştirme faaliyeti yürütmek için yeterli insan kaynağı, finansal kaynağa ve teknik altyapısı bulunmamaktadır. Üniversiteler tarafından elektrikli ticari araçlara yönelik araştırma ve geliştirme faaliyeti yürütürken üniversite sanayi iş birliğinin de güçlü olması önemlidir. Aksi takdirde piyasada kullanılmayacak çözümler ortaya çıkmaktadır.

Üçüncü fonksiyonu olan bilginin difüzyonu konusunda Türkiye'deki faaliyetler yeterli olarak görülmemektedir. Konferanslar, seminerler, fuarlar, atölye çalışmaları gibi farklı aktiviteler bilginin yayılmasında etkili olmaktadır. Katılımcılar Türkiye'de elektrikli araçlara yönelik etkinliklere sadece üst düzey yöneticilerin katıldığını söylemişlerdir. Bu durum araçların asıl kullanıcısı olacak şoförlerin konuya ilişkin bilgi sahibi olmamasına ve ön yargı geliştirmesine sebep olmaktadır. Şoförleri odak almayan bilgi difüzyonu çalışmaları saha direnci ile sonuçlanmaktadır. Ayrıca patent sistemine olan güvensizlik de bilgilerin yayılmasında bir bariyer olarak karşımıza çıkmıştır.

Dördüncü fonksiyon altında belirli stratejik hedeflerin ve ulusal politikaların varlığı araştırılmıştır. Belirli hedeflerin koyulması sürdürülebilirlik dönüşümü adına kıymetlidir. Bu noktada özellikle hedefleri koymak dışında takip mekanizmalarının gerekliliği ön plana çıkmıştır. Paris İklim Anlaşması ve Avrupa Birliği Yeşil Mutabakat metni çevresel sürdürülebilirliğe katkı verecek temel dönüşüm alanlarındandır. Ayrıca sektördeki büyük kargo oyuncularının şirket olarak hedefler belirlemesi ekosistemi dönüştürme gücüne sahiptir. Araç alımlarında sürdürülebilirlik maddesini şart koşan kargo firmaları, son kilometre operasyonlarının daha çevre dostu olmasını tetikleyebilir.

Pazar düzenleme faaliyetlerinde teşvikler ve düzenlemeler olmak üzere iki ana konu karşımıza çıkmaktadır. Kargo firmalarının elektrikli ticari araç alımlarında KDV ve ÖTV indirimleri yapılması, elektrikli ticari araçların şarj edilmesine yönelik istasyon kurulum ve elektrik tüketim desteği verilmesi, elektrikli ticari araç üretim destekleri sağlanması gerekliliği araştırmada ön plana çıkmıştır. Ayrıca kargo firmalarına sera gaz emisyonu konusunda bir üst limit getirilmesi sektördeki yeşil lojistik aktivitelerinin etkinliğini artırabilir.

Kaynakların mobilize edilmesi fonksiyonu altında Türkiye'de farklı bariyerler gözlemlenmiştir. Bu başlık altında finansal kaynaklar, şarj altyapısı, tamir & bakımı altyapısı ve insan kaynağı altyapısı incelenmiştir. Finansal kaynaklar konusunda Türkiye'de elektrikli ticari araçların pahalı olması dışında büyük bir probleme rastlanmamıştır. Çeşitli bankalar elektrikli şarj istasyonu kurulumu ve elektrikli araç alımına yönelik avantajlı krediler sunmaktadır. Elektrikli şarj altyapısı konusunda ise özellikle küçük şehirlerde şarj altyapısının olmaması ulusal faaliyet gösteren kargo firmalarını olumsuz etkilemektedir. Türkiye'nin Otomobili Girişim Grubu (TOGG)'un piyasaya çıkması şarj altyapısı konusunda pozitif gelişmeleri tetiklemiştir. Ayrıca elektrikli ticari araçların şarj konusundaki ihtiyaçları elektrikli yolcu aracından farklıdır. Ticari araçların mesai saatlerinde dışında şarj edilebiliyor olması şu anda yeterli olarak görülmektedir.

Bir diğer alan olan tamir ve bakım altyapısı konusunda ise Türkiye'deki çalışmalar devam etmektedir 12 farklı üniversitede hibrit ve elektrikli taşıt teknolojileri bölümü

nitelikli teknik personel yetiştirmek adına eğitim vermektedir. Buna ek olarak otomotiv üreticisi firmalar elektrikli araç bakımı yapabilecek personel yetiştirmektedir. Elektrikli araçların motorlarındaki yüksek gerilim sebebiyle tamir ve bakımın donanımlı personeller tarafından gerçekleştirilmesi gerekmektedir.

Çalışmalara meşruiyet ve kalıcılık kazandırmaya yönelik aktiviteler konusunda Türkiye'de çeşitli sivil ve resmi kuruluşların var olduğuna dikkat çekilmiştir. Paydaşların bir araya gelerek sektör sorunlarını ve dönüşümleri planlayabileceği platformların olması kritik öneme sahiptir. Türkiye'de faaliyet gösteren kargo, elektrikli araç veya sürdürülebilirlik dikeyindeki lobi gruplarının etkinliğinin daha da artırılması gerekmektedir. Bu örgütler kamu ile özel sektör arasında köprü görevi üstlenerek uygulanabilir politikalar üretilmesini temin edebilirler.

Türkiye'de kargo şirketlerinin son kilometre operasyonlarında elektrikli araç kullanımının önündeki bariyerleri araştıran bu çalışma sonucunda 7 farklı alanda bariyerler tanımlanmıştır. Yarı yapılandırılmış mülakatlar yöntemi ile elde edilen verilerin analizi sonrasında ortaya çıkan bulgular daha önceki akademik çalışmalar ile birlikte tartışma bölümünde tekrar ele alınmıştır.

Araştırma kapsamında bulgulara dayalı olarak Türkiye'de elektrikli ticari araç kullanımını kargo operasyonlarında arttırmak için farklı politika önerileri geliştirilmiştir.

Elektrikli araç üreticilerini desteklemek adına KDV başta olmak üzere indirimlerin sunulması, araç üreticilerinin AR-GE personellerinde sigorta muafiyeti ve istisnaların sunulması sektördeki firma sayısını artırabilir. Ayrıca bu firmaların iş yapma kapasitesinin iyileştirilmesi ve yeni firma sayısının artırılması adına elektrikli ticari araçlar dikeyinde bir kuluçka merkezi kurulması önerilmiştir. Elektrikli ticari araçların kullanımın önündeki en büyük engellerden olan teknik bariyerlerin (menzil, hız, yokuş çıkma, şarj süresi) çözümüne yönelik teknoloji yarışmaları ve araştırma merkezlerince düzenlenecek faaliyetler çözüm olabilir. Ayrıca akademik araştırmaları desteklemek adına elektrikli ticari araçlar dikeyinde araştırma çağrıları düzenlenebilir.

Nitelikli insan kaynağı sayısını artırmak adına mevcutta eğitim veren 12 üniversitenin öğrenci kontenjanı artırılabilir, sadece ön lisans seviyesinde eğitim veren bu bölümlere lisans, yüksek lisans ve doktora eğitim dereceleri eklenebilir. Bu durum piyasada başta tamir ve bakım olmak üzere ihtiyaç duyulan nitelikli insan kaynağının yetişmesinde etkili olabilir. Ayrıca mesleki eğitim veren liselerde motorlu taşıtlar bölümüne elektrikli araçların eklenmesi de önerilmiştir. Bilginin yayılmasına yönelik olarak etkinlik ve fuarların verimliğini iyileştirmek adına kalkınma ajansları yerel farkındalık yaratmak adına etkinlikler düzenleyebilirler. Seçilen üniversiteler bölgelerinde elektrikli araç konusunda temsilci olarak akademi – sanayi iş birliğini destekleyebilirler. Ayrıca meşruiyet kazandırmak adına üniversitelerde öğrenci kulüplerinin kurulması da teşvik edilebilir. Posta ve kargo firmalarının elektrikli araç kullanımına yönelik teşvikler verilebilir. Özellikle kamu kaynakları ilk kullanıcı rolünü üstlenerek kamu posta operasyonlarında elektrikli ticari araç kullanabilirler.

Türkiye'de faaliyet gösteren posta ve kargo firmalarına araç sayısına odaklı olarak belirli bir zararlı gaz emisyonu limiti getirilebilir. Şarj istasyonu kurulumuna yönelik teşviklerin de desteklenmesi ile birlikte araçların kullanımının önündeki bariyerler ortadan kaldırılabilir. TOGG'un Türkiye'de piyasaya çıkması hem farkındalığı artırmış hem de altyapının gelişmesine katkı vermiştir. TOGG ve sürdürülebilirlik hedeflerine rağmen Türkiye'de ulusal bir elektrikli araç politika belgesinin olmaması sektörün gelişmesinde etkilidir. Elektrikli araçların kullanımının son kilometre operasyonlarında iyileştirilmesi için son olarak lobi faaliyetlerinin etkinliği iyileştirilebilir. Verilecek tüm teşvik ve hibelerde proje başvurusunun konsorsiyumla yapılma zorunluluğu olması durumunda üniversite, özel sektör, sivil toplum örgütleri ve kamu eş zamanlı olarak konuya ilişkin güçlü iletişimi sağlayabilecektir.

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YAZARIN / AUTHOR

Soyadı / Surname : PARLAK
Adı / Name : Cemal Atakan
Bölümü / Department : Bilim ve Teknoloji Politikası Çalışmaları / Science and Technology Policy Studies

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