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THE IMPACT OF IoT ADOPTION ON LOGISTICS PERFORMANCE: THE MEDIATING ROLE OF REAL-TIME VISIBILITY IN PAKISTANI SMEs

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Abstract
This study examines the impact of IoT adoption (ITA) on Logistics Performance (LP) with the mediating role of Real Time Visibility (RTV) in Logistics SMEs in Pakistan, which suffer from inefficiencies, high costs, and poor visibility in their operations. With the growing opportunities created by IoT, many businesses are considering IoT technologies as solutions to these issues. The study adopted a quantitative technique, and primary data were collected from 290 employees of Logistics SMEs from Pakistan using structured questionnaires. The data was analyzed through Partial Least Squares Structural Equation Modeling (PLS-SEM). The findings indicate that ITA has a positive and significant effect on LP both directly and through RTV. The mediation analysis indicated that RTV positively mediates the relationship between ITA and LP. These findings are consistent with the Resource-Based View (RBV) perspective, which asserts that IoT is a technology resource that can contribute significant strategic value to improving the LP of a business. Therefore, this study contributes to the existing literature regarding ITA in logistics, provides practical implications for logistics SMEs, technology providers, and policymakers, and creates a framework upon which future research can build regarding technology and the improvement of operational outcomes in logistics.

1. Introduction

Logistics SMEs in Pakistan encounter many issues (poor supply chain visibility, inefficient inventory control, and delayed deliveries) that impede their growth and operational effectiveness (Khan et al., 2024; Shahab et al., 2025). The absence of current data creates confusion, increases costs, and leads to low customer service levels (Dwivedi and Dey, 2025). The implementation of the Internet of Things (IoT) offers prospective solutions to these obstacles. By providing a way to monitor goods and assets in real-time, IoT facilitates supply chain visibility, thus providing logistics SMEs in Pakistan with the ability to lower costs, deliver products more quickly, and enhance their overall performance (Anser et al., 2025). As a result of implementing IoT, logistics businesses have the opportunity to optimize their operations, make educated choices, and resolve the critical operational hindrances that limit their competitive advantage. The association between the adoption of IoT and enhanced LP can be attributed to the availability of real-time data (e.g., through IoT). This data allows access to all relevant information to improve the overall performance of logistics systems. Thus, RTV provides an avenue for timely decisions to be made, thereby reducing logistical delays by increasing coordination within the supply chain through the use of cloud computing and IoT technologies (Udeh et al., 2024). The increase in visibility also provides more opportunities for companies to capitalize on this visibility to enhance their operations and increase performance (Alonge et al., 2023; Dhiman & Madan, 2025). RTV is vital in linking the use of IoT technology with the improvement of LP.

The main objective of this research is to investigate how the use of IoT affects the LP of businesses in Pakistan through RTV. The logistics sector is essential for the growth of the national economy, yet in Pakistan, SMEs engaged in logistics do not fully benefit from cutting-edge technological developments (Anser et al., 2024). These SMEs face challenges in developing viable logistics systems due to the lack of advanced technical infrastructure, limited levels of technology adoption, and an inability to address many of the inefficiencies in their supply chain processes. Understanding how IoT can help them provide improved operational efficiencies will be of great benefit to these companies (Bohio et al., 2025; Sial et al., 2025; Naeem et al., 2025a). Therefore, the objective of the study is to fill the gap in the literature regarding how using IoT increases the performance of the logistics sector in Pakistan through the application of RTV and what conditions are necessary for the adoption of IoT within logistics organisations.

This research employs RBV as an analytic framework to investigate how technological resources can increase the competence of businesses and profitability of businesses (Ali et al., 2022; Farooq & Ahmad, 2023). By RBV theory, resources that are valuable, rare, and cannot be imitated can provide competitive advantages for companies when used efficiently (Naeem et al. 2024; Naeem et al. 2025b). IoT is a strategic asset that allows Logistics SMEs to enhance their competitive advantages by tracking delivery times, minimizing shipping delays, and more effectively managing risk (Alkhodair & Alkhudhayr, 2025). Under this paradigm, RTV becomes a key capability to maximize LP. This theoretical framework demonstrates how ITA directly and indirectly influences logistic operational efficiency by creating awareness of operational processes that enable businesses to manage their resources more effectively.

This study employs a quantitative, primary research methodology and deductive, positivist philosophy. 290 questionnaires were distributed to the employees of SMEs involved in logistics throughout Pakistan. Data analysed through PLS-SEM. The PLS-SEM enables the researcher(s) to establish a link between the degree of ITA, the level of RTV utilised by these SMEs, and, therefore, their overall LP; this research will also provide empirical validation of the mediation effect of RTV on the LP of logistics SMEs in Pakistan.

This study provides valuable insights into how the ITA improves LP of SMEs in Pakistan with the

mediation of RTV. A positive relationship exists between the ITA and LP, and that relationship is mediated by RTV. In addition to providing a theoretical contribution to the understanding of the mediation of RTV with respect to the ITA, the study provides practical implications to the stakeholders of logistics SMEs. This study's findings will help businesses understand the importance of investing in IoT technology to increase their RTV and thus improve their operational performance. It will also aid policymakers in supporting the adoption of technology for the growth of the logistics sector.

2. Theoretical Framework

According to the RBV of the firm, a firm's ability to acquire and use valuable, rare, not easily copied, and nontrivial resources gives that firm a competitive advantage over other firms (Mujtaba et al., 2025a, 2025b; Mahmood et al., 2025). In the case of logistics SMEs in Pakistan, one specific form of technology known as the IoT represents a significant technological resource for logistics SMEs and has the potential to increase both operational efficiency and performance (Shah et al., 2024). The IoT allows firms to make the collection of real-time data possible, track the locations and conditions of products in transit, and provide better overall management of logistics operations (Sallam et al., 2023). In addition to improving supply chain visibility, IoT provides logistics firms the ability to identify inefficiencies, shorten lead times, and reduce costs, all of which lead to increased logistics performance (Alonge et al, 2023). Based on RBV, the ability of a logistics SME to effectively implement IoT is a unique resource that differentiates it from other logistics companies in the current, increasingly complex and fast-paced logistics environment.

The technology that enables real-time visibility with IoT is an intermediary resource linking IoT adoption with improved LP (Dhiman & Madan, 2025). Real-time visibility includes a continuously updated stream of information about the shipment's location, condition, and status, thereby enabling logistics companies to use this data for risk management purposes, increase their efficiency, and improve their decision-making processes (Dey, 2023). The exchange of data into actionable insights is the key to increasing operational performance and enhancing decision-making capabilities (Riipa et al., 2025). When viewed from an RBV, the inclusion of RTV into logistics operations provides additional value and opportunities to maximize return on the IoT investments that logistics companies make. Therefore, the finding of this study is that the use of IoT technology in logistics provides enhanced performance for logistics organisations, with the middleware of real-time visibility providing the means to convert the potential value of IoT technology into practical operational enhancements.

3. Literature Review and Hypothesis Development

The term "IoT use within logistics" describes the implementation of networks of connected devices, sensors, and communications technology that allow organisations to track, supervise, and control assets at all times through the transmission of real-time information about their location, condition, and status (Tran-Dang et al., 2022). Adopting an IoT system will enhance the logistical operations of an organisation by allowing them to have accurate, timely data concerning the location, condition, and status of shipments, leading to better decisions and improved operational efficiencies (Rajabzadeh & Fatorachian, 2023).

Logistics efficiency refers to the effective and efficient execution of logistical operations and can be assessed through cost-cutting, quality of service, or reliability. In a competitive marketplace, such as logistics, organisations must continually strive to improve performance to maintain profitability and customer satisfaction (Shahab et al., 2025).

RTV is the capability of tracking and monitoring shipments, inventories, and other logistical materials as they move along in the supply chain (McKinney et al., 2015). The ability to provide a detailed view of the current status of goods enables RTV for businesses to quickly respond to any disruptions, maximize routing efficiencies, and eliminate delays.

3.1 Hypothesis Development

The hypotheses that are developed is include the examination of the relationship between the integration of IoT in logistics operations and key performance outcomes, through the mediating effect of real-time visibility.

3.1.1 IoT Adoption and Real-Time Visibility

The IoT, including Global Positioning System (GPS) Sensors, Radio Frequency Identification (RFID) Tags, Smart Sensors, etc., allows Logistics Companies to continuously collect and transmit data to provide Logistics Managers with RTV of asset location (Ding et al., 2021). The research by Bai et al. (2020) shows that ITA significantly increases supply chain visibility as it provides logistics managers with detailed, timely information concerning shipment and good status during the entire supply chain process. The continuous flow of data reduces uncertainty in operations and enables companies to ascertain which goods are on route to customers; therefore, increasing supply chain transparency (Udeh et al., 2024). In addition, IoT-generated information increases a Logistics firm's ability to make better logistical decisions through accurate, up-to-the-minute data regarding the exact location of inventory, the status of shipments, and the location of deliveries (Gul & Khan, 2024). The results of Alonge et al. (2023) demonstrated that "Integrating IoT into Logistics Operations" produces a significant improvement in the ability of logistics companies to perform real-time tracking of goods, thus allowing companies to respond more immediately to unforeseen events such as freight delays. Because of greater visibility, logistics companies are able to improve supply chain efficiency, optimize their operations, and improve the total flow of goods. It is thereby hypothesized that:

H1: IoT adoption has a positive effect on real-time visibility in logistics operations.

3.1.2 Real-Time Visibility and Logistics Performance

The second hypothesis investigates how LP is affected by RTV. With RTV, logistics managers gain continuous access to data about their shipments' locations and conditions, allowing them to make quick, informed decisions (Smith 2024). As stated by Dey (2023), because of the increased transparency resulting from IoT, companies can respond to disruption quickly and prevent delays, all of which improves LP. In addition, this greater ability to make timely decisions leads to more efficiently operated (e.g., reduced downtime, improved routing, optimized management of inventory) logistics operations (Pasupuleti et al., 2024); therefore, real-time visibility also increases supply chain coordination and allows for improved stakeholder relationships through better information sharing. Choi et al. (2018) stated, if all parties in the supply chain have the same level of visibility, they work together effectively and decrease the chance of sending incorrect information resulting in errors that could cost them money thereby improving customer service, increasing service quality, and reducing operational expenses. Based on these benefits, it is proposed that:

H2: Real-time visibility has a positive effect on logistics performance.

3.1.3 IoT Adoption and Logistics Performance

ITA itself has the potential to directly improve LP through the automation of critical processes and the improvement of operational efficiencies. (Lopes and Moori, 2021.) IoT solutions allow businesses to collect and analyze vast amounts of data for optimization opportunities across logistics functions, including inventory management, optimizing routes, and predictive maintenance (Gunasekaran et al., 2017). IoT solutions can determine when stock is running low and automatically reorder inventory; they can also predict when equipment will fail and possibly schedule maintenance before the failure occurs, thereby reducing costly downtime. Additionally, IoT systems provide customers with real-time updates about the status of their shipments; this increased level of service leads to greater customer satisfaction. Porter and Heppelmann (2014) state that IoT adoption creates new opportunities for efficiency by allowing businesses to better allocate resources, minimize the risks of human error, and streamline supply chains. Therefore, due to these

positive attributes of IoT adoption, we propose the following hypothesis.

H3: IoT adoption has a positive effect on logistics performance.

3.1.4 Mediation of Real-Time Visibility

The fourth hypothesis focuses on how RTV of supply chain data mediates the effect of IoT technology on LP, as opposed to other potential mediation variables such as measurement or logistics processes. IoT could serve as a foundation for leveraging new technologies to improve supply chain operations. However, how this collected data has been transformed from passive to active (i.e., having the necessary tools and technology to act on the information) is through the use of real-time visibility, which has been made available via IoT technology. According to Zhou et al. (2020), IoT's increased visibility of supply chain activity contributes to the increase in efficiency of operations and the improvement of decision-making. Therefore, an increase in logistics performance will be realised due to the increased visibility of the IoT applications and the ability to act on the information they provide.

Based on Al-Khatib (2023), Dhiman & Madan (2025), and Helo et al. (2017), the integration of RTV as a mediating variable was found to significantly increase the relationship between ITA and LP, because it allowed the information obtained through IoT to be used effectively. In addition, Helo et al. indicated that companies were able to respond more effectively to disruption in the supply chain by providing a means of visibility of the flows within their supply chains and, in turn, to better control the movement of their goods and products, hence, improving customer satisfaction. Therefore, real-time visibility is expected to have a positive impact on the operational efficiency gained via the adoption of IoT. Therefore, it is proposed that:

H4: Real-time visibility mediates the relationship between IoT adoption and logistics performance.

4. Research Methodology

In this study, a quantitative methodology with a deductive approach will be used to examine previously developed theories and hypotheses using empirical data. Specifically, the methodology will focus on testing the relationship between Logistics SMEs' adoption of IoT technology, their use of an RTV system, and their overall LP by collecting survey-based data and analysing it via PLS-SEM.

4.1 Research Philosophy

This study uses a positivist research philosophy to analyze the relationship. Using this research philosophy, the researcher has developed hypotheses based on existing theories that can be empirically tested.

4.2 Research Design

This study utilized a cross-sectional research design to gather data from a sample of logistics SMEs operating in Pakistan at one particular point in time. Additionally, the research aims to measure the degree of adoption of the IoT, the amount of RTV obtained, and the business performance achieved by Logistics SMEs, all at the same time.

4.3 Population and Sampling

In Pakistan, logistics SMEs are the target study population for this research study. According to the Pakistan Bureau of Statistics, the logistics sector in Pakistan has recently experienced very rapid growth. Logistics SME's are important to be able to identify the effect of ITA has on LP. A stratified random sampling approach is used to ensure that different types of logistics SMEs (e.g., freight companies, warehousing, and distribution) are represented in the sample. The sample size for this study is 290.

4.4 Data Collection

A structured questionnaire was created to collect primary data from key decision-makers in the logistics sector, such as managers, directors, and logistics officers of logistics SMEs. The questionnaire had major areas:

1. Demographic Information: This area contained demographic information about the respondent, i.e. gender and age.

2. IoT Adoption: This area measured how much IoT technology has been adopted within the company's logistics operations. The area also looked at what type of IoT technologies were being used by the firm, including RFID tags, GPS tracking systems, and

sensors. Scales created by earlier researchers (Álvarez López et al., 2018) were used to measure the level of IoT adoption.

3. Real-Time Visibility: This area assessed the level of RTV that the firm had obtained through the use of IoT. The questions asked about tracking shipments, monitoring inventory levels, and receiving real-time information regarding the status of goods in transit. Scales developed in earlier research (Pamisetty, 2023) were used to assess levels of RTV. (Pamisetty, 2023).

4. Logistics Performance: This section evaluated logistics performance based on several important metrics, including delivery time, cost savings created by reducing total supply-chain costs, service level, and shipment precision. The scale of measurement was designed based on the Bowersox et al. (2013) work, and it has been tailored specifically to the logistics SME environment of Pakistan.

The research instrument was pilot-tested with a limited number of logistics providers before being utilized for the full data collection, to establish that the research tool is clear and reliable in its measurement instruments. The results from the pilot will be used to modify and improve the research tool.

4.5 Data Analysis

The data obtained from the survey was evaluated by applying PLS-SEM. PLS-SEM is appropriate for this study because it enables an examination of complex models that include relationships between different constructs and have a large number of constructs involved in the model. Furthermore, when the sample size is modest, PLS-SEM offers the option to do this efficiently using the sample size limitations (Hair et al., 2017; Shaikh et al., 2025a, b; Memon et al., 2025).

5 Result

5.1 Demographic Result

290 respondents participated in this study, and the ratio of male respondents to female respondents was skewed significantly toward male respondents. The predominant level of educational attainment is a bachelor's degree, followed by a master's degree and matriculation. A smaller percentage of respondents possessed either intermediate education or PhD qualifications. This distribution of respondents creates an opportunity for respondents from different educational levels to be represented and provides insight into the diverse perspectives of respondents regarding the study's topic.

Table 1: *Demographic Statistics*

Demographics	Frequency	Percentage
Gender		
Male	197	67.93
Female	93	32.06
Qualification		
Matriculation	53	18.27
Intermediate	47	16.20
Bachelors	105	36.20
Masters	78	26.89
PhD	07	2.41
Total	290	100

5.2 Measurement of Model

Table 2 presents the factor loadings for each of the Constructs analysed in this study: ITA, RTV, and LP. The factor loadings for IoT Adoption range from .785 to .872 and demonstrate that the Construct has good reliability, as indicated by the Cronbach's alpha (.792) and average variance extracted value .5, which indicates that the construct has adequate convergent validity. The factor loadings for RTV range from .783 to .902, demonstrating even higher reliability with the Cronbach's alpha value of .794 and an average variance extracted value of .025; thus, it is deemed a valid construct. LP has good factor loadings, with scores from .793 to .876, providing

good internal consistency with a Cronbach's alpha value of .805 and an average variance extracted value of .052, which confirms convergent validity. All Constructs have high reliability and validity.

Table 2: *Discriminant Validity*

Items retained	Abbreviation	Factor Loadings	Cronbach's alpha	CR	AVE
IoT Adoption	ITA1	0.785	0.792	0.802	0.593
	ITA2	0.792			
	ITA3	0.843			
	ITA4	0.872			
	ITA5	0.795			
Real-Time Visibility	RTV1	0.783	0.794	0.799	0.598
	RTV2	0.902			
	RTV3	0.893			
	RTV4	0.834			
Logistics Performance	LP1	0.797	0.805	0.783	0.652
	LP2	0.804			
	LP3	0.876			
	LP4	0.793			
	LP5	0.799			

The HTMT Ratio matrix has determined that the constructs of ITA, RTV, and LP possess distinct constructs, as all HTMT values fall below the threshold level of 0.85. The HTMT ratios for the three constructs indicate that they retain separate identities: IoT Adoption and Real-Time Visibility (0.602), ITA and LP (0.517), RTV and LP (0.583). Therefore, each construct supports the validity of the separate constructs.

Table 3: *Heterotrait-Monotrait Ratio (HTMT) Matrix*

	IoT Adoption	Real-Time Visibility	Logistics Performance
IoT Adoption			
Real-Time Visibility	0.602		
Logistics Performance	0.517	0.583	

Additionally, the Fornell-Larcker criterion matrix reinforces this distinction as the diagonal values (that is, the square root of the AVE for each construct) are greater than their respective off-diagonal correlations.

Table 4: *Farnell–Larcker Criterion Matrix*

	IoT Adoption	Real-Time Visibility	Logistics Performance
IoT Adoption	0.597		
Real-Time Visibility	0.473	0.582	
Logistics Performance	0.439	0.237	0.473

5.3 Measurement of Hypothesis

The hypothesis test results reveal valuable insights regarding the relationship between ITA, RTV and LP. The results indicate that there is a positive effect of ITA on LP, with a path coefficient of 0.235, a t-statistic of 2.97, and a p-value of 0.001. By incorporating IoT technology into their logistics operations, companies can increase their logistics performance through improving operational efficiency, minimizing errors, and optimizing their resources. The positive and statistically significant relationship between ITA and LP is consistent with the RBV, which states that valuable and unique resources (such as IoT technology) positively affect the performance of the firm.

RTV also has a significant and positive impact on LP, with a path coefficient of 0.229, a t-statistic of 2.83, and a p-value of 0.000. As logistics firms gain

greater visibility into their operations through IoT-based RTV, they will be able to react more quickly to disruptions, optimize their routes, and manage inventories, thereby leading to better LP. Based on the RBV perspective, RTV is a critical dynamic capability that gives the company the ability to proactively respond to changing market conditions and improve LP.

H3, which states that IoT Adoption has a positive effect on RTV (0.327 path coefficient, 3.22 t-statistic, and 0.003 p-value). The adoption of IoT technologies is confirmed to add to the ability of logistics companies to monitor and track shipments in real-time. The RBV indicates that IoT integration is a strategic resource that offers logistics firms valuable information that allows companies to build both operational capabilities and a competitive edge over their competitors.

RTV is confirmed to have a mediating effect between ITA and LP, 0.320 path coefficient, 3.06 t-statistic, and 0.000 p-value. These findings indicate that RTV is an important tool for taking advantage of the benefits of IoT Adoption to improve LP. The findings also support RBV's conclusion about the need for logistics companies to have the correct capabilities and resources to fully exploit the advantages offered by IoT technologies. RTV acts as a mediator in turning data generated by IoT systems into actionable business intelligence, which ultimately leads to improved LP.

The findings of this study support all four hypotheses, confirming that the use of IoT technology enhances LP both directly and indirectly by providing real-time visibility into asset locations. This supports the RBV theory that organizations can gain a sustainable competitive advantage through the effective utilization of technology, thus enhancing their ability to operate within a rapidly changing logistics landscape.

Table 5: *Hypothesis Result*

Path	Path Coefficient	T-Statistics	P-value	Hypotheses Decision
ITA → LP	0.235	2.97	0.001***	H1: Accepted
RTV → LP	0.229	2.83	0.000***	H2: Accepted
ITA → RTV	0.327	3.22	0.003**	H3: Accepted
ITA → RTV → LP	0.320	3.06	0.000***	H4: Accepted

Model Fit Results for the SRMR: The SRMR value of 0.234 indicates that the model data fit reasonably well. However, the original model could be improved upon as values under 0.08 are usually considered ideal. Additionally, the R^2 scores of the endogenous constructs show that RTV explained 29.7% of the variance in performance and LP explained 37.5%. Moderate R^2 scores mean that while the model captured relationships between ITA, RTV, and LP effectively, there is still room for additional refinement.

Table 6: *Model Fitness*

Fit Index / Endogenous Construct	Value
SRMR	0.234
R^2 (RTV)	0.297
R^2 (LP)	0.375

6. Conclusion

The purpose of this study is to examine how the implementation of IoT affects the LP of SMEs in Pakistan, with an emphasis placed on the role of RTV in logistics businesses. The outcomes indicate that IoT positively impacts the LP, both directly as well as indirectly, through the increased level of RTV experienced by logistics organisations. These conclusions support the RBV, which states that IoT is a key resource that can help improve operational effectiveness, decision-making ability, and coordination among Logistics organisations. The

mediating influence of Real-time Visibility on the Logistics performance of SMEs in Pakistan also reinforces the importance of increasing the Transparency of Data sharing as a critical driver for optimising logistics operations and demonstrates the Strategic Value of implementing IoT technologies to improve performance levels and support the successful business model of logistics SMEs.

This research adds to the body of knowledge on the adoption of IoT within the Logistics industry and identifies the significant role of Technology as a Dynamic Capacity for improving the Logistics Business. The results also provide support for the model developed for this study, covering the manner in which the implementation of IoT influences the Logistics outcomes of organisations. These results are especially important for SMEs in Developing Countries, such as Pakistan, where IoT is currently being implemented, but still represents a significant opportunity for growth and development in the Logistics sector.

7. Implications

Logistics SMEs, policymakers, and technology innovators can all benefit from this research. The evidence from the study indicates that logistics companies need to invest in IoT technology so they have access to up-to-date information about their operations and can respond proactively to disruptions. This means logistics firms can optimise their routing and reduce any inefficiencies in their operations, ultimately increasing their logistics performance. For policymakers, the findings can be used to promote policies that support industry adoption of IoT technology in the logistics industry by advocating for increased integration of technology into the logistics sector and promoting policies that will support innovation in this field. For technology providers, the research stresses that technologies should be built specifically for the needs of logistics SMEs and should be designed to be accessible, affordable, and easy to adopt.

8. Limitations and Future Directions

The limitations of this study include: the data was collected at one point in time (cross-sectional) therefore it is not possible to conclude cause-and-effect over a longer period; in addition, it was based only on logistics SMEs operating in Pakistan, which could restrict the extent to which the findings would apply to other regional and industry sectors. Future studies can take the form of longitudinal studies, which would allow examination of the effects of IoT on logistics performance for a longer period of time, and would also enable the examination of additional variables that may mediate or moderate the relationship between IoT adoption and logistics performance (e.g., supply chain integration, technological readiness) on an international level and across different types of firms.

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