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THE EFFECTS OF INTERNET OF THINGS ON THE TRANSPORTATION COST MANAGEMENT: A STUDY OF LOGISTICS COMPANY

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ABSTRACT

Purpose- The purpose of this study is to examine the Internet of Things (IoT) conceptually and structurally. In this regard, the study will examine the potential effects of the investments of the Internet of Things in the transportation operations of logistics, discuss the potential effects of the transportation costs of the Internet of Things and investments on control and Management. This study also analyze and evaluate such investments in a logistics company.
Methodology- In order to examine the potential effects of IoT investments on the management of transportation costs, an interview was conducted with an Istanbul-centered company of logistics service provider in this study. The data were collected and evaluated by asking open-ended questions within the scope of qualitative research with an interview technique.
Findings- It was determined that the company gained the advantage of real-time monitoring and controlling of the transportation operations, real-time monitoring of vehicles and drivers, monitoring of the thermal conditions of loads, monitoring and controlling of the incidents of losses and accidents through hardware and various technology like the Internet of Things (IoT) and integrated sensors to it. On the other hand, the study received comprehensive support of data from the company about the transportation process and the control of vehicles, loads, and drivers with IoT investments and the costs of transportation. Thus, the study obtained significant advantages for determining, calculating, and controlling costs. However, since IoT investments are new, and R & D operations for some integrated technologies continue in the company, the quantitative data that include cost advantages have not been formed yet. Therefore, a limited evaluation was conducted.
Conclusion- Technically, IoT is a technology that connects the vehicles in transportation operations in logistics with smart networks. IoT enables complete control and real-time monitoring for transportation operations, and it can decrease setbacks and waiting during the transportation process. In this regard, it can increase the management power for the transportation costs by offering advantageous qualities, such as comprehensive data support and real-time monitoring for determining and calculating the transportation costs and controlling expenses or spending. Hence, IoT can increase value-added for transportation operations and provide competitive pricing advantages with its cost. Consequently, IoT investments can provide advantages like “offering a transportation service with high value-added to supply chains, decreasing the costs of vehicles and drivers, and optimal pricing” to logistics companies against their opponents.

Keywords: Internet of things, transport operations, logistics cost, transportation cost, cost management.
JEL Codes: L90, L91, M10

1. INTRODUCTION

Nowadays, Logistics Service Providers (LSP) utilize information technologies for transportation operations similar to warehousing operations to increase efficiency, optimize the usage of capacity and resource (the usage of containers and trucks to optimal fullness), decrease waiting period, achieve economic fuel consumption, decrease the expenses of drivers, and accelerate the deliveries (Prasse et al., 2014:20). Although technologies like automatization traditionally provide easiness to warehousing operations thanks to its central structure, new generation technologies that support mobilization should be used in transportation operations besides automatization (Forcolin et al., 2011:7). At this point, smart logistics express the use of new generation technologies in accordance with traditional logistic solutions for a mobilized transformation in which transportation operations can be optimally planned, managed, and controlled (Song et al., 2021:4253).

In other words, smart logistics is a Logistics 4.0-based transformation that aims gains, such as rapid adaptation to changes in demands, and changes in other environmental factors, development of operational skills, increasing value-added, improvements to costs, creation of rapid and flexible movement order, and professional management of operations, by utilizing new generation technologies (Chen, Sun et al., 2021:1-2). Logistics 4.0 describes an process in which logistic operations are installed with new technologies and smart systems, and labor force participation is decreased extensively in order to deliver an order to its consignee rapidly, impeccably, and profitably (Correa et al., 2020:1). At this point, the Internet of Things (IoT) is a network structure that things in different places in the production of logistics services (vehicles, facilities, other equipment, and items) are connected to each other with smart and secure networks. These things can also communicate with each other rapidly and transfer real-time data (Hopkins and Hawking, 2018:578). Therefore, IoT can provide some potential advantages in terms of “smart logistics” by connecting vehicles in different places that have been used in transportation operations to each other through a smart network.

The purpose of this study is to research the effects of a new generation field of investment, the Internet of Things, on monitoring, controlling, and managing costs. In this regard, research was conducted on IoT and a logistics company with supportive investments in IoT through the interview technique. The study also includes findings from the answers to open-ended questions and evaluations of these findings.

2. CONCEPTUAL FRAMEWORK

2.1. The Internet of Things

The Internet of Things (IoT) is a technology that senses various equipment operations in real-time by connecting them, supports logistic operations for produced data from this equipment, and transfers these data immediately (Liu et al., 2018:663). In other words, IoT is a new generation of technology that provides data transfers and communications between things in different places and supports the transformation of these data into information by processing them and the application of decisions through these data (Guo and Qu, 2015:935). IoT aims for a job environment that can expand when the number of included things in the network increases, can ease mobility, real-time monitoring and control can be conducted, high-volume data can be produced, these data can be utilized by analyzing them, and all things can connect to a network with a digital id (Tu et al., 2018:65-66).

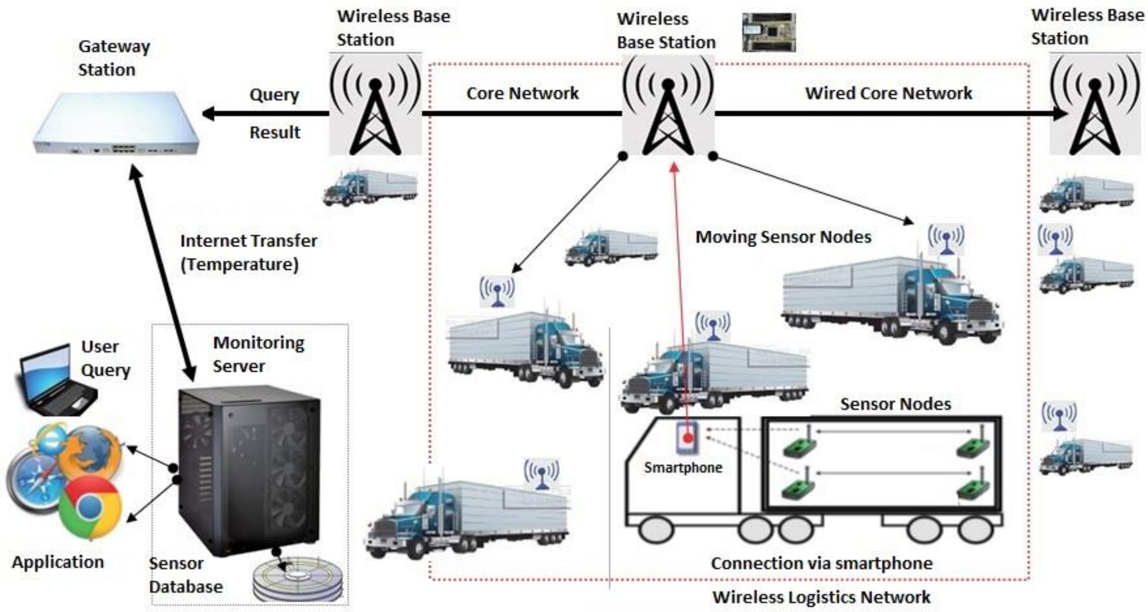
Basically, the architectural structure of IoT comprises four layers: “Sensing Layer, Network Layer, Processing Layer, and Application Layer.” “Sensing Layer” captures data about various physical activities with hardware integrated into IoT, such as the RFID (Radio Frequency Identification) System, cameras, sensors, and microphones. “Network Layer” transmits the collected data in Sensing Layer to upper layers in real-time. “Processing Layer” provides data collection from Network Layer in Cloud, and the presentation of the usage of decision-maker, or smart things by filtering these data with advanced software, computers, algorithms, and calculation techniques. The most upper layer, “Application Layer,” ensures the transmission of the final decision after analyses and interpretation of the data (Chen, Chen and Yang, 2021:4; Song et al., 2021:4255).

In terms of logistics system IoT unites a system of components such as trucks, containers, tankers, and ships which aim to deliver “the right product with the right quantity to the right place in the right time” with sensors, GPS (Global Positioning System), the RFID (Radio Frequency Identification) System, sound detectors, and cameras (Hopkins and Hawking, 2018:579). In addition to the applicational usage of new generation technologies during transportation operations, IoT also aims to install a smart network structure that increases the autonomous working skills of things (Chopra, 2020:261).

2.2. The Potential Effects of the Internet of Things to Transportation Operations

Nowadays, sensors with temperature, humidity, speed, and other perceptual qualities have been used along with technologies like GPS within transportation operations. Wireless Sensor Network (WSN) that connects these sensors to a smart network eases obtaining and transmitting data from vehicles and containers during the transportation process. In this regard, WSN can be a significant component for monitoring the transportation process, determining existing and possible issues, and providing solutions for those issues. (Song et al., 2021:4255). On the other hand, although the RFID system has been used extensively in warehousing, it can also contribute to transactions of obtaining, transmitting, and confirming data by installing the system into vehicle doors and containers during the transportation. Basically, the RFID System comprises RFID Tag (it can be used in the long-term by changing its components), RFID Tag Readers, Antennas, and computers. It is a technology that allows wireless uploads and transmissions of data. Thus, since the RFID system can be read wirelessly, and its tag component can be changed continuously and securely, it has become widespread along with WSN in transportation. Although RFID and WSN wireless technologies, IoT smart network system is essential for the real-time transmissions of produced data and movement sensors during transportation. Therefore, IoT connects trucks, containers, and other components in a broadband network by integrating hardware, such as WSN, RFID, GPS, cameras, and microphones, to itself. (Anandhi et al., 2019:544). The usage of IoT during transportation operations can be expressed with the aid of a figure:

Figure 1: Wireless Logistics based on Smart Sensor Nodes



Source: Byun, 2019, p. 522

When Figure 1 is examined, installed sensors in vehicles during the transportation process play a significant role in collecting captured real-time data by sending them to the gateway. While integrated sensors to IoT can provide instant monitoring of vehicles like GPS, they can also provide data about the conditions of loads in the vehicle. Similarly, IoT can accelerate vehicle drivers to send data to the gateway with their smartphones as well. When WSN is integrated into IoT, just like in Figure 1, it not only allows wireless monitoring and control of the transportation process operationally but also eases the transmissions of piled data in Sensor Nodes to mainframes (hence, to databases) without waiting. However, advanced software will be necessary for the transmission of obtained data from IoT and IoT-integrated technologies. On the other hand, adequate internet infrastructure and eliminating geographical connection issues for the materialization of functioning in Figure 1 have significant roles. In this way, produced real-time data with IoT will contribute greatly to the performance of the transportation process alongside determining, analyzing, and controlling transportation costs.

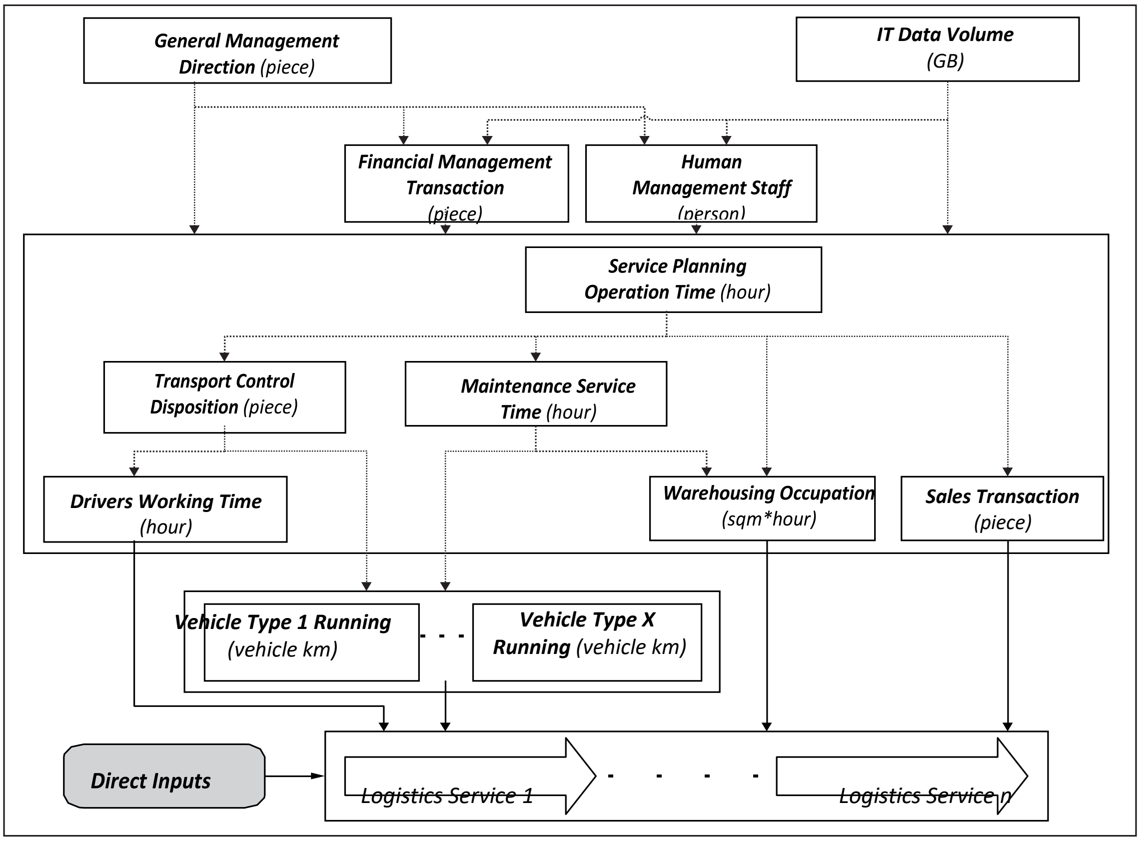
Installed gears to loads and containers with IoT like GPS and sensors enable real-time monitoring and control in several aspects, such as general conditions of loads, thermal and humid balance condition, conditions of weather and route, the possibility of an accident, conditions of vehicles' engines, and location of vehicles (Shah et al., 2020:253; Humayun et al., 2020:58). Thus, when the number of components like vehicles, containers, warehouses, transshipment centers, and delivery points increased, or the number of deliveries to geographically different points increased, flexibility and automatization will be easier. In other words, IoT will provide a service production responsive to the increases in the numbers of vehicles, containers, and facilities in the transportation process and pickups and deliveries to geographically different places (Liu et al., 2018:663-664; Bashir et al., 2019:1). In addition to these developments, the usage of IoT will decrease setbacks in the process thoroughly by contributing to determining and intervening with these problems following predictive maintenance procedures and malfunction indicator systems (through sensors) for the vehicles (Hopkins and Hawking, 2018:583). IoT will contribute to analyses and optimizations with its broadband network structure in accordance with the sudden changes of the route and order by presenting previous and current data about the transportation process to the decision-makers. In this regard, IoT will become a powerful supportive technology compatible with whichever update for the transportation process for the transactions of speed, time and cost estimation, and optimization (Lopes and Moori, 2021:4; Sergi et al., 2021:19).

2.3. The Potential Effects of the Internet of Things on the Management of Transportation Costs

Logistic costs consist of all the costs of operations (services like warehousing, packaging, preparations to dispatching, transportation, and insurance) that have been conducted from the supply of a product to the delivery of this product to the customer. Logistic cost items are: transportation costs, inventory and material handling costs, warehouse and distribution costs (planning and management of the centers of warehouse and distribution), and informatics costs (demand forecasting, order processes, and production scheduling costs) (Ozdemir, 2018:16). Transportation costs basically consist of fuel expenses, vehicle expenses, and driver expenses (accommodation, food, and document expenses), expenses about the route (tolls), and expenses for the protection of the order (Globerman and Storer, 2015:68). Transportation costs encapsulate various factors, such as expenses and investments related to weight and volumes of loads, risks, vacant capacity, equipment, labor expenses, and visible or nonvisible alternative costs (Kaya, 2018:130).

Consequently, transportation costs include routine expenses natural to transportation operations (expenses like loading-unloading and protection), unplanned expenses (abiding expenses for vacant capacity), extraordinary expenses (expenses due to delays from losses and accidents), and alternative costs (returns of the alternative investments) (Stępień et al., 2016:491). Supportive activities for transportation like warehousing, customs clearance, and other services should be included in transportation costs. Moreover, when transportation costs are calculated, situations stemming from waiting like "transactions of loading-unloading in different places, and break" during the management of transportation operations from pickup to deliveries should be considered carefully. Costs originating from these waitings should be included in analyses for the calculation of transportation costs as well (Shine-Der and Yen-Chen, 2014:23-24; Sebestyén, 2017:159-160). Hence, "order's content, hazard class, orders that belong to more than one customer, differences of delivery points, distance, route, transshipping, fuel, and other parameters" should be taken into account for the determination and calculation for the costs of transportation operations (Turkensteen and Klose, 2012:500). When it is considered from this aspect, the association between transportation costs and produced transportation services can be made as follows:

Figure 2: Cost Calculation Model for Logistics Service Providers



Note: sqm: Square meters; GB: Gigabyte; km: Kilometer
Source: Bokor, 2012: 519

According to Figure 2, when costs are calculated in transportation, routine expenses such as "fuel consumption, energy consumption for warehousing, the usage of facilities, and tolls" should be included in the calculation of transportation costs directly. Then, driver expenses following the calculation model for transportation costs, labor expenses, finance expenses,

expenses for information technologies, maintenance and repair expenses, process control expenses, warehousing expenses, and marketing expenses should also be included. Pricing in terms of route length became easier in the created model for the calculation of transportation costs within this framework. As seen in Figure 2, procuring the support of information technologies affects control costs and other expenses. Moreover, it can be seen that information technology should be monitored as a separate expense. In this regard, installing IoT network system for monitoring and controlling costs may provide significant data support for the calculation and determination of costs. Therefore, LSP can be used to determine, monitor, and control the transportation costs of IoT investments.

IoT will be a significant item for delivering various types and amounts of orders from the customers of different regions with minimum costs, especially like in Figure 2. In this regard, IoT will ease the performance analyses of the cost accounts model for cost elements by providing real-time data, efficiently and rapidly operating automatization and software, and running trial and error simulations in order to achieve minimum costs for transportation transactions (Wang et al., 2020:2-3). As determined before, since IoT will provide real-time data during the transportation process, it will support cost updates following possible or extraordinary developments during the course by easing the updates on the costs (Chen, Sun et al., 2021:3).

Furthermore, costs can be controlled with IoT in during the transportation with precautions like directing the vehicles to different routes without waiting, leading the vehicles to contracted gas stations or resting places aiming not to pass the limited spending budget, and providing rapid maintenance and repair services to malfunctioned vehicles. Therefore, the advantages of recalculations of transportation costs and live updates for the prices of transportation services will become a possibility with IoT (Guo and Qu, 2015:935). On the other hand, IoT will decrease transportation costs with contributions, such as decreasing fuel consumption, shortening delivery time, utilizing predictive maintenance procedures, and planning dynamic routes, thanks to its immense data support (Hopkins and Hawking, 2018:582-583). In addition, IoT has the potential to contribute to achieving calculation and optimizations of costs for the transportation process by ensuring automatic data flow from multiple databases, such as the banking system (Chen, Sun et al., 2021:4). However, IoT will cause increases in informatics expenses because it connects multiple things, users, and databases to a smart network. Thus, although IoT provides significant advantages to the costs in transportation operations, it will also increase informatics expenses in standard cost systems. In these circumstances, informatics expenses can be decreased if new generation vehicles like Autonomous Vehicles could be more widespread in transportation operations (Byun, 2019:522).

3. PREVIOUS STUDIES

A literature survey was conducted for the studies that examined the effects of IoT on transportation costs. In this regard, Chen, Sun et al. (2021) suggested an estimation method for vehicle routing and optimization of delivery time through components like IoT and GPS, cameras, sensors, and detectors integrated into IoT. The authors tested the Gradient Boosting Partitioned Regression Tree Model for this purpose. They observed positive results from this model. Moreover, they emphasized how high profits can be achieved with IoT by adding more data to the analysis.

Wang et al. (2020) suggested an IoT-supported smart dispatch platform that coordinates customers, order-picking robots, and Cloud Technologies. This platform has a three-level system. The first level is a framework structure for an IoT-based smart dispatch platform. The second is an optimization model for efficient coordination between customers, order-picking robots, and Cloud Technology, and the third is the core two-level algorithm with Dijkstra's Algorithm and the Ant Colony Algorithm that supports smart dispatch transactions. They determined that IoT-supported dispatching operations are more advantageous than traditional methods.

Hopkins and Hawking (2018) analyzed the role of IoT with Big Data Analytics for improving driver security, decreasing costs, and reducing negative effects on the environment in a logistics company. They analyzed telematics system data, sensor data (break, speed, and motor), and driver resting data by combining them with visual data (Truckcam Application). They observed results like the provision of eco-driving and the reduction of negative effects on the environment (emission effects) during the transportation process. Zhang et al. (2018) conducted a case analysis for the IoT system that aims at the integration of logistics activities in a production business. They concluded that IoT can decrease energy consumption and waiting times. Liu et al. (2018) designed and suggested an IoT-supported real-time data concentrated sensing model for the optimization of logistics processes in terms of costs, fuel consumption, environmental impact, and distances. They concluded that the optimization of logistics resources is possible with the total reduction of logistics costs, fuel, and distances through the simulation of the RFID-based twenty vehicles. Chen, Chen, and Yang (2021) applied the Analytical Hierarchy Process method (five primary factors and twenty-one evaluations) for generating basic achievement factors that will utilize IoT in smart logistics service production. At this point, they concluded that adopting IoT as an application will have significant effects on indicators like information gathering, wireless communication, low costs, getting real-time data, provision of data integrity, privacy, and cargo tracking. Correa et al. (2020) researched to measure Brazilian logistics companies' reasons for investing in IoT and Big Data Analytics and their expectations from these investments. In this regard, they detected that expectations like profitability, cost minimization, customer satisfaction, and estimation ability are salient for the companies.

Tu (2018) analyzed to discover the factors that affect the decisions of Taiwanese companies from different industries to adopt IoT with Structural Equation Modeling (SEM). The author detected that IoT is prominent in improving costs and technological benefits. Lopes and Moori (2021) researched IoT's role in the relationship between strategic logistics management and operational performance. They analyzed the survey data of seventy-six Brazilian logistics and retail companies that utilize IoT in their study. They concluded that IoT partially affected the relationship between strategic logistics management and operational performance. Moreover, they also detected that IoT contributed to the connection of things, automatization, remote control, and decreasing mistakes.

4. DATA, METHODOLOGY AND FINDINGS

This study analyzed the effects of one company's IoT investments on transportation cost management. In this regard, it will include an interview with one of the company's executives that provides domestic and foreign transportation services. Although the center of this company is in Istanbul, it has various facilities and a large vehicle fleet domestically. The company can produce logistical solutions for many sectors, especially cold chain services. It also has technological investments in transportation activities, especially for warehousing. The interview included questions to the executive of this company about the company's general structure, the structure of transportation activities (the structure of warehousing activities as well), IoT investments, the effects of IoT investments on transportation activities, and the potential effects of IoT investments on transportation cost management. Finally, the study conducted qualitative analysis and evaluation within the framework of the answers of this company's executive.

4.1. General Findings about the Company

The center of this company, which an interview was conducted for the research, is Istanbul, but it provides various logistics services both nationally and internationally, especially in "transportation, warehousing, and inventory management." This logistics company offers suitable solutions to products or load types like food, textile, electronics, domestic appliances, medicines, cold chain, and automotive. The company conducts its transportation operations with road transportation integrated with railway, maritime, and airline transportation types. In this sense, a figure was prepared for general information about this company:

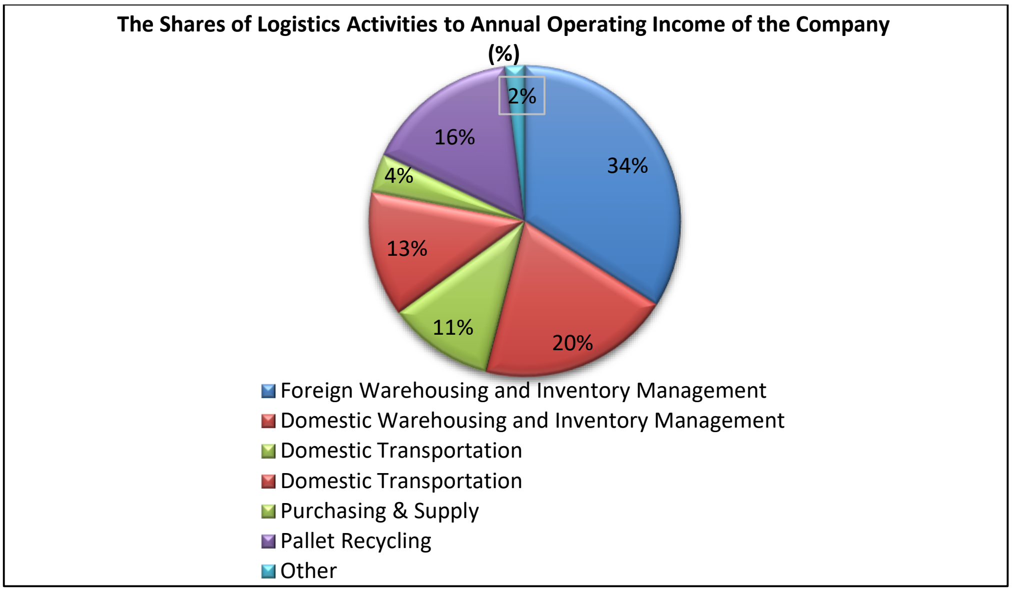
Table 1: General Information about the Company

Income of the Company (2021 Year)	9.7 billion TL
Operating Period	18 Year
Number of Employees	12.000
Number of Warehousing Centers	122
Number of HUB (Dispatching Consolidation Center)	21
Warehousing Space	1.200.000 m^2
Warehousing Capacity	3.500.000 m^3
Total Number of Vehicles (Self-owned vehicles)	4.000 pieces
Number of Pallet Allocation Centers	11 pieces (67.000 m^2)

Note: m^2: Square meters; m^3: Cubic meters

When Table 1 is evaluated, it is safe to say that the company conducts its logistics services extensively with self-owned vehicles. The company has 122 warehousing centers and 11 Pallet Allocation Centers (the warehouses with only pallets that the company either uses for its logistics services or rents them to other companies). Moreover, the company also has 21 HUB (Dispatching Consolidation Center) facilities special to dispatch transshipments and combinations. The space the company uses for warehousing activities is approximately 1.200.000 m2, and the warehousing capacity is 3.500.000 m3. The company has 4.000 self-owned vehicles for transportation operations. Finally, the 2021 incomes of the company are approximately 9,7 billion Turkish Liras, its operating period is 18 years, and the number of employees in the company is 12.000. Son In addition to the data in Table 1, the company's logistics activities are "Transportation, Warehousing, Inventory Management, Handling, Pallet Recycling, Barcoding, Labeling, Renting (Usually Equipment), and Cold Chain Logistics." The shares of these activities in the annual "Operating Incomes" are as below:

Figure 3: The Contribution Levels of Logistics Activities to Annual Operating Income of the Company



According to Figure 3, the shares of logistics activities in operating income are sorted proportionally. Foreign Warehousing and Inventory Management's share including labeling and barcoding are 34%. Domestic Warehousing and Inventory Management's share are 20%, and Pallet Recycling's share is 16%, Foreign Transportation Operation's share is 13%, Domestic Transportation Operation's share is 11%, Purchasing and Supplying Operation's share is 4%, and other operations' share (like renting equipment) is 2%. In this sense, when Figure 3 was analyzed, while the company's warehousing operations have a 54% share in "Operating Incomes," transportation operations have a 24% share. Finally, the company's executive emphasized that the company has a 60% market share, especially in warehousing and transportation for cold chains.

4.2. Findings about Transportation and Warehousing Operations

As expressed in Figure 3, the company's logistics activities are primarily transportation and warehousing. The company has vendor services for transportation activities like project type transportation (special to large loads with one vehicle and heavy tonnage), partial transportation, cold chains transportation, and hazardous materials and liquid food transportation. Since the company generally uses road transportation, relative information about this subject is summarized as below:

Table 2: General Information about Transportation Activities

Information about Road Transportation	
Number of Vehicles for Domestic General Load Types	1.720 Self-owned Vehicles
Number of Dedicated (Special to One Customer) Vehicles (for Pallet Allocation)	380 Self-owned Vehicles
Number of Vehicles for Cold Chain Logistics	1.200 Self-owned Vehicles
Load Quantity Domestic	8.000.000 tons
Number of Vehicles for Foreign General Load Types	700 Self-owned Vehicles
Foreign Load Quantity	500.000 tons

As seen in Table 2, the company has 4.000 self-owned road transportation vehicles. 1.720 of these vehicles are for domestic general load types like food, textile, medicine, and electronics. 1.200 of these vehicles are for cold chains. 700 of these vehicles are for internationally general load transportation. 380 of these vehicles are for Dedicated (Special to One Customer) Transportation that is designed for pallet allocation. When the quantities of loads are determined, the company has 8.000.000-ton domestic and 500.000-ton foreign transportation jobs. As seen in Table 2, the company extensively conducts its transportation activities with its vehicle fleet. The company spreads its technological investments to transportation activities as well. The researched company has various facilities for warehousing activities: "Central (Leading) Warehouse, HUB (Dispatching Consolidation Center) Warehouse, Dedicated (Special to One Customer) Warehouse, Multi-User (Designed for more than one customer) Warehouse, Bonded (Entrepot) Warehouse, and Cold Chain Warehouse." The company has multiple vendor services, such as handling, barcoding, labeling, inventory management, dispatch consolidation (HUB), and transshipment. When these vendor services are totally evaluated with warehousing activities, the information about this issue is summarized as below:

Table 3: General Information about Warehousing Activities

Number of Warehouses for General Load Types	96
Number of Warehouses for Cold Chain	26
Number of Pallets	2.500.000
General Warehousing Space	1.070.000 m^2
Warehousing Space for Cold Chain	130.000 m^2
Total Warehousing Capacity	3.500.000 m^3
Number of Packages Warehoused (Annually)	640.000
Number of Packages for Cold Chain Warehousing (Annually)	360.000

Note: m^2: Square meters; m^3: Cubic meters

As seen in Table 3, the company annually conducts warehousing services for 1.000.000 packages. 360.000 (36% of the sum of packages) of these services are for cold chain logistics, and 640.000 (64% of the sum of packages) of these services are for other loads. On the other hand, the company totally has 1.200.000 m2 of warehousing space. 130.000 m2 (10,8 % of the sum of warehousing space) of this warehousing space is allocated to cold chains, and 1.070.000 m2 (89,2% of the sum of warehousing space) is for other types of loads. Additionally, the company has a 3.500.000 m3 warehousing capacity and 122 warehouses. 96 (78,9% approximate sum of warehouse numbers) of these warehouses are for general load, and 26 (21,1% of the approximate sum of warehouse numbers) of these warehouses are for cold chain. Finally, the company has 2.500.000 pallets. The relative pallet data have consisted of pallets that the company either uses for its own warehousing and transportation services or rents to other companies.

4.3. Findings about IoT and Other New Generation Investments in Transportation Activities

The company interviewed for the research uses advanced software, sensors, RFID system, and Cloud-Computing supported automation in transportation activities for the transactions of "inventory input, racking, monitoring, controlling, preparations to dispatch, and inventory output." In addition to these transactions, the company also made various investments for its second basic logistics activity, transportation operations. At this point, investments that are directly related to the transportation process, except GPS, and investments for warehousing services that are conducted with transportation in an integrated manner are summarized in below table:

Table 4: IoT and New Generation Investments for Logistics Activities

Logistics Activity Type	Content of the Investment
Transportation Activity	*Internet of Things (IoT) *Wireless Sensor Networks (WSN) *Global Positioning System (GPS) *Cloud Computing *Electrical Truck (R&D studies continue.) *Autonomous Truck (R&D studies continue.) *Smart Container System (R&D studies continue.) *Big Data Analytics (R&D studies continue.) *Other software or programs (such as SAP, Manhattan Associates, RedPraire, JDA, Axata)
Warehousing Activity (including Handling, Inventory Management)	*Wireless Sensor Networks (WSN) *Radio Frequency Identification (RFID) System *Cloud Computing *Cyber-Physical Systems (R&D studies continues) *Big Data Analytics (R&D studies continues) *Machine Learning (R&D studies continues) *Other software or programs (such as SAP, Manhattan Associates, RedPraire, JDA, Axata)

According to Table 4, IoT and IoT-integrated WSN and GPS have been used in transportation operations lately. Nevertheless, the company also has software support with Cloud Computing that has been used in warehousing operations integrated with the IoT smart network. On the other hand, the company executive also expressed that they conducted R & D operations for new generation investments, such as "Smart Container, Autonomous Truck, Electrical Truck, and Big Data Analytics."

Moreover, the company executive was determined that IoT has been used in transactions such as "real-time monitoring during the transportation process, instant and locational monitoring of vehicles, monitoring and controlling thermal balances for the loads, route planning for vehicles, instant detection of incident or loss conditions, instant control of driver spendings, and performance analysis," in transportation. In addition, RFID, WSN, Cloud Computing, and various software have been used during warehousing activities as well. In this regard, the company executive indicated that R & D operations have been conducted in investments fields, such as "Big Data Analytics, Cyber-Physical Systems, and Machine Learning," for transportation activities and warehousing process that is digitally integrated into transportation activities with transportation activities. Although the company executive indicated that these investments are especially for cold chains logistics, he also mentioned that these investments have an important place in other services for other types of loads.

4.4. Findings about the Effects of IoT on Transportation Cost Management

The company executive indicated that they observed that IoT and IoT-integrated investments have significant advantages for general monitoring of transportation process and its control and management in addition to route planning and monitoring vehicles and loads in transportation operations. In this regard, the company executive expressed that the tolerated costs for transportation operations are driver expenses and vehicle expenses. Therefore, the transportation costs of the company have consisted of tolerated costs or expenses from picking up the loads to delivering them to their respective recipient. Within this aspect, the items of transportation costs can be expressed with a table:

Table 5: Transportation Cost Items of the Company

Transportation Cost Items	**Amount**
Fuel Expenses	XX
Document Expenses	XX
Insurance Expenses	XX
Tolls on Bridges and Highways	XX
Driver Expenses	XX
Communication (or Information Technology) Expenses	XX
Depreciation	XX
Maintenance-repair Expenses	XX
Taxes	XX
Management Expenses	XX
Total	**XX**

According to Table 5, transportation costs in process are tolerated expenses from picking up the loads to delivering the loads, such as fuel expenses, document expenses, tolls on bridges and highways, insurance expenses, driver expenses, communication (or Information Technology) expenses, depreciation, maintenance expenses, management expenses, and taxes. The company executive indicated that IoT investments provided advantages in terms of costs in addition to plannings for transportation process and monitoring and controlling the process in transportation operations. Within the scope of the research, the company executive indicated that they have not perceived IoT investments as a "cost item." Moreover, the company executive also expressed that they accepted IoT as "an investment field that provides high data support for decreasing the costs in comparison with the previous costs." This condition of IoT demonstrates that IoT investments are significant items of investment for monitoring and controlling transportation costs for the company.

On the other hand, the company executive expressed that IoT can provide more advantages for hindering losses and protecting loads, and delivering on time to the customers during the transportation process. This condition will create a decreasing effect on multiple costs tolerated in the transportation process. The company executive indicated that IoT and IoT-integrated investments provided, especially better pricing and customer satisfaction thanks to it about the effects of transportation costs. In this regard, he answered the question about the quantitative effects of IoT on transportation costs: "since IoT investments are relatively new, it is earlier to present quantitative data, and they can be observed in detail after more developments of the investments." Within the framework of the company executive's answers, IoT investments can affect transportation costs positively, like how they provide advantages to transportation operations' organization, monitoring, and control. IoT especially will provide optimal pricing with real-time data support for detection, calculation, and control of transportation costs. However, expenses for utilizing IoT investments can cause an increasing result for costs as items of transportation costs. In this regard, the improving effects of IoT on transportation costs can be observed clearer with materializing investments which their R & D operations continue. The company executive signified these investments in Table 4.

5. DISCUSSION

When the results of this study are compared with studies in the literature survey: Chen, Sun et al. (2021) tested the gradient boosting partitioned regression tree model as an estimation model for route planning through IoT and IoT-integrated components in their study. At this point, the model has been analyzed separately as “holidays, working days, peak and non-peak hours, and congestion and non-congestion hours.” According to this analysis, the model’s estimation accuracy is increased with Mean Absolute Error (MAE) from 26,51% to 46,82%. The model’s estimation accuracy is increased with Mean Absolute Percentage Error (MAPE) from 57,05% to 97,50%. The model’s estimation accuracy is increased with Symmetric Mean Absolute Percentage Error (SMAPE) from 38,88% to 76,03%.In this regard, when the model has more data support with IoT, they submitted that more advantageous results can be achieved. Wang et al. (2020) suggested an IoT-supported smart dispatching platform that coordinates customers, order-picking robots, and cloud technology. In this regard, they achieved results with their suggested model in IoT-supported smart dispatching platform about the robots: the robot pickup at an average speed is 40 cm, the average pickup robot path is 500 cm, and the robot’s average pickup time is 12,5 seconds. At this point, they observed that smart items supported with IoT are more efficient with their performances.

Zhang et al. (2018) detected that the model within the framework of IoT-supported system simulation successfully identifies problems about production logistics, self-organization, and adaptation. They detected 22% savings achieved from production logistics, 51% savings from production logistics time, and 37% from energy consumption from production logistics within the framework of IoT-supported system simulation. Liu et al. (2018) analyzed simulation analyses about the effects of costs, fuel, and environmental impact that encapsulate 20 vehicles with IoT-integrated RFID hardware. In this regard, they detected that sum of the costs can be decreased by 54,32%, total distance can be decreased by 61,46%, and the sum of fuel consumption can be decreased by 54,82% as a result of their simulation analyses. They argued that the environmental greenhouse effect would be decreased with optimal usage of logistics resources and optimal decrease of fuel consumption and distances within the framework of the model. On the other hand, the company executive in this study expressed that they observed multiple improvements, such as monitoring and controlling vehicles and drivers, monitoring and controlling conditions of losses, and monitoring and controlling thermal balances of loads, with IoT investments at the first stage. Hence, these conditions demonstrate that cost advantages can be provided, just like how IoT investments provided significant advantages for transportation operations’ performances.

On the other hand, Hopkins and Hawking (2018) detected that a logistics company gained significant advantages for decreasing attention deficit and fatigue problems of drivers and controlling speed and vehicle performances with sensor support through IoT-based Truckcam and Drivercam applications. Lopes and Moori (2021) supported the hypothesis that “IoT application has a positive impact on Operational Performance (OP)” in the research they conducted with 76 Brazilian logistics and retail companies. Tu (2018) researched to discover decisive factors for Taiwanese companies from different industries to adopt IoT. In this framework, these hypotheses are supported: “H2: Perceived trustworthiness of technology has a positive effect on the perceived benefits of IoT technology. H3: Perceived benefits have positive effects on a firm’s intention to adopt IoT technology. H5: External pressure has a positive effect on a firm’s intention to adopt IoT technology. H4: Perceived cost has a negative effect on a firm’s intention to adopt IoT technology. However, the upcoming hypothesis is not supported: “H1: Perceived trustworthiness of technology has a positive effect on a firm’s intention to adopt IoT technology. In a similar way, it can be said that IoT has benefits for time and costs rather than technically developing monitoring and controlling capabilities during transportation operations when the answers of the company executive are examined in the study. It can be said that this advantage can be observed with realistic detections and increasing controlling power, especially for the costs of pricing transportation services. In this regard, it can be said that IoT technology provides positive effects on activity performance and costs, and it is a perceived technology as a beneficial investment field. In fact, the expression of the company executive about how the company initiated R & D investments for mentioned technological investments in Table 4 in order to provide benefits of IoT in detail supports this perception.

Chen, Chen, and Yang (2021) applied the AHP method for determining factors of using IoT in logistics. In this framework, they found that some factors became apparent according to participants’ evaluations. These are Information Gathering Ability (factor score value: 0,3570), Wireless Communication Capability (factor score value: 0,3538), Expectation of Decreasing Operating Costs (factor score value: 0,4515), Expectation of Forming an Effective Market Information (factor score value: 0,2994), Expectation of the Integrity of the Data (factor score value: 0,4183), Expectation of Providing Information Privacy (factor score value: 0,3643), Expectation of Providing e-Logistics Services (factor score value: 0,3408), and Expectation of Creating a Cargo Tracking System (factor score value: 0,4017). Finally, Correa et al. (2020) analyzed profit expectations of businesses (grades of survey participants; 1: Zero Sum, 2: Low Profits, 3: Intermediate Profits, 4: High Profits, 5: Maximum

Profits) from IoT and Big Data Analytics in their study. They concluded that the expectation of mean profits for IoT is 2,54, and the expectation of mean profits for Big Data Analytics is 2,67. Moreover, they reached a conclusion that profit expectations for IoT are short-term (maximum one year). On the other hand, this study's observations of positive results about IoT investments in the company researched, such as developing monitoring and controlling capabilities, providing real-time data, developing controlling ability of drivers and vehicles, and developing controlling skills to decrease losses or incidents, cause more positive expectations. Also, the positive developments of pricings directed to transportation costs and realistic cost detections with IoT increase the company's expectations for higher profits. In fact, the company executive indicated that the investment should be developed properly in order to be observed in detail how IoT investments affected transportation cost management.

When IoT is examined with the conceptual framework, previous studies, and this study, it can be argued that IoT as an investment field provides technical real-time monitoring and control advantages and high-volume field data in transportation operations. On the other hand, it can be argued that IoT as an investment field provides cost advantages in terms of increasing value-added in transportation operations. In fact, the company executive who was interviewed indicated that the advantages have been observed with IoT investments, such as real-time detections, calculations, and pricing related with these transactions about transportation costs with monitoring and controlling the transportation process.

6. CONCLUSION

This study evaluated the collected data with an interview technique from a logistics company with IoT and IoT-integrated investments and the limited answers that one of this company's executive provided within the frameworks of these resources. In this regard, the company has investments directed to IoT, and IoT-integrated various software, such as GPS, WSN, the RFID System, and Cloud Computing. This company utilizes these investments in transportation and warehousing activities. In addition to IoT, the company continues its R & D operations with investments, such as Big Data Analytics, Smart Container Systems, Autonomous Trucks, and Electrical Trucks.

The benefits were observed in the company with IoT and IoT-integrated investments at the first stage like "the instant monitoring of transportation process, instant control of drivers and vehicles, monitoring and controlling thermal balances of loads, controlling losses or incidents, route planning, and performance analyses." On the other hand, positive effects in the company were observed in transportation costs in parallel with obtained benefits like monitoring drivers and vehicles, protecting loads, and decreasing losses. At this point, it was indicated that the advantages have been provided in pricing. However, the company executive indicated that since the quantitative data on IoT's direct impact on transportation costs and its provided advantages to controlling transportation costs have not been ready yet, the development of these investments in this subject should be waited.

Therefore, it can be argued that IoT and IoT-integrated investments contain potential such as providing significant data support in terms of detection, control, and management of costs besides the performance about transportation operations and providing data support about analyses about the behavior models of cost items. If the company uses IoT investments within the framework of below suggestions, they can provide significant advantages in terms of minimization and management of transportation costs:

- Every transportation cost item should be classified per the characteristics of being fixed or variable in its relations with the produced services. If some costs are associated with vehicles' kilometer usage status whenever stability is a possibility, the broad data support of IoT investments can become meaningful. Thus, the dynamic cost functions, which include the association of produced transportation services with transportation cost items, will be formed. In this regard, IoT investments will provide significant data support.
- The company can use suitable allocation keys and Activity Based Costing method to decrease transportation costs. Within this aspect, "the detection and monitoring expense components" about transportation cost items will be easier. Moreover, the company can manage these costs by utilizing variance analyses on transportation cost items. At this point, the company can gain significant advantages from IoT investments.
- The company can form standards for transportation cost items by receiving support from broad data (previous and current data). Hence, positive or negative variances for transportation costs will provide significant advantages in analyses for the company. In this regard, the company can obtain significant benefits from IoT investments.
- The company can make additional IoT-integrated investments, such as "Smart Tachograph, Telematics Applications, Augmented Reality, and Driver Sphygmomanometers," in order to get significant advantages for managing transportation costs.

Since the company executive indicated that IoT investments are relatively new, and the company executive provided limited answers due to the strategic protection of certain data, the study contains qualitative evaluations. Since this study, different from the previous studies that are close to this research field, includes direct evaluations in a logistics company and results depending on this evaluation, it is aimed to contribute to the literature as an infrastructure for the upcoming studies. However, qualitative analyses were conducted because the company's IoT investments have not been developed enough yet. In this regard, quantity-concentrated studies about transportation operations' performance and costs depending on how IoT and IoT-integrated new generation investments develop in the same or different companies can contribute more than this study to the literature in the future. Furthermore, studies can include a different perspective with surveys in a research dimension that more logistics companies can join for this research topic. Thus, these possible studies can contribute to the literature even more.

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