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Digital Technology Adoption and Its Impact on Third-Party Logistics Service Providers in Tamil Nadu

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Abstract - **The paper mainly focused on third-party logistics as the central part of the changes that have undergone quick development in digital technologies. It helps to improve service delivery and maintain competitiveness in changing markets to streamline operations. 3PL should provide TN, the center of manufacturing, trade, and logistics in India. This research study mainly explained that the 3PL services are provided to the TN used by digital technology. It also explored the various effects related to overall performance, cost reduction, and operational efficiency. These technologies impact cloud computing, big data analysis, warehouse automation, AI, and real-time tracking systems. The research findings are that digital technologies provide productivity to improve customer communications. Most digital platforms are enabled by delivering various services, such as response time, personalized solutions, and real-time tracking. Challenges include high implementation costs and data security. This research study mainly benefited from digital advancements. Digital technology adoption has various key factors, along with expansion and competitiveness among Tamil Nadu 3PLs.**

Keywords: **Cost Reduction, Data Analytics, Warehouse Automation, Real-time Tracking System, IoT, Blockchain Technology, AI**

I. INTRODUCTION

Supply chains and logistics deal with the final distribution of manufactured commodities that are no longer in production and significant and sequential increases in storage and resources. Therefore, supply and materials management represents the storage and flow from the point of final manufacturing to the clients or end users. The importance of this method, objective running, and storage is currently prioritized. Reverse logistics is the movement of used goods, and refundable paperbacks via the program are another crucial element. Several international organizations and commercial outfits have outsourced logistics services to 3PL businesses to optimize logistics and shipping costs while concentrating on core activities (Pecheranskyi et al., 2024). This has become standard procedure in global commerce because of extensive expertise and experiences that allow for the supply of transportation and logistics at low rates. The development and appearance of 3PLs primarily depend on significant competitive advantages in several industries (Hui et al., 2019).

Digital technology has emerged as a key force behind the substantial changes in the logistics sector during the last ten years. The quick adoption of digital technology has dramatically impacted third-party logistics (3PL) service providers, who provide outsourced logistical services like distribution, warehousing, and transportation (Hermansyah, 2023). These innovations are changing logistics operations, which are also increasing customer happiness, service levels, and efficiency. The logistics industry is essential to enabling the efficient flow of commodities throughout Tamil Nadu, a state in India that is a center for manufacturing, trade, and industrial activity. Efficient logistics services are in high demand due to the expansion of manufacturing, international trade, and e-commerce, which are the main competitive ideas to satisfy business needs. 3PL service provides help in implementing digital solutions. Various types of technologies are essential to the Tamil Nadu logistics industry (Arvinth, 2023). These technologies help with better tracking, inventory management, and optimization (Biswas & Tiwari, 2024). These types of technologies help boost operational performance. Adopting digital technology has various effects on TN 3PL. The high level of competitive sector results is followed by multiple factors such as faster delivery times, lower cost, and operational efficiency (Subbaiah et al., 2024). The main disadvantage is that integrating the new technology helps establish a new business model. This research model helps to change the 3PL provided in Tamil Nadu. Digital technologies help in logistics environments to overcome these difficulties.

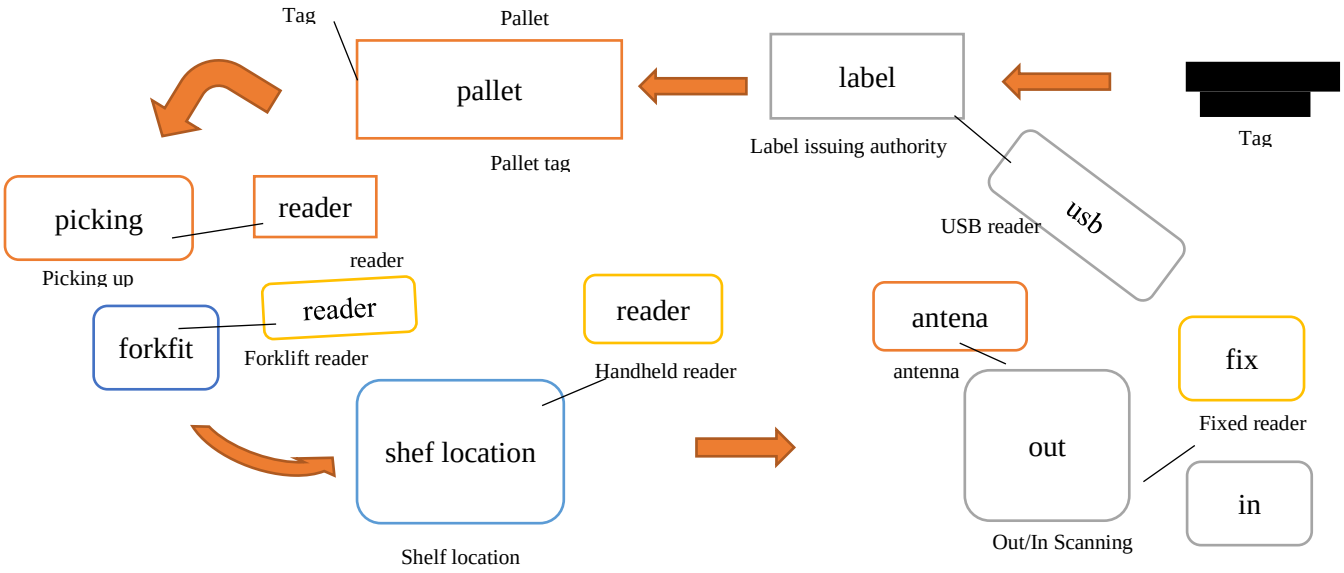

Fig. 1 Warehouse Operations

As shown in Fig. 1, the process is implemented through the storehouse operating system and 3PL. It's used to arrange the storehouse data through several factors. WMS technology is used to improve the picking and arranging of patterns. It communicates through an operating system and transport system. An author (Sivakumar, Ruthramathi, 2019) describes that the WMS system should be enhanced with other types of software to maximize efficiency. Additionally, 3PL provides various services related to consulting and store best actions.

Research Objective

- To understand the 3PL in the logistics and transportation sector.
- To describe the impacts of Technology on Third-party logistics provides
- To explore the benefits of the transporters by using Digital technologies (IoT)
- To classify the significant challenges faced by the transporters in Tamil Nadu.

II. Literature Reviews

Raja & Venkatachalam, (2020). According to this report, technology speeds up information exchange between supply chain participants and across supply chains. For example, sharing real-time information on products and items and enabling technologies like cloud computing, artificial intelligence, machine learning, and the Internet of Things increase supply chain visibility. Third-party logistics (3PL) is becoming increasingly important as more and more businesses worldwide outsource their logistics needs to 3PL service providers (Raja & Venkatachalam, 2020). N. Gayathri, R. Ruthramathi, and M. Senthil (2020). The study's objective is to raise awareness of how warehouse service providers are utilizing the newest technologies, as well as the notable advantages and difficulties that warehouse operators encounter when using technologies such as GPS, barcode, RFID, drones, IoT, artificial intelligence, cloud computing, robotics, and blockchain by 3PL service providers that work with VOC port in Tuticorin district. When developing a comprehensive strategy for implementing the exponential methods, it becomes necessary to consider the interdependencies of various technologies (Wang & Wijesinghe Mudiyanselage, 2024). Mateen, A., Gopinath, S., and Premkumar, P. (2021). Future studies should include route optimization, incentive scheduling, and real-time electronic tracking and communication to spur innovation, especially in the last mile. It should also concentrate on utilizing workers and offering shippers additional worth (Zhang, 2024). Another crucial path to follow in the future is supply chain transformation via enhanced logistics optimization and integration throughout the supply chain (Premkumar et al., 2021).

III. Impacts of Technology on Third-Party Logistics Provides

Online Tracking and User-Friendly Tools

Incorporating digital technologies in the logistics industry has profoundly changed how third-party logistics (3PL) providers function. These technologies have improved customer happiness, operational efficiency, and transparency (Bitirez, 2024). Online tracking systems and user-friendly tools are among the most influential technologies, completely changing how logistics organizations interact and manage their operations. The main effects of these technologies on 3PL providers are online tracking systems, which allow clients and service providers to monitor the real-time status of products in transit (Betrand et al., 2024). Most of the comprehensive analysis is followed by delivery time frames, location tracking, and checking the progress of goods through various applications. The effects of 3PL suppliers on the implementation of real-time tracking technologies. 3PL suppliers help to increase transparency and foster consumer trust (Singh, 2019). 3PL provides the interface relationship

between the corporate client and digital technologies (Shojaei Shahmirzadi, 2024). It is the simplest procedure to deliver the exact status through shipment status, delivery confirmation, and rescheduled shipments (Harsanto et al., 2024). The availability among the online tracking of the user-friendly tools is directly affected by the 3PL provides for customer satisfaction (Recker et al., 2024). 3PL provides a strong relationship between the client and shipments of real-time information through delivery status (Vinod Kumar & Aravind, 2019). Additional things to improve brand loyalty include promoting delayed shipments to the business (Mvubu & Naude, 2024).

Automation and Efficiency

Various types of technologies are used in 3PLs to improve service delivery and boost overall efficiency. 3PL Organizations in TN are undergoing various changes due to some technical breakthroughs, including automation with efficiency enhancements (Patel & Shivarama Rao, 2023). Operational Automation in Warehouse logistics defined the various changes (van der Westhuizen & Niemann, 2022). By eliminating the need for manpower, automation lowers operating costs and speeds up order fulfillment (Ekeskär & Rudberg, 2022). This is essential to satisfy the growing demand for quicker delivery times, particularly in retail and e-commerce. Improved efficiency in inventory management in advanced inventory systems such as Automated Inventory Systems, 3PL companies in Tamil Nadu are progressively using digital inventory management systems that automate order tracking, stock monitoring, and replenishment. effects on 3PL suppliers (Appu & Tania, 2024).

Automated solutions help prevent stock-outs and overstocking by guaranteeing that the appropriate products are accessible when needed (Prataviera et al., 2023). These technologies enhance inventory management accuracy, optimize storage, and minimize human error by reducing manual inventory checks and offering real-time stock level data. This results in cost savings and improved service delivery (Raja & Venkatachalam, 2022). Improved efficiency in inventory management (Ruthramathi & Sivakumar, 2023). In Tamil Nadu's 3PL industry, automation and efficiency-boosting technology are resulting in notable gains in customer satisfaction, cost control, and operational performance (Raja & Venkatachalam, 2023). 3PL providers are putting themselves in a position to satisfy the expanding needs of the logistics industry as they keep investing in technology like real-time data tools, AI-driven route optimization, predictive analytics, and warehouse automation (Zhang, 2024). These developments enable more effective competition in a dynamic and fiercely competitive logistics sector by streamlining internal processes and improving customer service (Ogbolu & Okpighe, 2024).

Enhanced Communication and Collaboration

Digital tracking systems, real-time tracking platforms connected to IoT, and GPS technologies enable 3PL service providers to communicate cargo statuses and changes to clients and partners rapidly. Effect on Interaction: Real-time data exchange enhances transparency and communication among 3PL providers, clients, and partners (Valashiya & Luke, 2023). Clients are kept updated on the progress of their shipments, which fosters trust and lessens uncertainty. Additionally, more efficient interaction among warehouse managers and transporters helps guarantee seamless transitions between delivery phases (Singha & Verma, 2019). Impact on Collaboration means all logistics chain stakeholders, including suppliers, carriers, and third-party logistics providers, may make prompt choices using real-time information (Wu et al., 2023). Stakeholders are notified of delays or problems, enabling swift supply chain modifications. Digital technology use has greatly improved communication and teamwork among Tamil Nadu's third-party logistics service providers (Kithae, 2024).

IV. Findings and Discussion

Methodology

This research paper mainly discussed the effects of digital technology adoption on customer happiness, cost effectiveness, and operational effectiveness. It used qualitative and quantitative methods, and the mixed-method approach was a deep analysis of the effects of digital technology. The demographics of service providers are discussed first, followed by their use of technology, the difficulties that transporters encounter when utilizing it, and the advantages of digital technology. Both quantitative and qualitative research methods will be applied. The impact of digital technology can be thoroughly explored and statistically analyzed according to this mixed-methods methodology. First, the demographics of service providers; second, how service providers use technology; third, the difficulties that transporters encounter while utilizing technology; and last, the advantages of digital technology. Both online and offline questionnaires were used to administer the survey. The survey was conducted utilizing both offline and online methods. 376 people lived in Chennai, and 281 lived in the Coimbatore area. The sample size comprises 243 possible participants out of the 657 total population. There were 376 people from Chennai and 281 people from the Coimbatore area. The sample size shall consist of 243 possible participants out of the 657-total population. The SPSS software was used to administer the online survey.

Applications in the Logistics Sector

TABLE I TECHNOLOGICAL FEATURES IN THE LOGISTICS SECTOR

Technological features	
Position and Route management	191
IT & W (Inventory Tracking and Warehousing)	251
BP (Breakdown Prevention)	261
IoT, Blockchain, Digital BOL	118
DBD (Drone-Based Delivery) (Senthil et al., 2020)	167

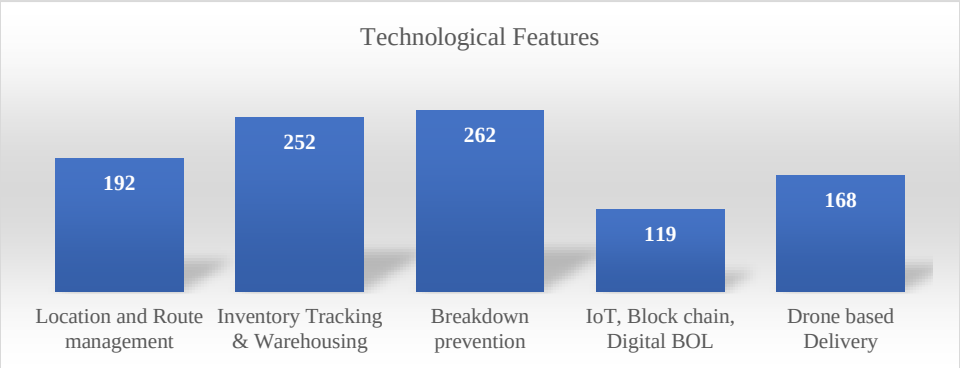

Fig. 2 Technological Features

From the above Table I and Fig. 2 analysis, Location and route management are used by various technologies such as GPS, GIS, and advanced types of route optimization algorithms. It also helps to manage locations, such as a location shipment, track the real-time position of the vehicles, and optimize delivery routes. The technological features of this application, such as GPS tracking, are for avoiding traffic and delays. Inventory tracking and warehousing are included in various technologies such as barcode scanning, WMS (warehouse management system), and IoT-based sensors. These technologies help allow real-time tracking for improved accuracy and enhance the efficiency of warehouse operations. Breakdown prevention is also used to predict and prevent vehicle breakdowns during transit, reducing downtime and improving fleet efficiency. Drone-based delivery is used for last-mile delivery in remote areas. Drones deliver small packages quickly and reduce delivery time and costs.

Percentage Analysis

TABLE II DEMOGRAPHIC INFORMATION

Sl.NO	Variable Name	Description	Frequency	Percentage
1	Gender	Male	150	60
		Female	100	40
2	Age	20-30	20	8
		31-40	60	24
		41-50	80	32
		51-60	75	30
		Above 60	15	6
3	Designation	Manager- (SCL)Supply chain Logistics	100	40
		TM- Transport Manager	65	26
		LM- Logistics Manager	85	34
4	Experiences	5 Years	15	6
		6-9 Years	73	29.2
		10-15 Years	84	33.6
		16-21 Years	16	6.4
		Above 21+	62	24.8
5	Qualification	Bachelor	13	5.2
		Diploma	115	46
		Master	51	20.4
		PG	46	18.4
		Others	25	10
6	Employees are Working	1 to 10 Employees	64	25.6
		11-30 Employees	87	34.8
		31-50 Employees	37	14.8
		51-150 Employees	10	4
		150 + Employees	52	20.8
7	Marital Status	Single	61	24.4
		Married	189	75.6
8	Salary	less than 15,000	71	28.4
		15000-26000	104	41.6
		27000-55000	65	26
		More than 1,00,000	10	4
9	Location	Coimbatore	114	45.6
		Chennai	136	54.4

The table II represents the percentage analysis of demographic information. The following variables are used for this demographic profile: gender, Age, Designation, Educational qualifications, years of experience, marital status, Location, monthly salary, and location. Here, the defined responded age range of 51 to 60 has high-frequency values. The supply chain logistics manager's designation is 100%. High-level Diploma people work for transportation companies.

Anova Analysis- Various Types of Technologies

TABLE III ANOVA ANALYSIS- VARIOUS TYPES OF TECHNOLOGIES

Warehouse Technologies in Logistics		Sum	df	Mean square	F	sig
GPS	B/w Groups	46.307	1	46.307	42.867	0
	WIG (With in Groups)	260.343	241	1.08	0	
	total	306.65	242		0	
Barcodes	B/w Groups	0.154	1	0.154	0.089	0.765
	WIG	414.422	241	1.72	0	
	total	414.576	242	0	0	
RFID	B/w Groups	0.583	1	0.583	0.671	0.414
	WIG	209.401	241	0.869	0	
	total	209.984	242	0	0	
Drones	B/w Groups	12.412	1	12.412	24.017	0
	WIG	124.551	241	0.517	0	
	total	136.963	242	0	0	
IoT	B/w Groups	20.457	1	20.457	35.885	0
	WIG	137.395	241	0.57	0	
	total	157.852	242	0	0	
AI	B/w Groups	18.839	1	18.839	14.972	0
	WIG	303.243	241	1.258	0	
	total	322.082	242	0	0	
Cloud Computing	B/w Groups	0.81	1	0.81	0.98	0.323
	WIG	199.19	241	0.827	0	
	total	200	242	0	0	
Robotics	B/w Groups	5.273	1	5.273	3.928	0.049
	WIG	323.5	241	1.342	0	
	total	328.774	242	0	0	
Blockchain	Between Groups	7.863	1	7.863	4.668	0.032
	WIG	405.988	241	1.685	0	
	total	413.852	242	0	0	

The analysis in Table III shows various warehouse technologies are used in logistics. These technologies have more excellent value than the significant values of 0.05%. The value of barcodes is 0.765, which is greater than the significant value of 0.05. RFID's value is 0.141. Cloud computing's value is 0.323, which is crucial for other transporters.

Benefits of Transportation Using Technology

TABLE IV BENEFITS OF TRANSPORTATION USING TECHNOLOGY

	Frequency	percentage
Access Capacity	82	10
Full supply chain visibility	59	7.9
communication through all platforms	54	7.4
cost savings	85	10
ROI improvement	56	7.4
Improved Service KPI	77	10
Offload Non-core business process	69	9
Operational control	98	12
Reporting & Analysis	147	18
Audit pay	123	15

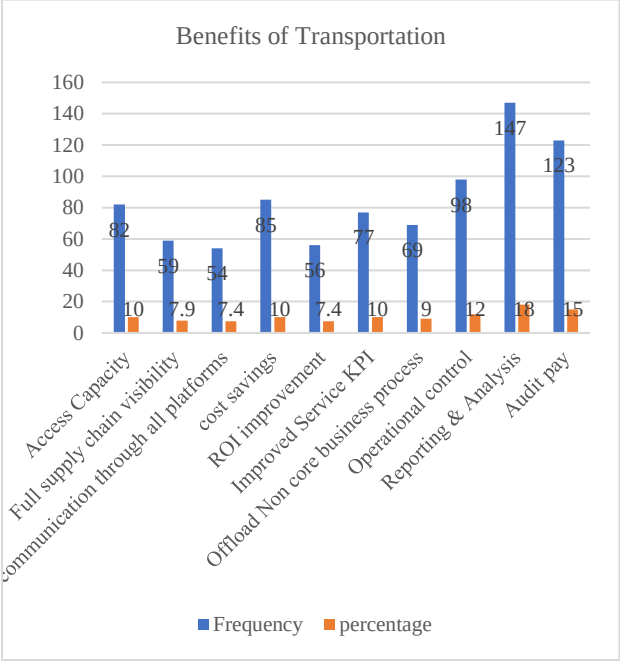

Fig. 3 Benefits of Transportation

Table IV and Fig. 3 represent the various benefits of transportation used by various types of digital technology. They are followed by access capacity, full supply chain visibility, cost savings, operational control, reporting analysis, freight audit and pay, ROI improvement, and offloading non-core business processes. After evaluating all metrics, reporting and benefits and Audit pay have the largest benefits.

Factor Analysis- IOT Development (Total Variance)

TABLE V FACTOR ANALYSIS FOR IOT DEVELOPMENT (TOTAL VARIANCE EXPLAINED)

Components	Initial Eigenvalues			Extraction sum of Squared loadings			Rotations Sums of Squared Loadings		
	Total	% of variance	Cumulative (%)	Total	% of variance	Cumulative	Total	% of Variance	Cumulative (%)
1	4.76	39.669	39.669	4.76	39.669	39.669	3.2	26.665	26.665
2	2.099	17.49	57.159	2.099	17.49	57.159	2.548	21.232	47.897
3	1.45	12.086	69.245	1.45	12.086	69.245	2.003	16.692	64.589
4	1.017	8.478	77.723	1.017	8.478	77.723	1.576	13.134	77.723

Following the table V analysis, each component has eigenvalues and unique elements. The twelve primary factors exhibit variances of 26.665, 21.232, 16.692, and 13.134. All components should meet all types of requirements and contain 50%. The total variance among the variables is 77.723, which contains the benchmark result of 77%.

Difference Between Transport Services and Capabilities and Education Qualification

TABLE VI DIFFERENCE BETWEEN TRANSPORT SERVICES AND CAPABILITIES AND EDUCATION QUALIFICATION WITH RESPONDENTS

ANOVA						
		Sum of Squares	df	Mean Square	F	sig
limited package	B/w Groups	49.046	3	16.346		
	WIG (With in Groups)	407.234	239	1.704	9.595	0
	Total(T)	456.28	242	0		
Final Mile/White glove	B/w Groups	13.64	3	4.547	2.419	0.067
	WIG	449.32	239	1.88		
	Total(T)	462.96	242	0		
Fleet Acquisition	B/w Groups	8.84	3	2.949	1.334	0.264
	WIG	528.17	239	2.21		
	Total (T)	537.02	242	0		
Equipment/Drivers	B/n Groups	10.3	3	3.46	1.878	0.134
	WIG	440.3	239	1.842		
	Total (T)	450.7	242	0		
Intermodal	B/w Groups	24.92	3	8.307	4.379	0.005
	WIG	453.37	239	1.897		
	Total(T)	478.29	242	0		
Ocean	B/w Groups	32.21	3	10.738	7.246	
	WIG	354.16	239	1.482		
	Total(T)	386.37	242	0		
Rail	B/w Groups	10.36	3	3.455	2.188	0.09
	WIG	377.27	239	1.579		
	Total	387.63	242	0		
Bulk	Between Groups	6.67	3	2.225	1.411	0.24
	WIG	376.86	239	1.577		
	Total	383.53	242	0		
Air cargo	Between Groups	4.26	3	1.421	0.835	0.476
	WIG	406.47	239	1.701		
	Total	410.74	242			

0.05% (Significant value)

In the table VI shown above, it can be inferred that among all the challenges faced by transporters, only four factors are relevant and have a significant value beyond the P-value. When compared to the other four criteria, all sectors and transporters are confronted with strategic challenges that are of significant importance.

V. SUGGESTION

Digital technology is becoming more interconnected, leading to the development of various technologies such as IoT, Cloud Computing, and AI or RFID/GPS. The digital revolution is assisting organizations in transforming their

operations to interact more effectively and remain connected with clients, vendors, and personnel. Using the Internet and related services creates a stimulating work environment for users. The use of digital logistics, such as WMS, is becoming more common among supply chain companies in the present day to enhance distribution methods. They also acknowledge the potential to automate the industry's transportation processes and shipper activities.

VI. CONCLUSION

The effects of digital technology on third-party logistics (3PL) in Tamil Nadu were investigated in this research. The use of these technologies is essential for the 3L providers in TN. Digital technology reduces labor costs due to improved data processing and reduced manual errors. Furthermore, this paper employed strategies for adopting digital technology and proposed a conceptual and empirical framework within the logistics and supply chain sectors. Technology is now an integral part of every step in the supply chain process. At the end of the day, connectivity improves efficiency and workflow realism to allow any business more adaptability (and therefore innovation), organization (awareness), agility (due diligence), and success.

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