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Article

Enhancing efficiency in Logistics through Automation

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Abstract: The logistics sector, which is essential to the world economy, plans the transportation, storage, and supply of products and services from the point of entry to end user. Its development has been intimately linked to changes in consumer behaviour, economic upheavals, and technological breakthroughs. Technological developments offer exciting chances to improve productivity, solve problems, surpass customer expectations, and revolutionize conventional logistics operations. Automating logistics processes helps to increase precision and agility, and especially in warehouse management. It will examine how automation improves stock control, leading to improved stock management. By improving decision-making procedures, cutting expenses, and boosting operational agility in logistics, automation gives businesses a competitive edge.By incorporating IoT devices, it is possible to constantly observe shipment updates and inventory levels, improving overall accessibility. Demand planning and predicting are being transformed by automation, which uses cutting-edge methods to greatly improve precision and attentiveness.Excellent demand satisfaction is possible through actual-time delivery tracking, concrete evidence of arrival, sensor-based surveillance all across journeys, visibility of inventory in transit, and other customer services facilitated by automation technologies in logistics. Separating, picking, and packing are the logistics jobs that robotics manages, increasing efficiency and lowering human mistakes.Perishables and valuable items, is ensured by sensors mounted on products, or containers that give information on site, temperature andstickiness.Businesses can increase operational effectiveness, lower manual failure rates, and speed up purchase orders and satisfaction by automating time-taking and monotonous work.

Keywords: Automating Logistics, precision and agility, shipment updates, delivery tracking, picking, and packing, reduce human error, increase operational effectiveness

1 Introduction

Automation is making logistics more effective, but there is still much work to be done to achieve optimal efficiency. Efficiency is crucial in the dynamic and intricate world of logistics that exists today. The foundation for increasing operational efficiency in logistics is automation. The secret to success in the dynamic world of international trade and commerce is logistical effectiveness. The logistics industry is entering a new phase of unmatched efficiency and productivity, thanks to the implementation of cutting-edge technologies, especially automation, which has emerged as a transformative force that is changing conventional frameworks.The industry is seeing a notable improvement in production as logistics providers embrace automated mechanisms like robots, drones, and self-driving cars. As these automated machines work nonstop, they are able to achieve economies of scale (George -2024). A new paradigm in logistics management is being ushered in by companies such as Amazon, which are leading the way in gaining efficiencies from economies of scale. The global logistics automation market is expected to grow at a compound annual growth rate (CAGR) of 11.6% from 2020 to 2027, reaching $125,797.5 million, according to Research Dive. Greener logistics processes are made possible by electric-powered robots and self-driving cars, which use no fuel. Workers can concentrate on higher-value tasks like process monitoring, route optimization, and operations improvement by automating labour oriented and repetitive tasks.Logistics workers operate in a safer environment due to automated systems, which lower the chance of mishaps and injuries. Automation has the potential to achieve a 100% success rate in preventing loss and harm during travel when paired with cutting-edge technologies like Blockchain. Building the physical infrastructure required to fully realize the advantages of automation is a challenge in developing nation like India.

Managing the rapport with suppliers and consumers is a part of logistics work and includes the actual transportation of the products. The efficiency of the logistics system depends on advancement of technology that plays a significant part in improving logistics capabilities and achievement. Automation, facts, and communication technologies have significantly accelerated the tempo of verification, data analysis, and data transfer in logistics while maintaining high precision. Technology can improve a company's effectiveness and capabilities (NirajChaudhari-2019). The process of organizing, obtaining, storing, and moving goods from one location to another is known as logistics management. To guarantee that goods are delivered on schedule and to the correct customer, it entails managing inventory, resources, and information. One crucial factor in the management of manufacturing, commercial, and service businesses is logistical orientation. The goal of logistic management is to oversee all of the logistical operations of businesses that collaborate in supply chains and logistic chains, rather than managing discrete, individual logistical operations.

2 Background

To boost productivity and expedite delivery procedures, Flipkart, Amazon, Nokia, Ceat Tyres, and Mahindra & Mahindra Ltd. in Chennai use robotics and automated warehouses, drones, Autonomous Inventory Monitoring Service (AIMS), Automated Guided Vehicles (AGVs), Robots are used by automated storage and retrieval systems (ASRS) to store and retrieve goods from shelves.A study revealed that best automated warehouses are chosen according to their automation competence, which ranges from manual operations (Level 0) to end-to-end automation (Level 4), precision in order picking, warehouse space utilization, on-time as real-time inventory level visibility, cost savings, various logistics services availed, experience and reputation, customer satisfaction, technology used, enhanced productivity and efficiency.

2.1.1Components of an Auto ID system

Automatic identification technology (AIT), also called Automatic Identification and Data Capture (AIDC), is a term used in logistics to describe a collection of technologies, such as barcodes, RFID tags, and sensors, that automatically detect and track objects and record information about them without the need for human involvement. Seizing external data through images, sounds, or videos, transforming it into a digital file, and saving it for subsequent review are all steps in the automatic identification process (Duncan Mcfarlane et al -2003).Supply chain managers will have extra time to spot an issue, evaluate its possible impact, and take the appropriate action if AutoID can enhance the data application process, ensure that discrepancies are prerecorded, and produce precise and complete data. Too many variables can be changed and more alternatives for a regulatory response are available when discovery occurs early.For instance, if a railroad shipment is disrupted, it may still be possible to truck it in time for the time limit, but if the issue is discovered later, a crucial component may need to be airlifted. Auto ID system heavily relies on recent and historical advancements in the field of radio frequency identification.

RFID offers a straightforward and progressively less expensive way to automatically determine an item's unique identity. Additional product data can be obtained by connecting these inexpensive RFID systems to networked databases. Bar code systems obviously offer a large portion of functionality.A human must consciously scan bar codes, which is a challenging process to automate. In contrast, RFID tags are easily scanned automatically without the need for human intervention. RFID tags can be interpreted in any configuration as long as they are within the reader's spectrum, bar codes must be in field of vision to be read.By minimizing waiting time and optimizing asset utilization, automation technologies such as RFID tracking and robotic route planning further streamline operations, improving productivity efficiency and cutting costs.Placing things and then obtaining them quickly are the main tasks of a warehouse. Real-time tracking of consistent inventory levels is one of the immediate advantages of auto ID systems in the warehouse. Workers can use Auto ID to locate items by sending a message to a local device, like a personal digital assistant. Workers can manage their work with such a system, enabling real-time events to impact and optimize their own work without obstructing others. By carrying out the required inspections regarding shipment content automatically and consistently, auto ID systems can guarantee that the correct shipments are routed from the inbound to the outbound amenities.

2.1.2 Issues in logistics operations

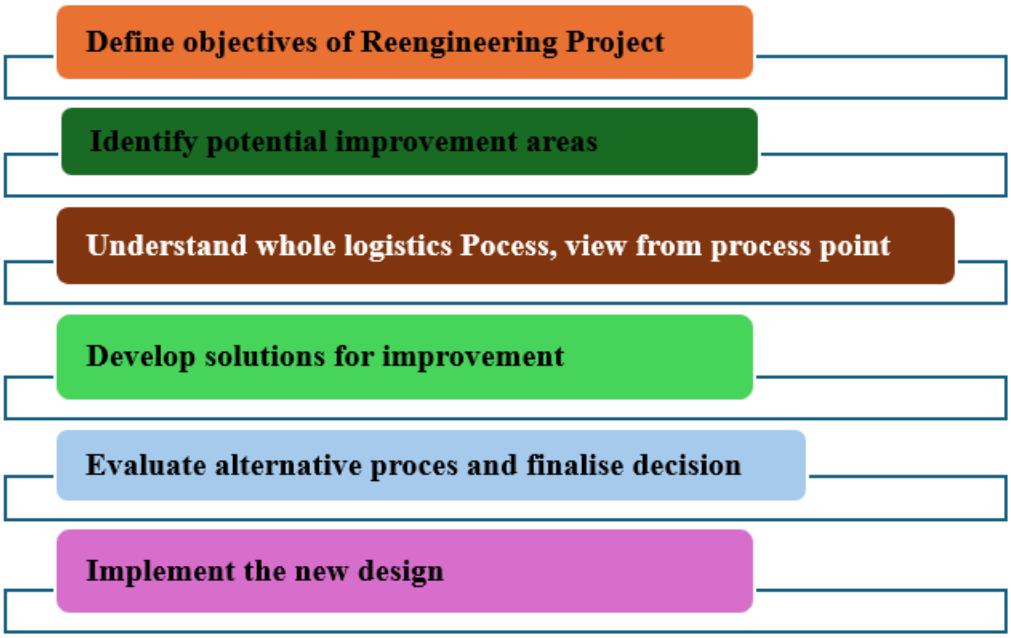
Failure to choose the suitable logistics service providers will bring loss to the company. There is lack of control on third party service providers, which leads to delay in delivery of goods, ultimately, they are unable to retain customers. Customer feedback or contact is lacking, so organisations are not in a position to understand their needs (MarzenaKuczyńska - Chałada et al -2018). Since many businesses are relying on service providers in logistics, they fail to observe their poor service effectiveness, poor collaboration efforts, poor information sharing with customers.

When organisations depend on service providers there is always the risk of losing expert knowledge, and risk of transferring sensitive data which are the most common issues with logistics ((LatifaFadile et al -2018).Demand ambiguity is typically controlled by setting operational parameters like inventory reorder levels and shipping schedules) based on prediction and fixed level-of-service regulations. An output forecast is used to set incoming buffer inventory or boost manufacturing needs in order to manage supply complexities.Since distribution network (supply) and demand are both random variables with multiple potential outcomes that are best described by a probability distribution, the control systems that govern are lacking in order to function effectively. All projections are therefore likely to be false and the resulting discrepancy can be addressed by either incorporating some ad hoc attentiveness or flexibility into the system or by employing buffer stock.

2.1.3 Re-engineering of logistics

The industrial engineering and management strategy for attaining notable increases in operational effectiveness for quality products in a warehouse or order fulfilment system is termed as logistics reengineering process (LRP). Performance improvements are crucial because the picking process in warehousing systems typically has a big influence on logistic performance, customer service standards, and expenses (Alberto Regattieri et al -2014). The Order Fulfilment Process (OFP) is the main focus of the recommended optimization procedure. The advantages of LRP are substantial in terms of reducing the workforce used and traveled distance. Without requiring major system changes or hard improvements like new machinery, staff, or equipment, reengineering can have a big impact on processes, processes, rules, and techniques. It can also lower logistics expenses and raise customer service standards.

Figure 1 Reengineering Process



Source: Alberto Regattieri -2014

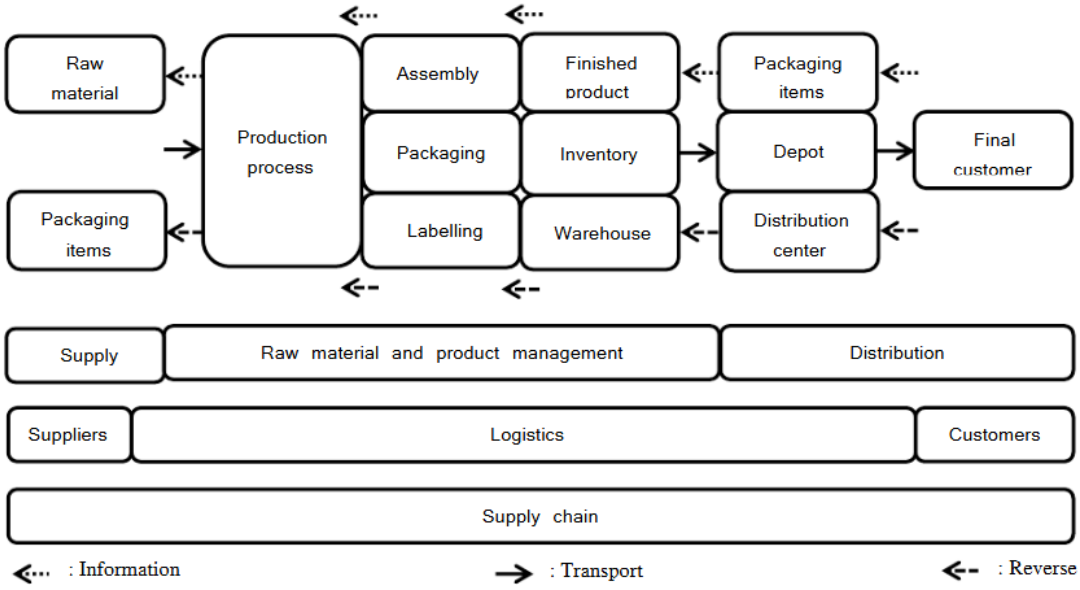
Decide which locations need to be reengineered and establish the project's parameters. This entails applying the returnable material in creative ways to either reduce expenses or enhance possible procedures, etc. Benefits analysis is made easier by dividing the entire process. Logistics is a fragmented process, and lastly, choose the most cost-effective method (Hing Kai Chan (2010). Evaluating processes both inside and between businesses is a key objective of logistic reengineering, which maximize final processes and get rid of jobs that don't add value for customers. Substantial progress in productivity improvements for quality goods in a warehouse are achieved through a number of organizational initiatives and the execution of management strategies for automated information processing through technological applications for substantial logistics activities (Amardeep Singh Khurana (2024).

2.1.4 Classification of logistics

Operational services outsourcing:

In logistics, operational services outsourcing refers to assigning certain logistics tasks, such as inventory control, transportation, or warehousing, to third-party logistics providers (3PLs) in order to optimize activities and concentrate on core business operations. As a result, the outward manifestations of logistics have been a two-pronged process, with businesses increasing the volume of traffic they entrust to outside agencies as well as the variety of services they source externally. Additionally, businesses are calling for more interconnected logistical services that are customized to meet their needs. The ability of the contractor to plan and customize logistics services is therefore highly valued (Alan Mckinnon-2018). The term "third party" refers to the provision of outsourced logistical services. The third-party logistics (or 3PL) provider is in charge of the actual product transport between the shipper (or consignor)- first party, the customer (or consignee)- second party, and the first party. For both international shipping and product distribution in overseas markets, manufacturers depend heavily on logistics service providers (LSPs).

Figure 1 Logistics Flow



Source: A. Rushton-2006

Information processing

Machine control, operational management, and logistics network conceptualization are associated with all management levels in the logistics chain provide a more accurate representation of logistics information. Principles and strategies, trade links, logistics attributes of handling units and resources of all kinds, monitoring, payments, and accounting, customer service, marketing, production engineering, insurance and legal requirements, operational data, machine data, and many other topics are covered in this information(KonradLewczuk et al -2020). Logistics chains are content systems that generate data at three fundamental organizational levels. The first level is business management level where information includes long-term strategic and commercial planning. The knowledge, inferences, and synthetic data are the basis of this information. The main goals of enterprise resource planning (ERP) and other high-level, interconnected informatics systems at this level are to connect clients with the supply chain environment, process business information to coordinate the supply chain, and engage in general planning and decision-making. The second level, offers solutions for operational management: production control and management systems, transport management systems, and warehouse management systems (WMS). Most of the work at this level basically consists of reacting instantly to orders from the higher-level systems.

The third level functions as a senior management layer of the second level and is responsible for controlling machinery and equipment. Numerous automated material handling systems, recognition and data scanning systems, assembly line control systems, and all remedies that are directly executed on the logistics site floor. The third level produces raw data directly, which can then be processed to aid in higher-level decision-making.The business environment is at the heart of the new framework of thought about information processing, which will lead to the widespread adoption of information exchange and use technologies based on dispersed obtaining, processing, and cataloguing systems. It will result in major adjustments to the planning and implementation of logistics processes.

Value added services outsourcing

Warehouses and 3PL service providers offer customized remedies known as value-added services (VAS). These consist of product customization, labelling, packing, kitting, and quality control. VAS has become essential in the fast-paced world of today, where e-commerce is flourishing and customer demands are changing. A business can concentrate on its main operations, create good products, enhance customer interactions, boost profits, and accomplish other strategic objectives by outsourcing logistics. Increased delivery returns, better cash flow, higher value-added new revenue streams, enhanced competitive position, and better information availability about air freight rates, foreign market conditions, and customs duties are all benefits of outsourcing (TiiaViissak (2023). A business can save workforce and overhead costs by outsourcing packaging and assembly to a logistics provider, which does away with the need for internal personnel and equipment.

Furthermore, VAS providers frequently have access to advanced equipment and cutting-edge technology, which can increase conformity and streamline procedures. Order fulfilment, which entails handling and shipping consumer orders, can be a laborious and mistake-prone procedure for companies. Businesses can increase order processing speed and accuracy and free up employees by contracting with a VAS provider to handle this operation. Another area where VAS can be useful is in reverse logistics, which is the process of sending products back to the manufacturer(PradeepMenon (2023).Businesses can charge more for value-added services like product personalization, which can help defray some of their operating expenses. Likewise, they can charge more for same-day delivery if they provide it, which will help them make more money. Value-added services can help businesses optimize their supply chains and maintain their competitiveness in the quickly evolving business environment of today, from cost savings and productivity improvements to satisfy their customers and sustain.

2.2 Research gap

The primary components of an Auto ID system are proposed along with analysis of major issues facing logistics operations. Potentials for extended period re-engineering of logistics are illustrated, and regions for brief Auto ID implementation are identified using classification of logistics activities.

3 Research Methodology

The methodical way the researcher plannedto investigate to guarantee accurate and trustworthy findings to answer the goals, objectives, and research questions is known as research methodology. The practical decisions taken by the researcher regarding data collection method, how to collect it, and how to analyse it are referred to as research methodology. Because the research questions and goals are exploratory in nature, a qualitative methodology was employed. In order to improve the effectiveness and performance of the company, the researcher employed a qualitative approach to try to understand how employees felt about automation in logistics. Convenience sampling method used and 50 respondents selected as sample for the study. Survey method adopted to collect data from the respondents (Derek Jansen et al -2025).

3.1 Data collection

The researcher systematically obtained information bystructuring questionnaire, to test hypotheses, and assess results called data collection. Data collected to find out the issues faced in business and try to find solution for the issues faced by the organisation. It is an essential component of research, and the information collected was analysed by conducting survey through circulating questionnaire to respondents and forecast whether automation in logistics increases efficiency. Primary data collected directly from respondents, and it is the fresh data gathered from the employees(Scott Robinson (2023). Efficiency of automation in logistics is based onautomation competence, precision in order picking, warehouse space utilization, on-time as real-time inventory level visibility, cost savings, various logistics services availed, experience and reputation, customer satisfaction, technology used thatenhances productivity and efficiency.

3.2 Data Analysis

The researcherchecked accuracy of data, and designed data in order to find whether automation increases efficiency, and it helped to offer suggestions termed data analysis. Researcher applied statistical tools to identify the relationship in usage of automation and enhancement of efficiency in organisation, which eventually gave insights that supported research conclusions. In order to minimize mistakes and discrepancies, raw data cleaned into a format suitable for analysis(Stephen Eldridge (2025). Data stored in databases which is a collection of related data that has been arranged so that data sets pertaining to a single entity obtained based on a number of different criteria. Statistical

tools used to find out the relationship between an independent variable influencingautomationand a dependent variable- increase in efficiency.Inferential statistical tools used to make assumptions and inferences about a larger population by interpreting data from a smaller sample using statistical techniques. 50 respondents are chosen to whom questionnaires distributed. Regression analysis tool used to check the relationship between automation and efficiency, helping to find if automation leads to increase in efficiency.

The level of automation found by number of robots used, automated systems used, automation competence (AC), precision in order picking (POP), warehouse space utilization (WSU), on-timedelivery to customers (OTD), real-time inventory level visibility (ILV), cost savings (CS), various logistics services availed, experience and reputation (E&R), customer satisfaction (CS), technology used, productivity(P) that enhances efficiency.

Table1 Variables influencing Automation -Independent variable

	POP	WSU	OTD	CS
Highly stable	10	14	14	18
Stable	22	20	18	16
Neutral	9	8	8	9
Unstable	5	5	6	4
Highly unstable	4	3	4	3
Total	50	50	50	50

Variables influencing efficiency of performance due to automation in logistics are skilled employees (SE), training (TR), non-repetitive job (NRJ), ease of use of technology (EUT), personal goal achievement (PGA), monitoring employee work (MEW), reduction in human errors (RHE)and satisfy customer needs(SCN) Efficiency is the ability to complete the most tasks with the least amount of time or effort. Applying automation requires trainings to be conducted at an appropriate level to reduce staff errors and boost their motivation for work. Automation in logistics affects the accomplishment of both personal and organizational goals; as a result, helps for the managerial decision making, organizational planning, and controlling. Automation also reduces issues by ensuring that goods are delivered on time and satisfy customers (Mohammad Taleghani-2020).

Table 1 Increasing Efficiency

R	R Square	Adjusted R Square	RMSE
.36	.13	.05	1.09

Table 2 ANOVA

	Sum of squares	df	Mean square	F	p
Regression	7.87	4	1.97	1.65	0.179
Residual	53.81	45	1.20		
Total	61.68	49			

Includes Independent variables precision of picking, warehouse space usage, quick customer delivery, cost saving

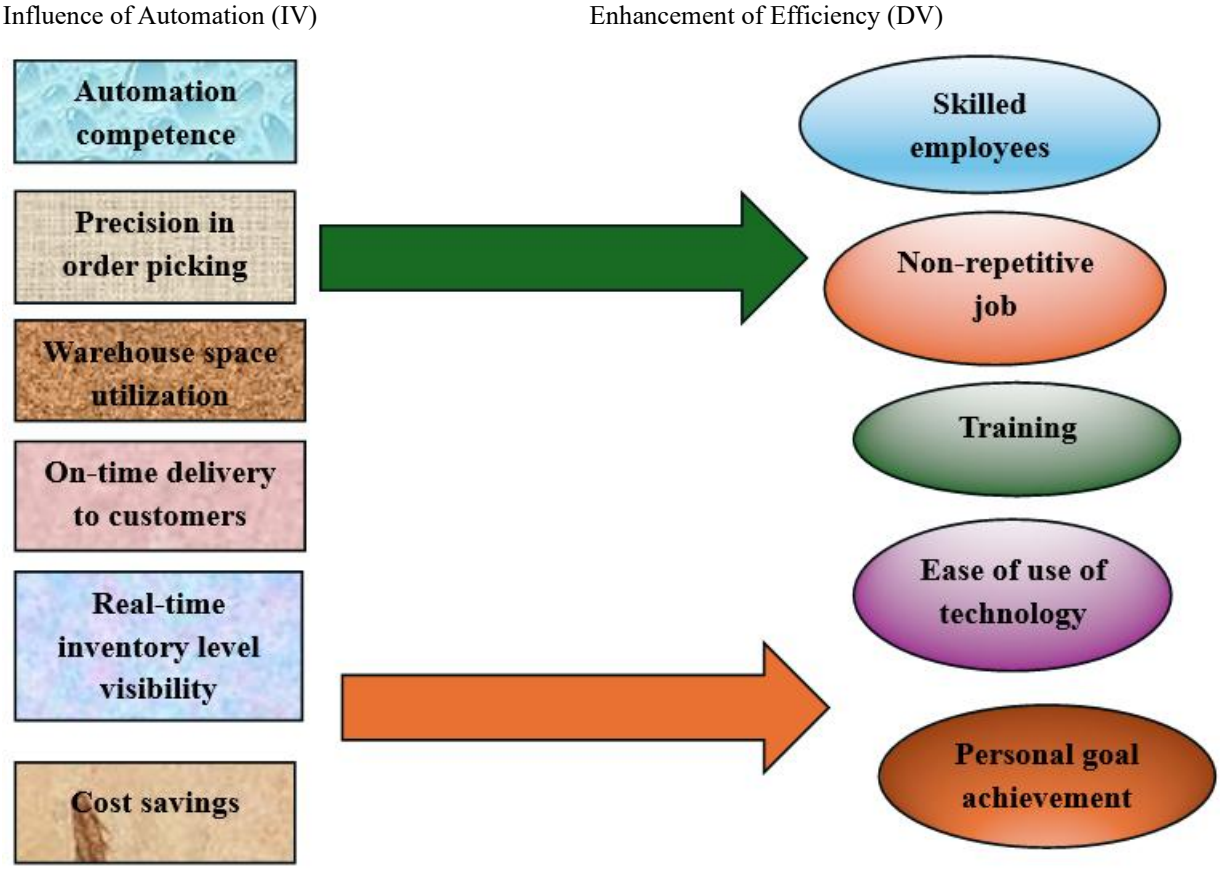
Table 3 Coefficients

	Unstandardised B	Coefficient Standard Error	Standardised coefficient Beta	t	p

Constant	1.03	0.66	0.00	1.55	0.127
POP	0.31	0.15	0.30	2.05	0.046
WSU	-0.07	0.17	-0.06	-0.44	0.660
QCD	0.16	0.15	0.15	1.04	0.305
CS	0.00	0.15	0.00	0.02	0.985

It is understood from the above regression analysis that p value for most of the variables is more than 0.05 and not significant with predictor variable. Precision of picking is significant with predictor variable.t value is more than 1 for most of the variables which means there is more significant relationship between Independent and dependent variable.A negative t-value indicates a negative relationship between the predictor and the response variable.The absolute value of the t-value indicates the strength of the evidence against the null hypothesis.

Conceptual model



4 Increase in Logistics efficiency

Logistics managers are trying staff to work digitize these low-value tasks in order solve the current problems. This will make the tasks more efficient and freer up the employees on other high-value tasks. The idea of digital transformation is presented at this point. Digital transformation (DT) can be summed up as an approach to use digital technologies to improve business operations, workflow, and performance. In order to turn a company into a digital enterprise, the logistics sector frequently uses three technologies: blockchain, artificial intelligence (AI), and robotic process automation (RPA). To complete the order-picking process quickly, automation helps to manage the incoming and outgoing procedures accurately and efficiently. Through automation, there would be no delay in getting and

providing orders from customers, which would meet their needs and maintain the company's image. With the implementation of automation in logistics they are able to immediately release additional capabilities to meet the demands of new business (HY Lam-2024).Logistics companies are looking for new conversion possibilities to improve their order-handling abilities, manage customer orders with varying needs, efficiently and precisely. Organisations must switch over from a human-centered to a digital one to run their business more efficiently.

Logistics firms can drastically cut back on manual worker by automating repetitive processes like scheduling, order processing, and inventory management. Overall logistics efficiency are improved as a result of minimizing human mistakes. distributing resources optimally, and maximizing human productivity (Noam Geffen (2024). Automated systems, enables demand prediction to predictive analytics, empower logistics managers to engage in more tactical plans, increasing logistics efficacy and adaptability and allowing businesses to quickly adjust to shifting market conditions. Advanced technologies like cloud-based platforms communication and cooperation IoT sensors giving businesses more transparency control over their processes, which enhances decision-making boosts customer satisfaction. The incorporation of disparate systems processes further paves the way for smooth communication and cooperation throughout the logistics processes.Logistics companies can confirm their leadership in the universal logistics ecosystem and open up new development and perseverance by embracing automation. Automation will play an increasingly significant role in logistics as technology develops further, significantly influencing the sector's future. It is evident that automation encourages innovation and ongoing development, allowing businesses to stay forward of the curve and seize potentials.Businesses can save a significant amount of money, enhance inventory control, reduce the amount of warehouse place needed for access points, and satisfy the expanding needs of contemporary logistics by utilizing the advantages of automation in robotic fleets.

5 Conclusion and future research

The cornerstone the of logistics is striking the correct balance between machine performance and human insights. The industry is changing as a result of persistent automation advancement, which holds promise for increased occupational health, market expansion, and conservation advantages. Logistics companies are well-positioned for a future in which sustainability, reliability, and security live in harmony as they negotiate the challenges of automation. Even though the path to fully automated logistics is still in its early stages, the end goal promises a positive transformation of the logistics environment.Automation reduces the possibility of expensive mistakes and fines by assisting in adherence to industry standards and legal requirements. Businesses can ensure adherence to safety procedures and quality standards, safeguarding their public image and reducing potential obligations, by utilizing automated auditing and reporting devices. Automation meets the threat by making it possible to accurately and efficiently handle increasingly complex jobs.By combining sophisticated algorithms and predictive analytics, logistics managers are better equipped to handle the complexities of supply chain management. In the process, this improves capital allocation and long-term planning, paving the way for creativity and adaptability in response to changing consumer tastes and market dynamics. Businesses can predict market trends and customer behaviour by utilizing technologies like artificial intelligence and machine learning.

Robotic pickers and conveyor belts are examples of automated systems that can run continuously without interruption, greatly boosting throughput. Businesses can lower payroll costs and operational costs related to mistakes and inefficiencies in manual processes by reducing their reliance on manual worker. Costly errors like incorrect shipments or inventory disparities are avoided due to the improved accuracy. Consumers get timely order notifications, which builds trust and improves their experience in general. Businesses can strengthen their customer relationships and decrease grievances and where is my order (WISMO) inquiries by making sure that products are delivered on schedule and in the right quantities (KomalPuri (2024).Work that could endanger humans, like heavy lifting or repetitive movements that could cause injuries, can be accomplished by automated machinery. This lowers expenses while also safeguarding workers.In spite of the significant advancements made in the past 20 years, there are still significant problems that needed further research.Future studies can focus on conducting research to gain a deeper comprehension of the intricacies that arise from the relationships between a logistics services provider and his clients.

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