Internet of Things (IoT) Impact on Oman's Road Freight Sector: The Importance of Perceived Utility

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Abstract: The growth of the global supply chain has brought numerous complications, particularly in freight transportation. Long lead times, high operational costs, and poor end-to-end visibility are examples of this. Modern technology must be included by freight businesses to streamline operations and maintain competitiveness. The freight transportation industry could change because of the Internet of Things (IoT). The way the road freight business operates has changed dramatically because of the IoT. By providing real-time tracking, predictive maintenance, improved security, and increased productivity, it has ushered in a new era for the road. Adopting the Internet of Things in Oman will guarantee long-term competitive advantage and future success in a dynamic road freight sector. The skills gap is one of the issues preventing IoT implementation. There hasn't been much research done on how the Internet of Things is being used and how it is affecting the Omani road freight industry. The overarching goal of this study was to document the potential impact of IoT on the road freight industry via the lens of perceived utility in Oman. A total of 203 structured questions were distributed online to workers in Oman's road freight sector. For the analysis of quantitative data in the study, structural equation modeling is used. Results show that the adoption of IoT in the road freight sector is a continuous trend. Further findings show that the relationship between IoT and operational effectiveness is considerably and favorably mediated by perceived usefulness. Improved operational effectiveness is the primary impact of IoT on the road freight sector. Managers are informed that smart sensor technologies can be used with the IoT to allow asset visibility and save operational costs. By outlining the Internet of Things (IoT) technologies used in Oman's road freight business, the paper adds to the body of knowledge on logistics management.

Keywords: road freight industry, internet of things; operational effectiveness, and perceived usefulness

1. Introduction and Research Contextualization

The Internet of Things (IoT) has had a significant impact on how the logistics industry operates. According to Zhou et al. (2015), the term "IoT" refers to a digital network of interconnected devices that communicate with one another via wireless technical systems. The Internet of Things (IoT) is defined similarly by Boyes et al. (2018) as a network of physical objects that are combined with sensors, software, and other technologies to connect and exchange data with other devices and systems over the internet. 5.18 billion people, or 64.6% of the world's population, are reportedly using the Internet as of April 2023 (Internet World Stats, 2023). Internet use in the road freight sector has become inevitable. As a result of the IoT's growth, there is a strong demand for supply chain transparency and integrity management (Barreto et al., 2017). According to Al-Fuqaha et al. (2015), the Internet has fundamentally changed how businesses organize and carry out their activities via networked common objects. IoT enables seamless communication between smart things while also orchestrating and integrating workflows (Lesch et al., 2023).

IoT facilitates communication between vehicles, people, and infrastructure in the road freight sector, enhancing visibility and decision-making (Dong et al., 2021). The introduction of autonomous freight tracking and tracing as well as temperature monitoring and maintenance of items in transit brought about a revolution in the road freight business thanks to IoT. Since it makes up the majority of the first and last miles of freight transit, road freight transportation is significant in logistics.

According to Macioszek (2018), a sizeable share of the cost of freight transit is incurred by road freight transportation. According to Tayyeb et al. (2019), freight transportation in Oman is essential to the development and expansion of the country's economy. To become the preferred logistics hub in the area, Oman seeks to grow and modernize. In Oman, demand for road freight transportation services has grown over time. The road freight sector experiences changes because of technical advancements. However, the road freight sector has several difficulties, including inefficient cold chain transportation, high transportation costs, and personnel management. Numerous other issues, including traffic jams, collisions, and environmental carbon dioxide gas emissions, are also attributed to the transportation of freight by road. To reduce operational expenses and waste, it is crucial to manage road freight operations carefully. To address these issues and boost the road freight sector's competitiveness, research is needed. The road freight transportation sector has a chance to manage operations and enhance decision-making thanks to IoT.

The Federal Transit Administration (2017), the impact of emerging technologies on freight transportation (Dong et al., 2021), IoT as one of the technologies when achieving smart mobility cities (Zahraei, Kurniawan & Cheah 2019), IoT enabled green logistics (Chhabra et al., 2021), and adoption of digitalization in certain industries are some of the studies that discuss the advantages and challenges associated with IoT implementation and developing an intelligence platform for shared freight services utilizing ToT (Heinbach et al., 2022). Unfortunately, there has only been a little amount of research done so far on how the Internet of Things (IoT) is affecting the road freight sector (Lee & Lee, 2015; Mishra et al., 2021). By examining the potential consequences of deploying IoT on the road freight business through the mediation of perceived usefulness in Oman, this study aimed to close the gap. The following research issues were so addressed:

a. What different IoT technologies are used by Oman's road freight industry?
b. What effect will IoT technology implementation have on Oman's road freight industry?

2. Literature Review

2.1 Road Freight Industry

Road freight transportation is a versatile means of transportation that offers door-to-door services, according to Farquharson et al. (2021). Road maintenance is less expensive than that of other forms of transportation, such the sea and the air. According to Xu et al. (2019), there are several issues facing freight transport firms, including those related to safety, efficiency, quality, dependability, flexibility, and punctuality. This increases the need for cost-effective fleet management with low empty mileage. IoT technologies can be used to address and mitigate the difficulties mentioned above. According to Ebrahim (2019), IoT technology adoption has altered the transportation sector, which ultimately promotes economic growth and development. According to Manavalan and Jayakrishna (2019), the use of ToT technology lowers the risk of shipment delays by alerting users to potential travel-related disruptions such poor road conditions. Systems in the road freight sector should exchange information with one another and with other applications, according to Choosakun et al. (2021). Road freight delays could result in significant operational costs for the business.

2.2 Internet of Things (IoT) for Road Freight Industry

IoT has recently seen rapid expansion with a wide range of applications across many industries. The road freight industry is one that has shown a lot of interest in IoT applications. According to Hwang, Lee, Park, and Chang (2017), the internet and information systems are employed in the internet of things to connect physical and digital devices. According to Haddud et al. (2017), physical objects may perceive, analyze data, and perform particular tasks by cooperating on decisions and sharing knowledge. Along with other intelligent objects, they can also communicate and connect with people (Ding et al., 2021). Al Fuqaha et al. (2015) claim that the addition of information technology systems, processing networks, sensors, and internet protocols transforms these inanimate items into intelligent ones. Visibility of all supply chain operations is made possible by the effective collection, analysis, and transformation of data from smart objects into useable information (Ben-Daya et al., 2019). This provides early notice of situations that can be fixed straight away. IoT can hasten the process of gathering data and making decisions, according to Ellis et al. (2015). As a result, management is more agile and responsive and can react to developments fast.

As IoT technology components, the FTA (2017) included sensors, gateways, networks, standards, and data analysis tools. According to Xu et al. (2014), one of the fundamental IoT technologies is radio frequency identification (RFID). RFID allows readers to track and keep an eye on items that have RFID tags by using microchips to wirelessly transfer data. Position and condition data are provided by sensors and GPS tracking devices (Gao et al., 2020). The ability to track cargo in real-time makes it easier for businesses to manage their supply chains by improving visibility and reducing the likelihood of lost goods. Real-time performance monitoring of vehicles and equipment, according to Al-Mashari et al. (2018), enables organizations to spot potential issues before they become serious problems. By doing so, safety may be improved while potentially reducing maintenance costs and downtime. Ben-Daya et al. (2019) and Lee et al. (2015) identified five IoT technologies: (1) which permits monitoring and tracing capabilities; (2) wireless sensor network (WSN) used to track and monitor various devices, such as temperature and position; and (3) which enables the usage of IoT devices to do various tasks; (4) Cloud computing; (5) IoT applications that enable device to device and human to device communication; and (3) middleware that permits interaction with devices like RFID tags. RFID tags, smart room controls, smart load sensors, activity trackers, fuel management sensors, navigation systems, and smart route sensors are just a few of the IoT-based applications that Farquharson et al. (2021) mentioned. The road freight sector may undergo a transformation thanks to IoT's real-time tracking, predictive maintenance, and other benefits. However, companies must be equipped to deal with issues related to data security and infrastructure integration (Kshetri, 2018). As technology continues to improve, it will be essential for logistics companies to stay on top of the most recent trends and developments (Wang et al., 2020).

As was mentioned before, the road freight sector makes use of a few IoT technologies. This study was unable to examine how widely these technologies have been used. IoT devices such RFID tags, smart room controls, smart load sensors, activity trackers, fuel management sensors, navigational systems, and smart route sensors were specifically picked for the study. These IoT innovations were used in Oman.

2.3 Operational Effectiveness

The main objective of any organization is better performance, which depends on operational effectiveness. Operational effectiveness is the ability to outperform competitors at similar tasks. Efficiency is one possibility, but it is not the only one (Porter, 1996). According to Pekuri et al. (2011), operational performance focuses on procedures that enable businesses to utilise input more effectively. Because they utilise technologies, certain businesses can make better use of their input (McFarlane, 1984). The rising use of IoT and access to data has produced several benefits (Monje, 2016). These include the possibility of using robotics to automate freight delivery, which can increase efficiency and allow transportation managers to better track cargo in real time. Implementing a fully autonomous vehicle has the potential to drastically minimize accidents, vehicle losses, and infrastructure damage. IoT can be utilized to ease traffic congestion in South Africa, according to Ebrahim (2019). According to Haddud et al. (2017), one of the benefits of IoT for logistics firms in the road freight industry is increased openness and visibility of information and material flow across the supply chain. IoT technology, according to Shao et al. (2019), offers accurate real-time information, enables tracking and tracing capabilities for items in transit, gives vehicle journey history, and permits the execution of routing plans. According to Bogataj et al. (2017), IoT-based apps can be used to measure ambient parameters including temperature, humidity, and gas concentration. This finally helps to lower supply chain post-harvest loss. IoT has many features, including location sensing and sharing, as mentioned by Chen et al. (2014).

Included in this is data on the location obtained through GPS, cell-ID, and RFID. IoT applications also include mobile asset tracking, which keeps track of and monitors goods via communication and location-sensing technology. Fleet management is one application of IoT technologies (Chen et al., 2014). In addition to getting real-time information on the position of the vehicle and traffic information systems, this can schedule drivers and cars. Through the tracking of the vehicle's location, traffic conditions are made known. Insight into sales data, operational and supply chain efficacy, enhanced customer service, higher driver safety and job satisfaction, and long-haul efficiencies are all measured in this study.

2.4 Perceived Usefulness

According to Hua et al. (2017), perceived usefulness (PU) assesses how much a user believes using a particular technology would enable them to perform their duties and jobs more effectively. If a user sees value in a system, they are more likely to be satisfied with it than if they do not (Al-Jabri, 2015). According to Chen et al. (2015), a system that completes tasks benefits users and enhances their performance and pleasure. According to Tan and Teo (2000), an innovation's PU has a significant role in deciding how effectively it is accepted. A system is more likely to be embraced if people believe it to be useful. Perceived benefits include things like lower transaction costs, more cash flow, increased productivity, and better customer service (Beatty et al., 2001; Al-Qirim, 2004; Awa et al., 2016). Managers in the road freight sector will only adopt IOT in this scenario if they think it will be more advantageous than using the existing methods. They must think that using IoT would either create new company possibilities or solve existing problems.

3. Hypothesis Development

3.1 Relationship between Internet of Things and Perceived Usefulness

The extent to which a person thinks employing a certain technology would improve his or her ability to accomplish a job is known as perceived usefulness. IoT benefits may be seen differently by users over time. People use information technologies for both intrinsic and extrinsic reasons, claim Davis et al. (1992). Extrinsic motivation places an emphasis on engaging in an action to obtain objectives or benefits (Vellerand, 1997). According to Doll and Ajzen (1992), intrinsic motivation refers to the enjoyment and satisfaction experienced when engaging in a behavior. The behavioral intention to adopt IoT is significantly determined by perceived utility. IoT technology and perceived utility have a favorable and significant relationship, according to Gao and Bai (2014). The functions of perceived benefits in influencing the propensity to utilize IoT services or goods are confirmed by Kim and Park (2022). According to Singh, Gaur, and colleagues' (2017) research, perceived utility, and behavioral intent to use IoT are positively correlated. According to Liew's et al. (2017) research, the perception of utility is the aspect that has the most impact on people's willingness to accept IoT technologies. Given the already mentioned justifications, the following theory is suggested:

H1: There is a considerable positive correlation between IoT and perceived utility.

3.2 Relationship between Perceived Utility and Operational Effectiveness

Amoako-Gyampah and Salam (2004) claim that users can accept a system if they are certain that it will enable them to achieve the desired performance goals. Chirchir et al. (2019) contend that user-friendly systems perform at their peak levels. It is impossible to exaggerate the significance of perceived utility in deciding how a system is utilized and how it impacts user performance. According to Santhanamery and Ramayah (2018), perceived usefulness is the key indicator of future usage intentions. According to Goodhue and Thompson (1995), the system needs to be viewed as useful for users to benefit from it. Given the already mentioned justifications, the following theory is suggested:

H2: Perceived usefulness and operational effectiveness have a favorable relationship.

3.3 Internet of Things and Operational Effectiveness: A Relationship

The IoT and operational performance have a favorable and statistically significant link, according to Al-Khatib (2023). According to Farquharson et al. (2021), integrating IoT will mostly result in improved customer service and cost savings. Additional advantages include enhanced process simplification, interruption minimization, and improved driver safety. According to Monje (2016), integrating transportation infrastructure has significant benefits, such as cutting commute times, eliminating traffic deaths, and lessening the harmful effects of climate change. The use of IoT to increase the surface transportation system's efficiency and safety. Some of the effects of IoT for logistics organizations, particularly the road freight industries, include increased transparency and visibility of information and material flow across the supply chain (Haddud et al., 2017). IoT technology can offer opportunities for the road freight transport industry by providing accurate real-time information, enabling tracking and tracing capabilities for goods in transit, providing travel history of vehicles, and enabling the execution of routing plans, according to Shao et al. (2019). Given the already mentioned justifications, the following theory is suggested.

H3: Internet of Things have an Effect on Operational Effectiveness

3.4 Mediating Effect of Perceived Usefulness on Operational Effectiveness

Previous studies posit that there is a positive relationship between perceived usefulness and the use of the new technologies (Zaremohzzabieh et al., 2015; Muhaimin et al., 2019). Gong et al. (2004) added that people were more likely to accept new technology when companies explain the benefits and advantages of new technologies with logical arguments, which increase the perception of usefulness. Koufaris (2002) found that the perceived usefulness is an important predictor of intended system. Tsourela and Nerantzaki (2020) demonstrated that perceived usefulness significantly influences the attitude of people and their behavioral intention towards IoT products and applications.

H3: The operational effectiveness of the Internet of Things is impacted.

3.5 Operational Success is Mediated by Perceived Usefulness

According to earlier research (Zaremohzzabieh et al., 2015; Muhaimin et al., 2019), there is a correlation between perceived utility and the application of new technologies. According to Gong et al. (2004), individuals are more inclined to adopt new technology when businesses provide logical justifications for its advantages and benefits, which heightens the technology's perceived usefulness. According to research by Koufaris (2002), the planned system is significantly predicted by the perceived usefulness. Perceived usefulness has been shown by Tsourela and Nerantzaki (2020) to have a considerable impact on people's attitudes and behavioral intentions toward IoT apps and devices. Martins et al. (2014) discovered that when individuals think new technologies are valuable, they want to use IoT services. The association between simplicity of use and propensity to utilize IOT technologies is mediated by perceived utility (DoyduK & Bayarçelik, 2019). Customers have a positive opinion of a service when they find it beneficial and are likely to use it again. Unfortunately, there has not yet been much research done on the role that perceived usefulness plays in mediating the link between operational performance and IoT. Therefore, it is assumed that:

H4: The relationship between the internet of things and operational effectiveness is mediated by perceived usefulness.

3.6 Conceptualized Model

The study investigates how IoT has affected the road freight industry while considering how effective Oman thinks mediation is. Figure 1.1 illustrates a research paradigm that was suggested based on earlier research. In this case, there are both direct relationships (such as those between the internet of things and perceived usefulness, between perceived usefulness and operational effectiveness, and between the internet of things and operational effectiveness) and indirect relationships (such as those between the internet of things and operational effectiveness being positively mediated by perceived usefulness). Internet of things, perceived usefulness, and operational effectiveness were the three constructs used in the study. The internet of things was used as the dependent variable while operational effectiveness served as the independent variable. The mediating factor was perceived utility. Four hypotheses are incorporated into the model.

H_1: There is a considerable positive correlation between IoT and perceived utility.
H2: Perceived usefulness and operational effectiveness have a favorable relationship.
H3: Internet of things have an effect on operational effectiveness.
H4: The relationship between the internet of things and operational effectiveness is mediated by perceived usefulness.

A research hypothesis, which encompasses Internet of Things, perceived usefulness, and operational effectiveness are displayed in Figure 1.

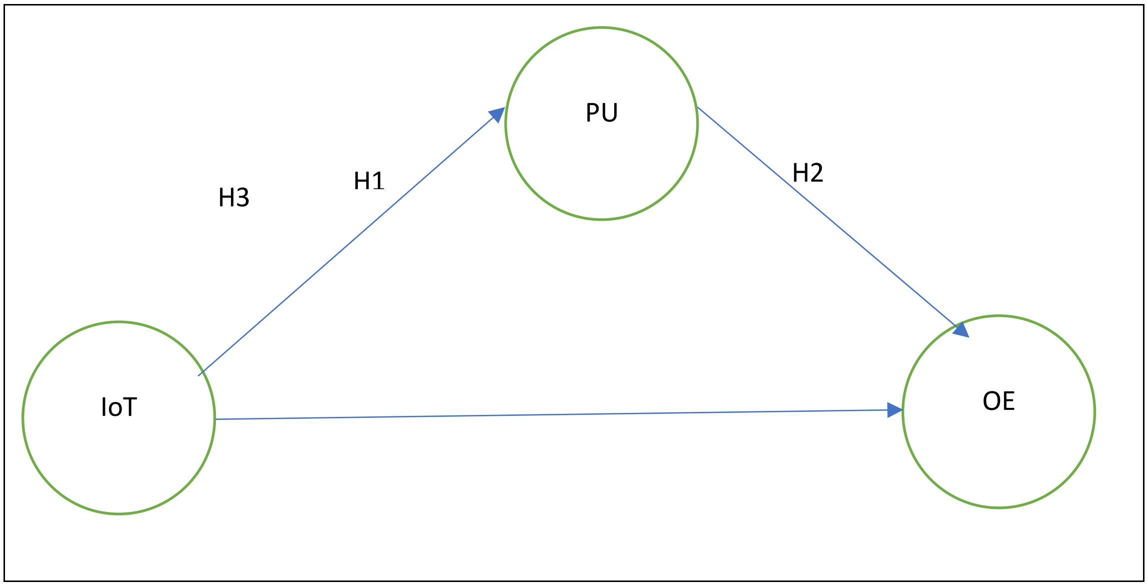

Figure 1. Conceptual Framework of Research Hypotheses H1 to H4

The study included 15 measuring items in a structured questionnaire, among which 5 items pertained to Internet of Things, five items to the perceived usefulness, and four items to the operational performance. The items are measured using a five-point Likert scale with a different measurement scale for each section. The scale ranged from 1 to 5, where 1 = Strongly Disagree and 5 = Strongly Agree.

4. Research Methodology

A quantitative method was used within the positivist worldview. To gather primary data, a descriptive survey design was used. The unit of analysis was workers employed in road freight companies within Oman. A list of 126 road freight operators was obtained from the Ministry of Commerce, Industry, and Investment Promotion. This was used as an official database of the study. Only five companies were purposively selected for the study. Email and phone calls were made to these companies. A list of 398 employees was developed from the human resources (HR) databases of five companies. Workers were middle and senior managers for the five companies. To gather information from respondents, a structured questionnaire containing closed-ended questions was used. Questions were derived from literature on ToT, road freight industry and perceived usefulness. The goal was to assess the causal connections between the different latent constructs in the survey. The hypotheses came from a review of the literature. The questionnaire was organized around the sections: Section A, demographic information, section B, implementing ToT technologies, Section C, perceived usefulness; and Section D, operational effectiveness. The survey was administered using a five-point Likert-style scale, which made it simple for respondents to select their preferred response from strongly disagree (1) to strongly agree (5). The link between the variables was assessed, as well as the internal consistency of each latent construct, using structural equation modelling. Additionally, correlations between the various constructs were examined. The viability of the questionnaire was examined during pilot research, which ran from June 04 to August 24, 2022.

5. Demographic Results

The data collection period ran from November 16, 2022, through February 18, 2022. A self-administered questionnaire was used. The respondents completed 203 research questionnaires. This corresponds to 52 percent of the respondents who were being targeted. Findings suggest that 81 percent of respondents were males, while 19 percent were female. Results indicate that 51 percent were aged between 36 and 45, 21 percent between 46, and 55, 14 percent between 26 and 35, 6 percent were less than 26 years old; and lastly, 6 percent were more than 55 years old. Results found that most respondents were aged between 36 and 45 years. Most respondents had completed a diploma which meant that they could interpret the survey questions and provide relevant responses. The study found that 3 percent of the respondents had less than one year, 8 percent had between 1–5 years, 56 percent had between 6–10 years, 25 percent had between 11–15 years and, lastly, 8 percent had more than 15 years. This implies that most respondents had more than five years of experience in road freight industry in Oman. They could provide qualified opinions about the road freight industry in Oman. Findings suggest that 70 percent (n=201) of respondents were employed as full-time workers and 30 per cent (n=88) were part-time employees. They were likely to give an informed opinion would be given since most of the respondents were full-time employees.

5.1 Internet of Things Adopted in Oman

Respondents were asked to tick the Internet of Things technology used by their businesses. Results indicate that there were different IoT technologies available in the market. They thought that connected devices will make up the Internet of the future and further the boundaries of the world with physical and virtual elements. The IoT technologies used are shown in Figure 2. Most respondents pointed out that they were using fuel management sensors. Activity sensors together with smart load sensors were recognizable IoT technologies. In addition, RFID tags were used as revealed by the sample data. Half of the respondents mentioned that they were implementing navigation systems. Surprisingly, only a few respondents showed signs of employing smart route sensors and smart room controls. This was mostly due to the lack of incentives for implementing such IoT technologies.

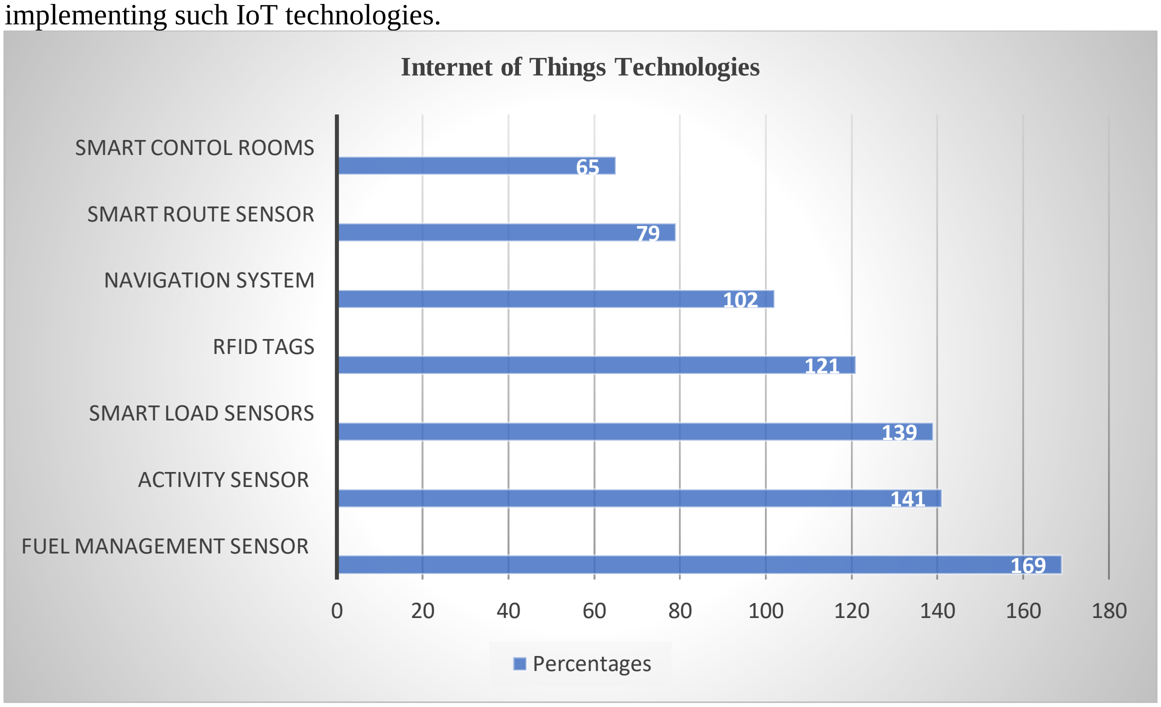

Figure 2. Internet of Things Technologies

5.2 Normality Tests

The Kolmogorov-Smirnov (K-S) test (Oztuna et al., 2006) and Shapiro-Wilk tests (Barton & Peat, 2014) were employed to check the normality of data. This was important to ensure that all variables (IoT, perceived usefulness, and operational effectiveness) were normally distributed.

Table 1. *Normality Tests*

Variables	**Kolmogorov-Smirnov**			**Shapiro-Wilk**			**Skewness**	**Kurtosis**
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**		
IoT1	.164	240	.073	.243	240	.220	0.347	1.269
IoT2	.119	240	.124	.322	240	.155	0.071	1.332
IoT3	.118	240	.165	.261	240	.288	0.346	1.265
IoT4	.176	240	.085	.302	240	.063	0.347	1.269
IoT5	.122	240	.028	.325	240	.164	0.346	1.265
PU1	.134	240	.185	.316	240	.223	0.911	0.239
PU2	.123	240	.075	.256	240	.193	0.783	0.006
PU3	.153	240	.066	.316	240	.197	0.766	0.045
PU4	.164	240	.093	.256	240	.071	0.662	0.449
PU5	.175	240	.081	.212	240	.088	0.887	0.156
OE1	.186	240	.075	.210	240	.092	0.510	0.578
OE2	.127	240	.097	.327	240	.073	0.512	0.595
OE3	.174	240	.121	.288	240	.081	0.941	0.207
OE4	.168	240	.173	.201	240	.168	0.922	0.227
OE5	.159	240	.089	.217	240	.163	0.925	0.196

The Shapiro-Wilk Test results in Table 1 were larger than 0.05, indicating that the data is normal. The data considerably deviates from a normal distribution if the values were less than 0.05. The null hypothesis, which proposed that the data from sampled variables were normally distributed, was used to conduct the test. For the Kolmogorov-Smirnov test, the statistic value and degrees of freedom are provided along with the significance level. All the measuring items have p-values greater than 0.05, indicating that they are normally distributed. The study also used skewness and kurtosis scores to test normalcy. According to Collier (2020), for data to be considered normal, skewness values should fall between -2 and +2, whereas kurtosis values should fall between -10 and +10. The skewness and kurtosis values in Table 2 show that they were within acceptable range.

5.3 Sample Adequacy

The Kaiser-Meyer-Olkin (KMO) measure of sample adequacy and Bartlett's test of sphericity were assessed for each scale. In Table 2, given that the criterion of 0.6 (Pallant, 2020), the KMO values of 0.805, 0.730, and 0.863 for the constructs on IoT, perceived usefulness, and operational effectiveness, respectively, were acceptable. All of the measures showed statistical significance in Bartlett's test of sphericity, proving that they were appropriate for factor analysis.

Table 2. *KOM and Bartlett`s Test*

Latent variable	**Sample adequacy**	
	KMO Measure	**Bartlett's test**
IoT	0.805	0.000
Perceived usefulness	0.730	0.000
Operational effectiveness	0.863	0.000

5.4 Scale Reliability

The mean and standard deviation of each measuring item was tested. Three constructs were considered for the study: IoT, perceived usefulness and operational performance. A total of 15 measuring items were considered for evaluation. The mean rating ranged between 2.586 (SD=1.444) and 3.802 (SD=1.140). Findings demonstrate that most responses strongly agreed with the measuring items. Cronbach's alpha was used to evaluate the consistency of each construct. According to Hair, Anderson, Tatham and Black (1998) and George and Mallery (2016), Cronbach's alphas of at least 0.7 indicate that the measuring items have acceptable reliability. For the IoT, perceived usefulness, and operational effectiveness, Cronbach's alpha values were 0.945, 0.895, and 0.855, respectively. The values were all more than the cutoff of 0.7, indicating strong internal consistency for each scale (Pallant, 2020). According to Netemeyer (2003), the study looks at composite dependability, which measures the internal consistency of scale items. The recommended cutoff point for the CR values is 0.7 (Fornell & Larcker, 1981). In Table 3, results show that the CR values were 0.941, 0.894 and 0.860 for ToT, perceived usefulness, and operational effectiveness, respectively. This indicates good reliability (Ketchen & Berg, 2006).

Table 3. *Validity and Reliability Analysis*

Latent Variable	**Item**	**Descriptive Statistics**		**Cronbach Alpha**	***CR***	***AVE***	**Factor Loadings**
IoT		Mean	SD	0.945	0.941	0.837	
	IoT1	2.586	1.444				0.974
	IoT2	2.970	1.427				0.630
	IoT3	2.590	1.441				0.974
	IoT4	2.586	1.444				0.973
	IoT5	2.59	1.441				0.973
PU	PU1	3.802	1.140	0.895	0.894	0.705	0.776
	PU2	3.698	1.127				0.776
	PU3	3.690	1.132				0.882
	PU4	3.552	1.228				0.881
	PU5	3.795	1.221				0.877
OE	OE1	3.507	1.186	0.855	0.860	0.639	0.775
	OE2	3.515	1.183				0.884
	OE3	3.757	1.315				0.884
	OE4	3.765	1.299				0.663
	OE5	3.772	1.289				0.768

Construct validity was checked using the average variance extracted (AVE). According to dos Santos and Cirillo (2023), the EVE measures how much of the overall variance in the indicators is explained by the latent construct. Fornell and Larcker (1981) claimed that the EVA is accepted when a value for a construct is 0.50 or above. The AVE values range from 0.860 to 0.946, which shows that the constructs adequately account for measurement error-related variance. Results are shown in Table 3 as factor loadings, which show how strongly each item is related to its corresponding latent variable. All the factor loadings that were above 0.5 were considered for this study. This indicates that they are good measures of their corresponding construct.

5.5 Discriminant Validity

The study examined the discriminant validity of the measuring constructs. According to Smith (2005), discriminant validity means that two latent variables that represent different theoretical concepts are statistically different. Two validity tests were conducted, namely Heterotrait-Monotrait ratio (HTMT) and Fornell-Larcker criteria. The similarity between latent variables is measured by the HTMT of correlations. If the HTMT is unmistakably below one, discriminant validity is proven. The HTMT criterion suggests that all variables are uniquely different at the cut-off value of HTMT 0.90.

Table 4. *Heterotrait-Monotrait Ratio*

	Heterotrait-Monotrait ratio (HTMT)
U<->OE	0.659
T<->OE	0.459
T<->PU	0.228

In Table 4, HTMT values ranged from 0.228 to 0.659, showing that they were noticeably different at levels below HTMT 0.90, supporting the discriminant validity of the data. The Fornell-Larcker criterion (FL criterion) was developed by Fornell and Larcker in 1981 to assess discriminant validity. The correlation of latent constructs is compared with the square root of the average variance extracted (AVE). According to Hair et al. (2014), a latent construct should be able to account for the variance of its own indicator more effectively than the variance of other latent constructs. As a result, the correlations with other latent constructs should be smaller than the square root of each construct's AVE.

Table 5. *Fornell-Larcker Criteria*

	OE	**PU**	**IOT**
E	0.799		
U	0.580	0.840	
OT	0.502	0.533	0.915

According to Fornell-Larcker, the square roots of AVE for the three latent constructs in Table 5 were higher than the correlation between the constructs.

5.6 Structural Equation Modelling

The structural links that the research model predicted were examined using structural equation modeling. They used a bootstrap approach to verify the importance of each path coefficient. The study applied the criterion of meaningfulness to establish a standardized path coefficient that is considered significant in the model and relevant to managerial decisions (Herse 1969; Kerlinger & Pedhuzard, 1973). All path coefficients with less than 0.10 were considered not meaningful and removed in the model (Land, 1969). The path coefficient is significant in SmartPLS 4.0 at the default 5 percent threshold of significance. The significance of the path coefficients connecting latent constructs was investigated to evaluate the hypotheses. The highest value suggests that the predictor (exogenous) latent variable has the largest influence on the dependent (endogenous) latent variable (Wong, 2013). The significance level of the value must be assessed using the t-value test. The non-parametric bootstrapping approach was used to conduct the test. Structural path results are presented in Table 5.

Table 6. *Hypothesis, Path Coefficients, and Results*

Path	**Path Coefficient (β value)**	**Confidence Interval**		**T-value**	**P-values**	**Significance Level**
		2.5%	**97.5%**			

IoT→PU	.221	.096	.342	3.558	.000	Significant
PU→ OE	.514	.413	.608	10.150	.000	Significant
IoT → OE	.300	.219	.382	7.095	.000	Significant
IoT→ PU→OE	.114	.027	.112	3.119	.002	Significant

Table 6 presents the path coefficients, confidence intervals, t-values, p-values and significance levels for each hypothesized relationship in the model. The path shows a significant positive relationship between Internet of Things and perceived usefulness *(β*=0.221; t=3.558; p=0.000). Therefore, hypothesis H1 was accepted at a 95 percent confidence interval (t-value >1.96). The higher level of perceived usefulness is associated with high implementation levels of Internet of Things technologies. In Table 6, results indicate a significant positive relationship between perceived usefulness and operational effectiveness *(β*=0.514; t=10.150; p=0.000). Therefore, hypothesis H2 was accepted at 95 percent confidence interval (t-value >1.96). This means that a higher level of perceived usefulness is associated with a higher level of operational effectiveness. Findings show a significant positive relationship between Internet of Things and operational performance *(β*=0.300; t=7.095; p=0.000). Therefore, hypothesis H3 was accepted at a 95 percent confidence interval (t-value >1.96). This suggests that a higher level of Internet of Things is associated with a higher level of operational effectiveness.

For moderation, the study proposed in H4 that perceived usefulness mediates the relationship between Internet of Things and operational effectiveness. The main objective of mediation analysis is to identify an indirect influence and determine its statistical significance. Two key strategies were used to do this: the bootstrapping method (Preacher & Hayes, 2004) and the Sobel test (Sobel, 1982). It was stated that the mediator was the perceived usefulness. The research found that there is a positive significant relationship between Internet of Things, perceived usefulness, and operational performance (*β*=0.114; t=3.119; p=0.002). Therefore, hypothesis H4 was accepted at a 95 percent confidence interval (t-value >1.96). This implies the relationship between Internet of things and operational performance is partially mediated by perceived usefulness. The path coefficients together with statistics provide evidence that the relationships between the latent constructs in the model were significant and supported the hypothesized model.

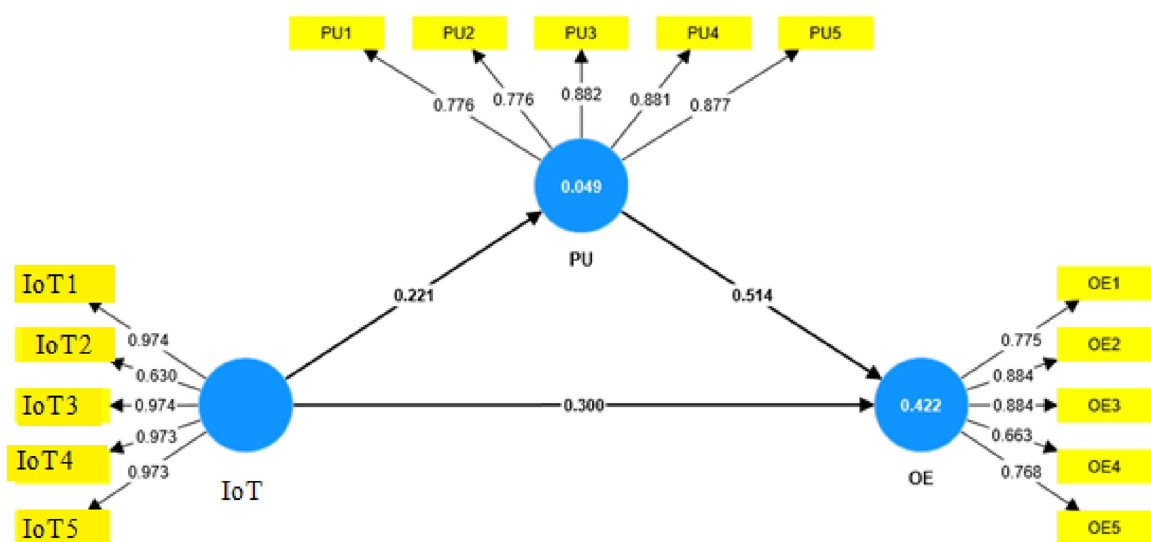

Figure 3. Final Structural Hypothesized Model

The resulting structural model of the connections between operational success, perceived usefulness, and the Internet of Things is shown in Figure 3. The breadth of the linkages between the constructs relevant to this study and the factor loadings for each item in the constructs are both illustrated by a detailed structural model. Internet of Things has a significant positive relationship with perceived usefulness. Perceived usefulness has a significant positive relationship with operational effectiveness. The Internet of Things have a significant positive relationship with operational effectiveness. There is a relationship between Internet of Things perceived usefulness and operational effectiveness. In summary, hypotheses H_1, H_2, H_3 and H_4 are accepted. The model coefficients and factor loadings of the fitted model are presented in Figure 3.

5.7 Goodness-of-fit Statistics for Final Model

According to Kline (2011), the absolute fit index, incremental fit index, and parsimony-adjusted index can all be used to measure the fitness of the model. The difference between the residuals of the sample covariance matrix and the proposed covariance model is known as the Standardized Root Mean Residual (SRMR), which is equal to the square root of this difference. The values of SRMR, which are standardized, ranged from 0 to 1 (Byrne, 1998; Hu & Bentler, 1999). In Table, SRMR value of 0.09 demonstrated that the research model fit the data well. The Normed Fit Index (NFI) result was more than the minimally acceptable level of 0.9. This implies it was a good fit (Hair *et al.* 2006). The difference between the observed and assumed covariance matrices is measured by the Chi-square. It is now more common to mention it mostly for historical reasons rather than for judgments regarding the quality of model fit.

Table 7. *Goodness-of-fit Statistics for the Final Modified Model*

Index	**Recommended value**	**Sources**	**Estimated model**
SRMR	0.08–0.10	Hair et al. (2010)	0.09
d_ULS	-	Hair et al. (2010)	1.725
d_G	-	Hair et al. (2010)	9.863
Chi-square	-	Hair et al. (2010)	5928.509
NFI	> 0.90	Hair et al. (2010)	0.429

The measurement model was acceptable and nomologically valid.

6. Discussion

The goal of the study was to determine the most likely impact of IoT technologies on operational effectiveness in the context of road freight transportation in Oman. The study investigated the IoT technologies implemented in the road freight industry. Findings show that IoT technologies, including fuel management sensors and activity sensors, were employed. Fuel management sensors were used to remotely monitor and collect information from fuel storage tanks (Wang, Cao, Shen & Zheng, 2018). It takes information about the fuel level in tank in real-time through its sensor and live streaming of the site, then uploads it directly to the internet, where it can be read anytime and anywhere through web application (Ahmed et al., 2017). IoT technologies that were well-known included activity sensors and smart load sensors. The sample data also indicated the use of RFID tags. The findings supported earlier studies in road freight industry. IoT technologies employed in the transportation industry were categorized into tracking, information management, and navigation systems (Muuzuri et al., 2020). According to Dlodlo (2015) and Taliaferro et al. (2021), IoT technologies assist managers in gathering sufficient data on the location of freight, environmental conditions, potential delays, and the detection of incidents and potential disruptions. Although smart route sensors and smart room controls were recognized as IoT technology, respondents did not frequently use them. Dong *et al.* (2021) found that smart sensors were utilized to monitor environmental variables, such as humidity, pressure, and temperature of cargoes, and send real-time reports to the control room for efficient decision-making. Golpira et al. (2021) classified IoT technologies based on a qualitative approach. In this study, IoT technologies were determined using quantitative technique.

The study explored the relationship between IoT and perceived usefulness. Findings, which are validated by prior research, show that there is a significant and positive relationship between IoT and perceived usefulness. A failure to clearly convey a benefit to potential users may be one of the primary causes of the sluggish adoption of IoT technology applications (Roger, 1995). Users will only accept innovations if they offer a distinct benefit over currently available alternatives. Users must feel improved performance when they use a particular technology (Venkatesh et al., 2003, 2012). Perceived usefulness is the most important driving factor in the intention to use IOT (Dong et al., 2017). Compatibility, result demonstrability and trialability are the main factors that affect perceived usefulness (Hong & Tam, 2006; Gumussoy & Calisir, 2009; Porter & Donthu, 2006; Zhou, 2013).

The study found that there is a significant positive relationship between perceived usefulness and operational effectiveness. This indicates that the variation in operational effectiveness was mostly explained by perceived usefulness. Perceived usefulness could be used to measure how far a user believes a specific application to increase work performance. Ghani et al. (2022) claimed that perceived usefulness significantly influenced digital banking effectiveness. When users find a service beneficial, they have a good attitude about it and are more likely to use it in the future (Davis, 1993). Perceived usefulness favourably impacts attitude and intention to use the service. Users are increasingly cherishing the benefits of digital services, such as time-saving.

The study found that IoT has a significant and positive impact on operational performance. Similarly, Al-Khatib, (2023) found that IoT enhances operational performance. Consistently, Gao and Bai (2014) established that IoT technologies can supply retail stores with faster processes, lead to less queuing time, and improve service quality perceived by users. According to Wang et al. (2013), IoT technologies enable railway maintenance employees to receive data from transponders through a mobile reader in their hand and determine whether they require maintenance, increasing efficiency. IoT keeps an inventory, and plans maintenance schedules based on accurate mileage for each part of the train. Michie, Andonovic et al. (2020) stated that IoT solutions reduce operational costs and minimize waste, whilst ensuring high standards. Anosike et al. (2021) suggest that IoT significantly improves the operational performance of manufacturing organisations, despite the early stage of the technology. Dahlqvist et al. (2019) highlighted that IoT platforms improve financial performance across cost, revenue and operational efficiency.

The study found that perceived usefulness partially mediates the relationship between implementation of IoT and operational effectiveness. The results demonstrate that the implementation of IoT had a sizable indirect impact on operational effectiveness through the mediation of perceived usefulness. This implies that the perceived usefulness will enhance the combined effect of IoT and operational effectiveness. In summary, little is known about the mediation effects of perceived usefulness on the relationship between IoT and operational effectiveness. Therefore, this study sought to address this research gap in literature. However, perceived usefulness has been employed in several research as a mediating variable.

7. Conclusion

The study investigates the IoT technologies applied in the road freight sector in Oman. A survey was conducted to establish the existing IoT-based applications in the road freight industry. The main logistical activity in Oman for moving shipments from the origins to the destinations is road freight transportation. According to Oman’s Vision 2040, the Sultanate's efforts to diversify away from its reliance on oil should focus on five key areas, one of which is transportation and logistics. The efficiency and service quality of the road freight transport is impacted by mode of transport as well as strategic planning. Traffic congestion, poor roads, and weather conditions can negatively affect the cost of operations as well as delivery time. Such difficulties result from a lack of real-time information. According to this study, IoT-based applications are essential for securing the success of enterprises in the contemporary world. Today, more than ever before, it is now crucial that the road freight sector adopt cutting-edge technologies like IoT. IoT technologies can enhance business operations and processes.

IoT technologies, according to Golpira et al. (2021), had not yet been properly defined or identified. Therefore, it was challenging to include all IoT technologies. However, the study only listed those used within the road freight industry. These include, among other things, activity trackers, RFID tags, and smart route sensors. Farquharson et al. (2021) argue that IoT technologies are constantly being improved. As a result, it is anticipated that the list will continue to grow.

The adoption of IoT technologies can enhance customer service, job satisfaction, operational and supply chain performance, and driver safety in the road freight sector. The installation of IoT-based applications and operational effectiveness are amplified by perceived usefulness. An indirect relationship was found between IoT technologies, perceived usefulness, and operational effectiveness.
Practitioners Managers will be advised about the IoT technologies that can be used and their potential advantages for businesses. However, the application of these technologies requires a significant investment in capital and skill capability. According to this study, benefits are greater because adopters are probably extremely competitive. Managers need a thorough understanding of the behaviors of drivers as well as the visibility of products in transit. Managers can lower transportation costs, miles driven, and vehicle wear and tear by implementing IoT solutions. Real-time knowledge of the location of the asset and its condition is key to logistics management. IoT technologies can also be used to monitor operations, enhancing visibility and transparency. They can help create sustainable and effective operations by avoiding traffic jams by adopting alternative routes. IoT gives managers an opportunity to use the internet and smart devices together to gather information and make smarter decisions.

The study offers a fresh perspective on the field of logistics management. A few limitations were identified. The information used in this study was gathered in the province of Muscat. Data gathered from all of Oman's provinces could provide a more complete view of how IoT technologies are being used. The study only covered the road freight sector. It is possible to expand the scope of the study in the future by incorporating additional industries, such as public transportation, aviation, and maritime transportation. The study employed a quantitative approach, but future studies may employ a mixed research method to learn about the subject. The study looked at how perceived usefulness affected the relationship between IoT-based applications and operational effectiveness. Other mediating factors, such as competitiveness, compatibility, and security, may be used in future investigations.

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