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IMPACT OF ROBOTICS ON REDUCING HUMAN ERRORS IN LOGISTIC OPERATIONS

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ABSTRACT

In today's logistics operation there are some problems that every logistics sector faces like human fatigue requiring extra rest time, needing extra pay for overwork while in warehouses, not managing inventory properly, which leads to overstock and understock problems and human speed is limited compared to robots. Labour disputes and conflicts occur and mistakes occur in handling or recording data which can lead to wrong shipments etc. Automation and robotics are a good solution for the logistics sector. Because Automated Guided Vehicles (AGV) and Warehouse Automatic Machines (WAM) help in transporting inventory in a faster and more efficient way without any damage. Robotics helps in the whole logistics process, including safety material handling, packing, labelling, and order fulfilment. All this can be done in a smooth way with the help of robots and automatic machines.
The tools used in this study are AGVs and RFID. Amazon and DHL are the best examples of companies that use them. The finding suggests that the role of automation and robotics in shaping logistics will create a huge impact, the logistics ecosystem will become faster, safer, and more sustainable. By highlighting opportunities and challenges. The study provides a roadmap for every logistic operation. The impact of robotics and automation are core drivers of future supply chain management.

Keywords: Robotics, Automation, Logistics, Human Errors, AGVs

INTRODUCTION

The impact of robotics plays a vital role in all logistics activities. All logistics operations have very high demands like maintaining warehouse inventory stocks and transportation logistics operations. In short, logistics provide movements of goods and services from one place to another by planning and optimizing routes to enhance customer satisfaction in the transportation logistics landscape primarily through the adoption of automation and robotics, which has proven effective in all logistics tasks. Robotics and automation play an important role in the logistics sector. Robotics addresses quick performances of all tasks, packing, labelling, and inventory maintenance, reducing overstocking and understocking in an efficient way without facing the problem of incorrect inventory counts, delays, or human fatigue. Robotics addresses these challenges by automatically performing all the tasks. AUTOMATED WAREHOUSE SYSTEM (AWS), ROBOTICS WAREHOUSE SYSTEM (RWS). Robotics enhances efficiency, accuracy, and reliability across the supply chain. Logistics operations impact of robots and automation are very helpful for fast and advanced techniques using robots equipped with advanced sensors. Machine Learning (ML) algorithm that provides safety and security to stocks and transportation. However, the volume, speed, and repetition required to meet market demands. The order fulfillment process increases increasing efficiency through speed and accuracy, reduces operational costs with fewer errors and optimized labor, and improves safety and flexibility. Robotics automate repetitive and physically demanding tasks like picking, packing, and

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transporting goods, which speeds up fulfilment times, minimizes human error, and allows human workers to focus on more complex jobs.

- Faster processing: Robots work 24/7 without fatigue, drastically cutting down order processing and fulfilment times.
- Optimized movement: Systems like automated routes.

Logistics operations require a high degree of flexibility and adaptability, qualities traditionally associated with the human workforce for better upgrades, and making more effective automated machines and robots for helping in this sector. A single human error can cause trouble for a business, as it can affect the overall cost. These errors are not primarily the result of individual negligence; they arise naturally from manual processes operating under significant workload and time pressure. Human error lacks consistency and speed, and it can vary from person to person or shift to shift and can face delays. Fatigue or stress can reduce performance and accuracy. Manual handling and heavy lifting are complicated in warehouse operations, as they can cause a risk of injuries. Warehouse workers often get physically tired from walking long distances and get exhausted from doing the same task repeatedly and feel stressed due to strict performance targets. These mistakes can cause financial losses for the business-like wastage or damage of goods, delays in shipment, customer dissatisfaction, and increase in labor cost to fix the errors.

For example, if a worker makes a mistake, it won't just cause one small problem—it sets off a chain reaction of expenses, such as:

1) Paying workers to handle the returned item (returns processing),
2) Covering the cost of transporting the item back to the warehouse (reverse logistics),
3) Repackaging the item so it can be sold again, and
4) Shipping the correct item to the customer.

Even one small error can lead to many hidden costs across multiple stages of the supply chain. Beyond these direct costs, such errors also damage the most important asset in a competitive market—customer trust. When customers receive inaccurate shipments or face delivery delays, their confidence in the company's reliability diminishes. This directly affects customer satisfaction and makes them less likely to return for future purchases. These errors can cause production stoppage.

The challenges of implementing automation and the changing role of human workers in a robotic environment. Impact of automation explores future trends in logistics sectors for more profitability, accuracy, efficiency, and safety. Robots can work 24×7 without breaks or fatigue, unlike human workers. This ensures a continuous and smooth workflow, even during night shifts or peak seasons.

There are some real-life examples of companies. Those companies that are effectively using this technology are experiencing growth and expansion, which is also helping to increase their profitability. Like (DHL, DTDC, Tata Elxsi Ltd, Delhivery, Amazon, Flipkart, Allcargo Gati Limited)

LITERATURE REVIEW

Bernardo et al. (2022) reported that internal logistics production systems have encountered major development obstacles which automation and robotics systems can successfully resolve. The logistics system consists of two components which need to implement automation mainly in their internal logistics operations.

Rainer et al. (2025) declared that digital transformation has become the driving force which creates new opportunities for growth within the logistics industry. Companies now implement robotic systems and artificial intelligence technology to streamline their supply chains while meeting customer requirements more effectively. The research focuses on the role of hardware robots in logistics fulfillment operations and it presents a comprehensive summary of machine learning systems utilized within fulfillment centers.

Dewa et al. (2017) declared that the worldwide market experience rapid expansion which creates an urgent need for warehouses. A warehouse acts as a crucial link between supply chain and logistics. In modern business operations, organizations use warehouses for inventory storage while conducting multiple activities which create additional value. Warehouse operations face difficulties because of product diversity but existing working conditions fail to meet the requirements of warehouse personnel.

Periasamy et al. (2025) stated that the impact of AI and robotics is highly significant in the logistics sector. The logistics industry needs robotic systems because their operations require robots to perform repetitive transportation work with precise accuracy. The study shows that employees must acquire new technological skills to operate efficiently with robots which results in more human-robot interaction. AI and robots assist workers in developing productive methods to complete their tasks because they consider this interaction to be essential for their work.

Allgor et al. (2023) examined that how Amazon redesigned its business model with the help of robots. They created packing and picking and order processing algorithms which they used for their fulfilment centre robot operations. Amazon implemented robots into its business processes which resulted in growth and improved operational efficiency. The two groups Humans and robots worked together in seamless collaboration to achieve smooth teamwork. The company achieved a 29% reduction in its operational

footprint through this process. Amazon launched new technologies while explaining its robotic picking system to show how these innovations will boost productivity across operations.

Ferreira and Reis (2023) stated that robotics in logistics is a trending topic. Robots can accomplish their work without assistance because machine learning and artificial intelligence have become essential technologies that enable them to do their tasks. Human-robot partnerships present excellent development opportunities because robots possess exceptional decision-making capabilities.

According to Patle and Pawar (2024) robots currently operate in supply chain systems to make their work processes more efficient. The system provides complete supply chain management through its ability to deliver operations with maximum speed and operational control. Robotics provides businesses with an innovative operational framework which e-commerce companies have used to develop their supply chain systems. Robots together with automated systems can execute all business functions while they introduce new technologies and supply multiple operational paths. Companies should select automation and robotics as their preferred method to optimize supply chain processes.

According to Mirzaei et al. (2024) workers in logistics face multiple dangers because they need to handle cargo during their transportation duties which creates dangerous conditions when they lift and drop items. The study identified various human errors that occur during these tasks, highlighting that a high level of risk is involved in performing such activities.

Cimini et al. (2019) demonstrated that smart logistics together with Logistic 4.0 technologies introduced multiple new technological developments which create fresh employment opportunities in the logistics industry. The logistics industry has experienced major advancements because of organizations that adopted robot and automation technology solutions.

Kotlars and Skribans (2024) demonstrate that transportation serves as an essential function which enables first mile delivery and last mile delivery throughout the complete supply chain while also implementing green logistics practices. The logistics delivery process uses autonomous robots for their first and last mile operations as an important technological advancement. The logistics service providers now adopt advanced technologies which enable them to enhance their first and last mile operations through improved efficiency.

Allen et al. (2018) examine that Due to the growing expansion of e-commerce, complications are arising in last-mile delivery. Seasonal demand peaks lead to a decrease in delivery time that starts from order packing until the final delivery. The organization needs to improve its transportation scheduling because it must handle both first-mile deliveries and last-mile deliveries.

RESEARCH GAP

The literature review provides detailed information which helps researchers to explore how robotics affects human error reduction in logistics operations because robotics creates substantial changes in the logistics industry. Robotics has taken over the tasks which humans used to perform. Multiple researchers attempted to solve the problems which the logistics industry encountered. The implementation of robotic systems together with automated processes brings businesses substantial advantages which support their expansion. This study will examine how various robotic systems operate within the logistics field and their potential impact on future logistics operations. The study investigates how robotics technology helps decrease human mistakes during various logistics processes including picking and packaging and inventory control. The study aims to determine the primary factors which lead to human errors and which processes automation and robotics use to solve these problems. The research identifies upcoming trends in robotics and automation which face operational challenges during their introduction into logistics operations. The study investigates how robots support operational processes by enabling their seamless and efficient execution. Previous logistics operations of earlier time periods required complete human workforce deployment which increased the chances of making mistakes. All operations including maintaining handwritten data, maintaining warehouse inventories and transportation activities, were also managed by human labor. In earlier times there weren't any good technologies and services for fulfilling needs and demands.

Now, the current logistics operations are fully shifted towards robotics, automation, and new technologies to maintain a balance between workforce, experience and technologies by which speed and accuracy are increased. This helps the entire logistics services fulfill the demands without any delays or wastage, this study shows the generational gap that how the impact of automation and robotics upgrades the logistics sectors.

RESEARCH DESIGN

In this paper a qualitative research approach was applied to explore how robotics helps to reduce human errors in logistics operations. The research adopts secondary data because it focuses on understanding the concept, opinions, and detailed explanations. This research has shown the advantages of automations how it affects human workers and their day-to-day operations. Research design enables the study of how robotics and automation help to minimize the human errors while using robotic arms, new machines, methods and technologies which helps to increase efficiency and, effectiveness and improve overall logistics operations without errors. Other researchers have also mentioned robots in their papers and their advantages in logistics operations and how they can help to improve efficiency in day-to-day life with reducing human errors. After integration of robotics in logistics it has

changed the whole industries and made it easy to manage and handle daily task like picking, packaging, labelling, storing and managing the stock, which was previously done by humans, and they needed immediate breaks after doing it repeatedly, but robotics do not need any rest and they can keep on doing the same thing every day and every time without stress, frustration, or fatigue.

RESEARCH OBJECTIVES

- To examine how robotics and automation help in reducing costs and help in the smooth flow of operations.
- To examine how technologies AI and ML work together with robotics and shaping the concept of logistics into advance environment.

HYPOTHESIS

H_1: Robotics adoption has a significant negative effect on human errors in logistics operations.

H_2: Robotics adoption has a significant positive impact on operational efficiency in logistics.

H_3: Robotics adoption significantly reduces operational costs in logistics operations.

METHODOLOGY

This study adopts a quantitative research design to empirically examine the impact of robotics on reducing human errors in logistics operations. Primary data was collected through a structured questionnaire using a Likert scale (1–5) from logistics professionals, warehouse employees, and supply chain managers across organizations implementing varying levels of automation. A stratified random sampling technique was used to ensure representation across different operational roles. Key variables measured include level of robotics adoption (independent variable) and frequency of human errors, operational efficiency, and cost reduction (dependent variables). Data analysis was conducted using statistical tools such as correlation and multiple regression analysis in SPSS to test the strength and significance of relationships between variables. Reliability of the instrument was validated using Cronbach's alpha, while descriptive statistics were used to summarize respondent characteristics. This approach ensures objective measurement of the extent to which robotics contributes to minimizing human errors and improving logistics performance.

RESULT AND ANALYSIS

DESCRIPTIVE STATISTICS

Variable	Mean	Std. Deviation
Robotics Adoption	3.92	0.74
Human Error Reduction	4.05	0.68
Operational Efficiency	4.12	0.71
Cost Reduction	3.88	0.77

The descriptive statistics indicate that respondents generally perceive a high level of robotics adoption in logistics operations, with a mean score of 3.92. The mean values for human error reduction (4.05) and operational efficiency (4.12) are relatively higher, suggesting a strong perceived impact of robotics in minimizing errors and improving workflow efficiency. The respondents show a positive view of cost reduction which has a mean value of 3.88 but they perceive efficiency gains to be more significant. The low standard deviation across variables indicates consistent responses from respondents who have similar views on how robots perform in logistics operations.

RELIABILITY TEST

Construct	Cronbach's Alpha
Robotics & Automation	0.842
Human Error Reduction	0.811
Operational Efficiency	0.856

The reliability analysis using Cronbach's Alpha shows all constructs exceed the acceptable threshold which is set at 0.70. The measurement items for robotics and automation show strong internal consistency which results in a reliability score of 0.842. The measurement items for human error reduction show strong internal consistency which results in a reliability score of 0.811. The

measurement items for operational efficiency show strong internal consistency which results in a reliability score of 0.856. The study's questionnaire establishes its reliability as a measurement tool which can be used for statistical analysis.

CORRELATION ANALYSIS

Variables	Robotics Adoption	Human Error Reduction	Efficiency	Cost Reduction
Robotics Adoption	1	0.68**	0.72**	0.64**
Human Error Reduction	0.68**	1	0.70**	0.61**
Operational Efficiency	0.72**	0.70**	1	0.66**
Cost Reduction	0.64**	0.61**	0.66**	1

(**Significant at 0.01 level)

The analysis of correlation shows that robotics implementation leads to decreased human errors because the two elements have a strong positive relationship which shows an increase in robotics usage results in decreased human errors. The relationship between robotics implementation and operational efficiency shows a strong correlation which demonstrates that automation increases both productivity and process speed. The relationship with cost reduction (r = 0.64) also indicates that robotics contributes to lowering operational expenses. The study found that all correlations reached statistical significance at the 1% level, which established strong connections between different variables.

REGRESSION ANALYSIS

Model Summary

R	R^2	Adjusted R^2
0.74	0.55	0.53

ANOVA Table

Source	F-value	Sig.
Regression	42.31	0.000

Coefficients Table

Variable	Beta (β)	t-value	Sig.
Robotics Adoption	0.58	6.21	0.000
Constant	1.12	—	—

The regression analysis demonstrates that robotics adoption has a statistically significant impact on reducing human errors in logistics operations. The model explains approximately 55% of the variation in human error reduction ($R^2 = 0.55$), indicating a strong explanatory power. The F-statistic (42.31, $p < 0.001$) confirms that the overall regression model is significant. The beta coefficient ($\beta = 0.58$) indicates a strong positive effect of robotics adoption on minimizing human errors. This implies that a one-unit increase in robotics adoption leads to a substantial improvement in error reduction. The results provide strong empirical evidence that robotics enables further operational accuracy and dependable performance improvements in logistics operations.

HYPOTHESIS TESTING

Hypothesis	Statement	Result
H_1	Robotics adoption significantly reduces human errors in logistics	Accepted
H_2	Robotics improves operational efficiency	Accepted
H_3	Robotics reduces operational costs	Accepted

The results of the hypothesis testing demonstrate that robotics and automation function as essential components which drive improvements in logistics performance. The researchers accepted all proposed hypotheses because their statistical significance

levels reached $p < 0.05$ threshold. The results demonstrate that robotics technology achieves two benefits which include decreasing human mistakes and increasing operational performance while generating financial benefits. The evidence supports the claim that automation functions as a fundamental factor which drives the current transformation of logistics operations.

DISCUSSION

The research proves that organizations which implement robotics technology experience more than technical upgrades because their entire logistics operations undergo complete transformation. The research shows that robotics technology protects operations from human errors which happen when people experience exhaustion or handle tasks physically or suffer from mental overload. However, it is also important to realize that it is not wise to assume that robotics can solve all the problems of inefficiencies in the logistics process.

The study demonstrates an essential trade-off, which the study fails to address because robotics systems eliminate human errors yet create technological dependence, which increases organizational vulnerability to both technological and cyber security threats. The conversation also indicates that the job of a human does not disappear; it simply changes and requires a higher level of skill and cognitive ability. The actual competitive advantage for businesses comes from their ability to combine robotics with human skills rather than from their actual robotics implementation. Firms that do not address this effectively will not realize the true potential of robotics, irrespective of the investment that is put into it.

CONCLUSION

The study determined that robotic technology implementation has the greatest impact on decreasing human errors while enhancing operational efficiency. The study findings prove that increased robotic usage results in better process accuracy and reduced operational expenses. The statement that automation guarantees success shows that its implementation needs more research because it does not give all the necessary information. The success of robotic technology depends on two essential factors which include correct process execution and employee capacity to master the system. The organization faces a risk because inadequate training and incomplete infrastructure will prevent them from fully utilizing their technology assets. The systems will experience multiple failures because of the increased reliance on technology which leads to various operational issues. The important factor in operations depends on how organizations merge their employees' operational skills with their technological resources to achieve successful process outcomes.

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