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Impact of Warehouse Design on Order Dispatch Efficiency - A Case Study of Amazon Warehouse

Vinayak Suhas[1], Prof.Venkatesh[2]

[1]*MBA 4th Semester Student,, RV Institute of Management, Bengaluru, Karnataka, India*
[2]*Professor of Practice, RV Institute of Managemen, Benagluru, Karnataka, India*

***Abstract*- The fast pace of e-commerce has led to the need of highly optimized supply chain processes that have made warehouse design and order dispatch efficiency to be at the center of competitive advantage. The study explores how warehouse layout, storage design and technological integration affect the efficiency of order dispatch using Amazon fulfillment centers as a case study. A descriptive research design was used whereby a sample of 350 professionals in warehouse operations was used to gather primary data through a structured questionnaire with 5-point Likert scale. Descriptive statistics, Chi-square tests, Multiple Regression and Pearson correlation were included in the analysis to determine the relationships between layout navigation, automation, design related delays, and the general performance of dispatch. The results show that there is a significant positive correlation ($p < 0.001$) between efficient layout navigation and dispatch speed. Also, the regression model ($R^2 = 0.353$, $p < 0.001$) confirms that automation, barcode tracking, and technology-based design have a significant influence on predicting overall dispatch efficiency. Operational bottlenecks are also determined by the study and the relationship between poor zoning/congested pathways and dispatch performance is found to be medium negative ($r = -0.530$). The research finds that the robotics-first architecture and dynamic storage optimization of Amazon are essential in order to fulfill orders quickly, but continued layout assessments are required to reduce the amount of human-machine congestion left behind.**

***Keywords*— Warehouse Layout Optimization, Order Dispatch Efficiency, Supply Chain Management, Automation, Amazon Fulfillment.**

I. Introduction

The rapidity and precision with which orders are fulfilled are the key factors of customer satisfaction and loyalty to the brand in the extremely competitive e-commerce industry. Amazon has transformed the expectations of the world supply chains by providing next-day and same-day, an operation that has greatly relied on its sophisticated warehousing and distribution network.The core of this success is the careful design of its fulfilment centers where physical design and digital implementation systems are integrated to reduce the order processing time.

The most labour intensive and time-consuming parts of the supply chain traditionally are warehouse operations, picking, sorting, and dispatching. Human movement between picks is the biggest operation inefficiency in a traditional warehouse. Modern warehouse design is aimed at fighting this through the optimization of storage points and the enhancement of the aisle navigation with the introduction of zoning strategies that minimize the unnecessary movement (Nasir, Venkitasubramony, and Jakhar, 2025; Raghuram and Arjunan, 2022). Moreover, warehouses have turned into the destination of high-velocity distribution centres with the implementation of Industry 4.0, including autonomous mobile robots (AMRs), real-time inventory monitoring, and AI-based predictive placement (Khetani et al., 2025; Kamali, 2019).

The model of operation of Amazon is the standard of this development. Amazon has changed the patterns of traffic in the warehouse fundamentally by rolling out hundreds of thousands of robots that deliver shelving pods to human pickers. Nevertheless, even with such improvements, bottlenecks related to design, like overcrowded corridors and lack of adequate sorting areas, continue to present serious problems to the overall dispatch efficiency (Sao et al., 2024). This paper analytically evaluates the effects of particular physical design features and technological incorporations on the rapidity and accuracy of order delivery, based on the Amazon business model as the case study.

II. Review Of Literature

- Bhavani, G. D., et al. (2025) studied the impact of green investment on warehouse inventory systems. Green investments and optimized dispatching policies maximize storage efficiency.
- Khetani, N., et al. (2025) optimized warehouse design and management in the Industry 4.0 era. IoT and automation integration significantly enhance efficiency and reduce costs.
- Nasir, D., et al. (2025) optimized storage locations based on order pickers' energy expenditure. Strategic SKU placement reduces human fatigue and improves picking speed.

- Sao, A., et al. (2024) analysed key dimensions of warehousing affecting operational efficiency. Layout, technology, and inventory affecting operational efficiency.
- Abdul Rahman, N. S. F., et al. (2023) analysed warehouse productivity performance indicators. Real-time tracking and automated sorting are primary drivers of logistics efficiency.
- Raghuram, P., et al. (2023) optimized order picking and storage using agent based modelling. Agent-based dynamic routing significantly reduces order picking times.
- Tulli, S. K. C. (2023) explored techniques for improved order fulfillment through layout optimization. Aisle design and zoning are critical for minimizing travel time during fulfillment.
- Raghuram, P., & Arjunan, M. K. (2022) developed a design framework for a lean warehouse. Lean principles applied to warehouse layouts eliminate non-value-added movements.
- Shekhawat, S., et al. (2022) optimized cost for a manufacturing supply chain with MFIFO dispatching. Specific dispatching policies (MFIFO) improve green supply chain metrics.
- Tamizhinian, A., & Pillai, V. M. (2022) evaluated cargo warehouse operations using discrete event simulation. Bottlenecks in sorting and dispatch areas are the primary cause of operational delays.
- Kumar, S., et al. (2021) reviewed warehouse research through an evolutionary lens (19902019). Warehousing has shifted from pure storage to strategic order fulfillment centers.
- Kim, T. Y. (2020) improved warehouse responsiveness via job priority management. Dynamic prioritization of picking jobs significantly improves dispatch responsiveness.
- Raghuram, P., & Singh, A. (2020) optimized warehouses using demand data analytics. Data-driven SKU placement (high demand items near dispatch) maximizes throughput.
- Kamali, A. (2019) compared smart warehouses against traditional warehouses. Smart warehouses heavily outperform traditional ones in accuracy and speed.

III. Research Gap

Although the literature is rich with automated routing algorithms (Raghuram et al., 2023) and theoretical lean frameworks (Raghuram and Arjunan, 2022), there is a lack of empirical and employee-level evaluation of the interaction between physical design issues (such as overcrowded routes and ineffective zoning) and high-end automation to influence the dispatch efficiency. Most literature considers automation an ideal answer but even fewer in a quantitative sense have assessed the remaining problem of operations in a highly automated system such as Amazon, in terms of how human-led layouts still affect the overall speed and accuracy.

IV. Research Design

A. Statement of the Problem

The high-volume distribution centers often have delays in receiving orders, even after significant investment in automation and robotics. These inefficiencies are often not due to technology, but as a result of poor physical design of the warehouse, zoning, lack of sufficient sorting space and overcrowded aisles, etc that impede the harmonious relationship between human workers and automated systems. This research solves the issue of determining which particular layout designs and technological applications are most efficient to minimize dispatch time, and what physical design shortcomings are still the main bottleneck in modern fulfilment centres such as Amazon.

B. Objectives

- *Objective 1:* To examine the influence of warehouse layout and storage design on the speed and accuracy of order dispatch at Amazon Warehouse.
- *Objective 2:* To evaluate the role of automation, technology, and picking systems in improving order dispatch efficiency.
- *Objective 3:* To identify the key operational challenges in warehouse design that affect overall dispatch performance and suggest improvements.

C. Research Methodology

The research design used is the Descriptive Research design. This research design is very appropriate to record systematically the present situation of the operation of the warehouse, the performance of layout design, and the statistical correlation between the use of technology and the efficiency of dispatch without any experiment control.

D. Sources of Data

- *Primary Data*: Gathered in person through a sample of 350 supply chain professionals, warehouse managers, and floor operators who were knowledgeable on advanced fulfillment operations through a structured questionnaire.
- *Secondary Data:* Collecting academic journals, case studies in supply chains, and industry reports that provide information on proprietary warehouse architecture and automation systems at Amazon.

E. Sampling Plan

- Sampling Unit: Professional and employees working in the logistics, supply chain, and warehouse operations.
- Sample Size: 350 valid responses.
- Sampling Technique: The sampling method was convenience and snowball in which industry professionals were reached using professional networks and logistics forums.

F. Tools for data collection

- Survey: A questionnaire survey that will be conducted online, using a 5-point Likert scale (Strongly Disagree/Very Poor to Strongly Agree/Excellent) to evaluate perceptions regarding layout navigation, the effectiveness of automation.

G. Plan of Analysis

- Data gathered was tabulated, coded and analysed in IBM SPSS and MS Excel. The analysis tools used are Descriptive Statistics, Chi-Square Test of Independence, Multiple Regression Analysis, and Pearson Correlation used to confirm the hypotheses framed.

V. CONCEPTUAL FRAMEWORK

Dependent Variable (DV)

- Overall Order Dispatch Efficiency: The speed, accuracy, and general effectiveness with which a customer order is picked, packed, and shipped out of the warehouse.

Independent Variables (IV)

- Warehouse Layout & Storage Design: Ease of navigation, aisle width, zoning strategies, and the proximity of high-demand goods to the dispatch area.
- Technological Integration: The effectiveness of automation (robotics), barcode tracking systems, real-time inventory software, and conveyor sorting systems.
- Operational Challenges: The frequency of delays caused by design flaws, such as congested pathways, poor lighting, or insufficient sorting space.

VI. RESULTS

Tools for Data Analysis

- Software: IBM SPSS Statistics, MS Excel.
- Techniques: Descriptive Statistics, Chi-Square Test, Multiple Regression Analysis, Pearson Correlation.

Hypothesis Framework

Hypothesis 1 (Chi-square Test - Objective 1)

- H0: There is no significant association between warehouse layout navigation and overall order dispatch efficiency.
- H1: There is a significant association between warehouse layout navigation and overall order dispatch efficiency.

Hypothesis 2 (Multiple Regression Test - Objective 2)

- H0: Automation, tracking systems, conveyor/sorting systems, real-time inventory systems, and technology-driven design do not significantly predict overall dispatch efficiency.
- H1: Automation, tracking systems, conveyor/sorting systems, real-time inventory systems, and technology-driven design significantly predict overall dispatch efficiency.

Hypothesis 3 (Correlation Test - Objective 3)

- H0: There is no significant correlation between warehouse design-related delays and overall dispatch efficiency.
- H1: There is a significant correlation between warehouse design-related delays and overall dispatch efficiency.

Layout Navigation Category	Impact on Overall Dispatch Efficiency
Average (n = 44)	Negative Impact: 2 (4.5%) No Impact :11 (25.0%) Positive Impact: 27 (61.4%) Very Negative Impact: 0 (0.0%) Very Positive Impact: 4 (9.1%)
Excellent (n = 52)	Negative Impact: 1 (1.9%)No Impact: 1 (1.9%)Positive Impact: 28 (53.8%)Very Negative Impact: 0 (0.0%)Very Positive Impact: 22 (42.3%)
Good (n = 224)	Negative Impact: 7 (3.1%) No Impact: 24 (10.7%) Positive Impact: 152 (67.9%)

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Layout Navigation Category	Impact on Overall Dispatch Efficiency
	Very Negative Impact: 0 (0.0%) Very Positive Impact: 41 (18.3%)
Poor (n = 22)	Negative Impact: 6 (27.3%) No Impact: 3 (13.6%) Positive Impact: 9 (40.9%) Very Negative Impact: 4 (18.2%) Very Positive Impact: 0 (0.0%)
Very Poor (n = 8)	Negative Impact: 2 (25.0%) No Impact: 3 (37.5%) Positive Impact: 1 (12.5%) Very NegativeImpact:2 (25.0%) Very Positive Impact: 0 (0.0%)

Descriptive statistics

1. Gender_Code: N = 350, Minimum = 1, Maximum = 3, Mean = 1.38, Std. Deviation = .532.
2. AgeGroup_Code: N = 350, Minimum = 1, Maximum = 4, Mean = 2.13, Std. Deviation = .863.
3. CurrentRole_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 2.04, Std. Deviation = 1.130.
4. MonthlyIncome_Code: N = 350, Minimum = 1, Maximum = 4, Mean = 2.27, Std. Deviation = .872.
5. LayoutNavigation_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.83, Std. Deviation = .839.
6. StorageOrganization_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.75, Std. Deviation = .891.
7. LayoutReducesPickTime_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.84, Std. Deviation = .913.
8. HighDemandNearDispatch_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 4.29, Std. Deviation = .908.
9. AisleWidthPathway_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.57, Std. Deviation = .960.
10. ZoningReducesErrors_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.90, Std. Deviation = .874.
11. PeakPeriodSupport_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.56, Std. Deviation = 1.002.
12. PoorStorageCausesDelays_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.73, Std. Deviation = .982.
13. AutomationImprovesSpeed_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.90, Std. Deviation = .765.
14. BarcodeTrackingReducesErrors_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 4.31, Std. Deviation = .865.
15. ConveyorSortingEffective_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.83, Std. Deviation = .898.
16. RealtimeInventoryReducesDelays_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 4.34, Std. Deviation = .853.
17. TechDrivenDesignReducesDispatchTime_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.85, Std. Deviation = .782.
18. PickPackMinimizesMovement_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.82, Std. Deviation = .913.
19. TechnologyToolsSatisfaction_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.70, Std. Deviation = .941.
20. DesignIssuesCauseDelaysFreq_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 2.89, Std. Deviation = .960.
21. InsufficientSortingSpaceSlowsDelivery_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.16, Std. Deviation = .991.
22. PoorLightingSignageAffectsSpeed_Code: N = 350, Minimum = 1, Maximum = 5, Mean = 3.13, Std. Deviation = .973.

Interpretation

Descriptive statistics indicate that the study is founded on 350 valid responses, and none of the variables analysed has missing values. The layout navigation (3.83), storage organization (3.75), high-demand goods near dispatch (4.29), barcode tracking reducing errors (4.31), real-time inventory reducing delays (4.34), and overall design impact on dispatch efficiency (3.92) have mean scores of 3.83, 3.75, 4.29, 4.31, Simultaneously, the average on the design problems leading to delays (2.89) and inadequate sorting space slowing down delivery (3.16) indicates that there are still operational issues in certain areas.

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On balance, the descriptive findings indicate that the warehouse design of Amazon is viewed as conducive to dispatch effectiveness, but some limitations associated with the design continue to impact performance.

Chi-Square Analysis Results:

- Total respondents: 350.
- Respondents rating layout navigation as Good or Excellent predominantly reported Positive or Very Positive dispatch efficiency.
- Chi-Square value = 140.080; df = 16; p = 0.000.
- Likelihood Ratio = 94.731; p = 0.000.
- The findings indicate a statistically significant relationship between warehouse layout navigation and dispatch efficiency.

Interpretation

- Chi-square test indicates that warehouse layout navigation has a statistically significant relationship with the overall order dispatch efficiency. The result is statistically significant, as the p-value is less than 0.05: 0.000. Thus ,the null hypothesis (H0) is rejected and the alternative hypothesis (H1) is accepted. This indicates that the respondents who ranked the warehouse layout more favourably also tended to report a higher dispatch efficiency in general, which validates that layout and storage design have strong impacts on the order dispatch speed and accuracy.

Test 2: Multiple Regression Test

Objective

To evaluate the role of automation, technology, and picking systems in improving order dispatch efficiency.

Dependent variable

- Question 25: Overall, how would you rate the impact of the current warehouse design on the order dispatch efficiency at Amazon Warehouse?

Independent variables

- Question 13: How effectively does Amazon's use of automation and robotics improve the speed of order picking and dispatch?
- Question 14: The use of barcode scanning and digital tracking systems reduces errors in order dispatch.
- Question 15: How would you rate the effectiveness of the conveyor belt or sorting system in the warehouse for faster dispatch processing?
- Question 16: Real-time inventory management systems integrated into the warehouse design help reduce order processing delays.
- Question 17: How much has technology-driven warehouse design contributed to reducing the overall order dispatch time at Amazon?

Dataset variables

- *Dependent Variable:*

OverallDesignImpactDispatchEfficiency_Code

Independent Variables:

o AutomationImprovesSpeed_Code
o BarcodeTrackingReducesErrors_Code
o ConveyorSortingEffective_Code
oRealtimeInventoryReducesDelays_Code
oTechDrivenDesignReducesDispatchTime_Code

Hypotheses

- H0: Automation, tracking systems, conveyor/sorting systems, real-time inventory systems, and technology-driven design do not significantly predict overall dispatch efficiency.
- H1: Automation, tracking systems, conveyor/sorting systems, real-time inventory systems, and technology-driven design significantly predict overall dispatch efficiency.

Regression Analysis Results

- Model strength: R = 0.594, indicating a moderate positive relationship between predictors and dispatch efficiency.
- Explanatory power: $R^2 = 0.353$, showing that 35.3% of variations in dispatch efficiency are explained by the model.
- Overall model significance: F = 37.539, p = 0.000, confirming the model is statistically significant.
- Strongest predictor: Barcode tracking systems (β = 0.259).
- Other significant predictors: Technology-driven design (β = 0.161) and automation improving speed (β = 0.140).
- Conveyor sorting systems (β = 0.103) and real-time inventory systems (β = 0.094) showed positive but statistically weaker effects.

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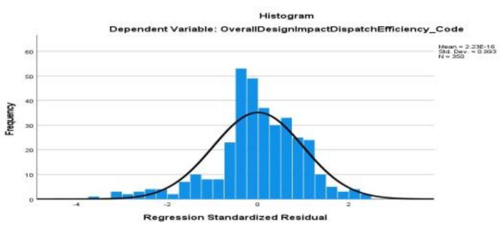
CHART



Interpretation

The multiple regression analysis reveals that automation that enhances speed, barcode tracking that minimizes errors, conveyor or sorting effectiveness, real-time inventory that minimizes delays and technology-driven design that minimizes dispatch time all significantly predict overall dispatch efficiency. It is statistically significant with R = 0.594, R 2 = 0.353, F = 37.539, p = 0.000 that is to say that these predictors are used to explain 35.3% of the overall dispatch efficiency. The predictors exhibiting a strong positive impact include barcode tracking, automation speed and technology-driven design, whereas the conveyor sorting effectiveness and real-time inventory systems have a positive but not statistically significant effect at the 5 per cent level. Thus, the null hypothesis (H0) is rejected, and the alternative hypothesis (H1) is accepted and technology and automation are significant factors in enhancing dispatch efficiency.

Test 3: Correlation Test

Objective

To identify the key operational challenges in warehouse design that affect overall dispatch performance and suggest improvements.

Questions selected

- Question 20: How frequently do warehouse design-related issues such as congested pathways or poor zoning cause delays in order dispatch?
- Question 25: Overall, how would you rate the impact of the current warehouse design on the order dispatch efficiency at Amazon Warehouse?

Dataset variables

- DesignIssuesCauseDelaysFreq_Code
- OverallDesignImpactDispatchEfficiency_Code

- *Hypotheses*

- H0: There is no significant correlation between warehouse design-related delays and overall dispatch efficiency.
- H1: There is a significant correlation between warehouse design-related delays and operational efficiency.

Correlation Analysis Results

- Pearson correlation coefficient (r) = -0.530.
- Significance level (p) = 0.000.
- Sample size: 350 respondents.
- The negative correlation indicates that increasing warehouse design issues such as congestion and poor zoning reduce dispatch efficiency.
- The relationship is moderate in strength and statistically significant at the 1% level.

Interpretation

Pearson correlation analysis indicates that the relationship between the delays that are related to the design of a warehouse and the efficiency of the dispatch overall is moderate and negative. This gives a correlation coefficient of -0.530 and p-value of 0.000 that is below the value of 0.05. Therefore, the null hypothesis (H0) is not accepted and the alternative hypothesis (H1) accepted. It means that the greater the number of issues with the warehouses design (e.g., aisles congested or poor zoning), the less efficient the dispatch process is, which proves that the issues with the operational design influence the performance of the warehouse considerably.

VII. Discussions

Descriptive analysis of the 350 respondents: The analysis of the 350 respondents reveals a very positive perception of modern warehouse optimizations. There is a strong agreement among the respondents that real-time inventory systems (Mean = 4.34) and location of high-demand goods near the dispatch area (Mean = 4.29) significantly lower fulfillment delays.

Barcode tracking systems (Mean = 4.31) are known to be the most effective in eliminating the number of manual dispatch errors. Nonetheless, respondents did not overlook long-standing physical difficulties stating that lack of enough sorting areas (Mean = 3.16) and the congestion caused by the design (Mean = 2.89) continue to slack deliveries occasionally.

Objective 1 (Chi-Square): The test revealed that there was a statistically significant correlation between ease of layout navigation and overall dispatch efficiency ($p < 0.001$).

Those respondents that rated the layout navigation as Good or Excellent, by an overwhelming margin reported that the layout design had a Positive or a Very Positive influence on efficiency. This demonstrates that although automation is high, logical physical layout is still core to quick order picking.

Objective 2 (Regression): The multiple regression model (R^2 = 0.353, F = 37.539, p < 0.001) was able to confirm that overall dispatch efficiency can be predicted significantly by technological integrations. Barcode tracking (Beta = 0.259) and technology-driven design (Beta = 0.161) were the strongest individual predictors. This shows that speed is enhanced by robotics, but equal emphasis is put on digital accuracy tools (such as barcode scanning) to avoid dispatch bottlenecks.

Objective 3 (Correlation): It was found that the frequency of design-related delays (e.g., congested pathways) was correlated with overall dispatch efficiency in a moderate negative way (r = -0.530, p < 0.001). This proves the fact that the bad physical zoning is a direct source of worsening the speed benefits of automation, underlining that robots and humans need differentiated, uncrowded working areas.

VIII. CONCLUSION

This paper concludes that order dispatch efficiency in high-velocity settings such as Amazon is the result of a symbiotic interaction between intelligent physical layout and high-tech integration. It has been established that although automation and real-time inventory tracking are important in speeding up the fulfillment process, these systems cannot be fully efficient in a defective physical area. The rejection of all null hypotheses highlights that logical aisle navigation, dynamic storage (fast-moving SKUs near dispatch) and barcode accuracy are essential factors that drive dispatch speed. Nevertheless, the adverse correlation on overcrowded routes brings to the fore a vital operational fact: as warehouses introduce more autonomous robots, physical layouts need to be redesigned on a regular basis to separate human and machine traffic. Finally, layout optimization should be ongoing to ensure real ROI of warehouse automation and sustain next-day delivery rates.

IX. SUGGESTIONS

- Dynamic SKU Placement: Warehouse managers are encouraged to adopt AI forecasting to adopt dynamic storage zoning. Fast-moving SKUs (high velocity items) should be regularly rearranged as near as possible to the packing and dispatching stations to reduce the travel time of both humans and robots.
- Separate Human-Robot Traffic: To eliminate the negative correlation in terms of congested pathways, warehouses are to redesign their floor plans to make autonomous mobile robots (AMRs) have their own lanes that would be located far apart the zone of human picking to minimize bottlenecks and safety accidents.
- Increase Sorting Space Capacities: Since the insufficient outbound staging area has a moderate score (Mean = 3.16), the facilities will need to increase the outbound staging spaces. The use of multi-tier (vertical) conveyor sorting systems can help make the maximum of the vertical space utilization without increasing the building area.
- Ongoing Layout Reviews: Create quarterly review program to examine heat maps of warehouse traffic. The application of Digital Twins (digital simulations of the warehouse) may allow the managers to test various layouts and find out possible areas of congestion without moving even a single rack or shelf into place.

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