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WAREHOUSE OPERATIONAL EFFICIENCY: ROLE OF MATERIAL HANDLING TECHNOLOGY, SKILLS SET, SUPPLY CHAIN COMMUNICATION NETWORK AND STAFFING LEVEL

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Research Paper

Abstract: *The primary objective of this study is to identify and optimize the critical variables that influence the operational effectiveness of warehouses. This study adds to previous research by providing a deeper understanding of how these factors affect operational effectiveness. Specifically, it is found that insufficient workforce numbers have a negative effect on operational performance and increase expenses. These findings contribute to the existing body of knowledge and emphasize the importance of considering these variables when optimizing warehouse operations, thereby increasing productivity and efficiency. SPSS is used as the analysis tool to examine the relationships between Warehouse Operations Efficiency (WOE) and various parameters. The findings demonstrate strong positive relationships between all of the variables. These findings demonstrate the importance of warehouse optimization in boosting productivity and efficiency. Aspects that affect operational efficiency include staffing levels, personnel skill sets, communication throughout the supply chain network, material handling technology, and inventory management systems. The report also discusses warehouse layout issues, such as inefficient picking metrics, unnecessary motions, safety and security concerns, dead-end aisles, and inadequate overflow space. The study also identifies supply chain visibility obstacles, limited resources, and resistance to technological advancements as obstacles to achieving warehouse operating efficiency.*

Keywords: *Warehouse Management, Supply Chain Management, Inventory Management, Operational Efficiency, Staff Skills, Effective Communication.*

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1. Introduction

A warehouse is a commercial building that serves as a central location for receiving, storing, and distributing goods, products, and materials along a supply chain (Custodio & Machado, 2020). The warehouse is a vital component of supply chain management that ensures the efficient and effective movement of goods from production to the final consumer. In addition, to achieve optimal warehouse operation efficiency, it is necessary to identify the key factors that influence warehouse performance and to develop strategies to address them (Abushaikha et al., 2018).

In the current competitive business environment, achieving warehouse operational efficiency is crucial for the success of any supply chain management system. However, implementing key factors such as communication, staffing levels and skill sets, and material handling technology can be hindered by several barriers (Custodio & Machado, 2020). The barriers include ineffective communication channels, inadequate collaboration, language barriers, cultural differences, technological limitations, insufficient staffing levels, lack of appropriate skills, high turnover rates, and difficulties in attracting and retaining skilled workers (Bienhaus & Haddud, 2018). Moreover, the research of Singh, Chaudhary, and Saxena (2018) demonstrated that the complexity of technology could hinder the implementation of advanced material handling technology, the need for specialised skills and training, limited space, and layout constraints. These barriers can result in delays, errors, and increased operating costs, adversely impacting warehouse performance (Singh et al., 2018). Therefore, it is essential to minimize the specific barriers through relevant strategies that impede the implementation of these factors and devise effective solutions to overcome them (Mahroof, 2019).

Warehouse operations play a vital role in the supply chain network, and increasing operational efficiency can result in significant cost savings, enhanced customer service, and enhanced competitiveness (Laosirihongthong et al., 2018). Nevertheless, according to Geng et al. (2019), optimizing warehouse operations is a complex task requiring an in- depth understanding of the factors influencing efficiency. In addition, by elaborating on these factors, such as communication, staffing levels and skill sets, and material handling technology, and developing optimization strategies, this research can aid warehouse managers in enhancing warehouse performance, reducing operational costs, and enhancing customer satisfaction (Geng et al., 2019).

In addition, the research could reduce the barriers to implementing these factors in the warehouse (Abushaikha et al., 2018). In addition, this research is significant because it contributes to the existing knowledge of warehouse operations and supply chain management. By focusing on the specific factors that impact warehouse efficiency, this research can provide warehouse managers and practitioners with actionable recommendations (Mahroof, 2019). In addition, supply chain managers and executives can use the research findings to improve the overall performance of the supply chain network by optimizing warehouse operations. Additionally, other stakeholders, such as policymakers, academics, and researchers interested in enhancing the efficiency and effectiveness of the supply chain network, can benefit from the research (Bienhaus & Haddud, 2018).

2. Literature Review

2.1 Overview of Warehouse Optimisation

According to Ekren's study, warehouse management optimization is integral to a company's growth strategy and contributes directly to its increased productivity. Historically, warehouse optimization has been challenging for businesses due to the influence of various external factors, including partner relationships, logistics, technology, and the state of the global economy. Modernization and the accelerated transition to a digital economy have also created new challenges, according to Kattepur (Kattepur, 2019). Warehouse management has evolved due to the rapid expansion of e-commerce and the rise of multichannel and omnichannel distribution systems. Consequently, supply chain networks, the emergence of autonomous mobile robots, the popularity of micro-fulfillment centers, and the expansion of same-day and next- day delivery demand are also influencing new directions in warehouse management. According to Grznár et al. (2021), warehouse optimization solutions deliver a return on investment in months, making them a valuable asset for businesses of all sizes (Grznár et al., 2021). Automation contributes to reduced overhead costs while increasing productivity and efficiency.

Automating operational procedures reduces labor, equipment, maintenance and management costs, as well as less manual entry also processing is the workforce's responsibility, which considerably reduces the possibility of errors (Madakam et al., 2019). Thus, automation can assist warehouse optimisation in reducing ongoing running costs, such as energy usage, the quantity of storage space needed, and money spent on safety-related issues, resulting in significant cost reductions. It has been highlighted by the study of Ramirez et al. (2022) that inventory and warehouse operations are not the only things that warehouse optimisation streamlines because lowering lost goods, shrinkage and misplacement also contributes to the make a complete inventory system in the company (Ramirez et al., 2022). For example, companies manage their inventories smoothly, resulting in fewer fulfilment and shipping mistakes. Automation solutions can also help coordinate material handling equipment like mobile devices and barcode scanners. Consequently, the optimization of a logistics warehouse makes it possible, among other things, to increase storage capacities, reduce handling operations and accelerate the management of the flow of goods.

2.2 Factors affecting Warehouse Operational Efficiency

An efficient warehouse is important for increasing productivity and utilizing the available surface area. There are various factors that can directly create an impact on the warehouse's operational efficiency, some of these factors are listed as follows:

2.3 Staffing Level of the Warehouse

People and staff within the warehouse are highly essential to warehouse operations. Even when the systems are highly automated, the role of the people to manage and supervise the operations is imminent. As highlighted by Andiyappillai (2020), warehouse staffing is such an integral part of the overall warehouse operational function that the warehouse's efficiency is largely affected by it (Andiyappillai, 2020). The workforce structure including the operational staff, material picking workers, and system operators can impact the warehouse efficiency as indicated by De la Fuente, Gatica, and Smith (2019). Overworked and understaffed manpower provides substandard operational results leading to problems like slackness, increased cost, and frequent rescheduling of orders (De la Fuente et al., 2019).

2.4 Skill Set of Employees

In warehouses, efficient operations require system compliance which can only be obtained by ascertaining the right person for the right job (De Koster et al., 2017). The skill set required is directly linked to the functional capability of the person working in a warehouse compared to educational requirements or academic knowledge. People dealing in fork lifting and transportation would require a greater sense of control and direction as indicated by (Lorson et al., 2023). The skill set of employees in warehousing plays an essential role in ensuring warehouse operations' smooth and efficient functioning. The specific abilities and competencies possessed by warehouse employees profoundly impact the overall productivity, accuracy, and safety of various tasks performed within the warehouse. Moreover, warehouse employees should possess excellent physical stamina and the ability to handle the job's physical demands. They may be required to lift and move heavy objects, operate machinery or equipment, and endure extended periods of standing. Physical fitness and adherence to proper safety protocols and ergonomic practices are critical for preventing workplace injuries and maintaining a safe working environment (Aguilar et al., 2020).

2.5 Communication within Supply Chain Network

As indicated by Singh et al. (2018), an adequate mode of communication within the supply chain network ensures the synchronization of various functions within the warehouse (Singh et al., 2018). Communication enables a working environment and prevents accidents by providing sufficient information about companies' policies and current operations (Faber et al., 2018).

Communication within the supply chain Network is highly essential to efficiency in warehouse operations as it provides the ability to acquire resources at disposal, leading to cost minimization and profit maximization. Effective communication skills are also indispensable for warehouse employees. Seamless communication within the warehouse team and with other departments or external stakeholders ensures smooth operations. Clear and concise communication helps in averting misunderstandings, facilitating coordination, and enhancing overall efficiency. Strong communication skills are crucial in inventory coordination, shipment tracking, and collaborative problem-solving tasks.

2.6 Material Handling Technology

Frazelle (2016) indicates that material handling is a significant part of warehouse operations and commonly includes movement, protection, and control of the products in the warehouse (Frazelle, 2016). The infusion of technology in material handling can significantly impact warehouse operations' efficiency (Reis et al., 2017). Some of these technologies include handheld scanners, warehouse management systems, and other computer applications to track inventory mobility at all times.

Inventory management systems highly drive the warehouse operations. Physical inventory tracking can be difficult to track and requires matching at all times indicated by Panigrahi et al. (2021). The warehouse inventory system should be matched with physical transactions and the alignment of the inventory system in place can highly affect the warehouse operations efficiency (Panigrahi et al., 2021).

Warehouse designs have a significant impact on the effectiveness of warehouse operations. This could take many forms, including regular delays, bottleneck situations, and in many cases, inventory obsolescence. According to Salomonsson (2021), the facility's layout affects the hours required to relocate and store goods in various locations throughout the period (Salomonsson, 2021). The work path should be optimized to reduce workers' wasted effort. Unoptimized warehouses tend to produce fewer units per hour (UPH). According to Altarazi and Ammouri (2018), this creates shipping bottlenecks for warehouse operations and significantly reduces overall efficiency by wasting money and time (Altarazi & Ammouri, 2018). The warehouse layout should be optimized by redefining pricking paths to reduce time and effort.

Füchtenhans et al. (2023) indicate that an inadequate and suboptimal warehouse layout reduces the space for safety equipment (Füchtenhans et al., 2023). This could also imply product breakage or any other safety hazard, including stolen raw materials leading to ineffective warehouse operations. Inventory loss also affects customer orders leading to lower customer retention. A good warehouse layout creates an optimized flow of goods and work processes. The inadequate warehouse layout might impact the overall integration of work. Van Gils et al. (2018) highlighted since one work in the warehouse is dependent upon the other, the slower pace in one could create traffics and dead ends in the aisles (Van Gils et al., 2018). Wasted movements would affect the work of more than one person within the warehouse.

When there are restrictions on the amount of raw material that can be acquired or when the raw material is one of the primary components of the company's product, the company's warehouse may be required to store a large quantity of the product. According to Ren et al. (2023), an inappropriate warehouse outlet can impede this opportunity window for the company, and there is no apparent space for temporary storage (Ren et al., 2023).

3. Literature Gap

This allows for the optimized management of the flow of goods throughout the various storage areas. In an economy driven by e-commerce, warehouses face increased demand. Multiple optimization mechanisms and introducing a new layout by integrating inventory management present obstacles. It has been evident that several works of literature were conducted on warehouse design with planning and implementing new warehouse facilities (Boysen et al., 2019).

There is limited research on warehouse optimisation to increase existing operations efficiencies of warehouses. In addition, gaps in this literature are evident because most literature addresses warehousing problems and warehouse supply chain operations and narrowly discusses the optimization problems of warehousing operations. Thus, this research study is expected to fill the gap between warehouse optimisation operational efficiency and any key factors that influence optimisation.

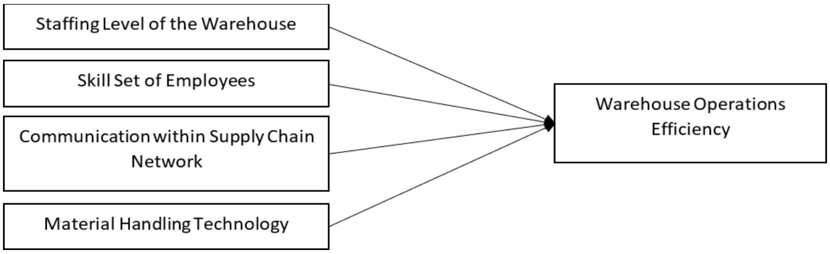

Figure 1: Research Framework

3.1 Hypothesis

- ***H1:*** *Staffing Level of the Warehouse (SLW) positively influences Warehouse Operations Efficiency (WOE).*
- ***H2:*** *Skill Set of Employees (SSE) positively influence Warehouse Operations Efficiency (WOE).*
- ***H3:*** *Communication within Supply Chain Network (CSCN) positively influence Warehouse Operations Efficiency (WOE).*
- ***H4:*** *Material Handling Technology (MHT) positively influences Warehouse Operations Efficiency (WOE).*

4. Methodology

A survey questionnaire was created based on the determined independent and dependent variables to gather data for the study. The questionnaire was designed to assess the warehouse's level of staffing, workers' skill sets, communication within the supply chain, and material handling technologies. The questionnaire also contained questions to gauge the effectiveness of warehouse operations (Park, 2021). Using a suitable sampling technique (e.g., random sampling, stratified sampling), a representative sample of the target population was selected to receive the survey questionnaire. Participants were individuals who work in the warehouse industry or are directly involved in warehouse operations.

Saudi Arabian warehouse personnel are the study's target population. To ensure that the sample accurately represents the wider group of interest, it is crucial to identify the population. The population in this instance consists of people who work in various Saudi Arabian warehouses. The sample size for this study was set at 100 based on available resources, time constraints, and other practical factors. Even if a sample size of 100 may be seen as small compared to the overall population, it can offer insightful information and permit useful analysis, particularly in exploratory investigations. It is significant to remember that the appropriate sample size relies on several criteria, including the research design, the statistical methods used, and the magnitude of the variables under study.

5. Analysis and Results

5.1 Reliability Analysis

The reliability analysis refers to the extent to which the values comprising a scale accurately assess the same attribute. In addition, Cronbach's alpha coefficient, a commonly used measure of reliability, represents the average correlation between all values within a scale. The table provides information about the variables examined in the research study. Each variable includes its abbreviation, the number of items used to measure it, and the measurement reliability as determined by Cronbach's Alpha. Four items were used to evaluate the dependent variable (DV) known as Warehouse Operation Efficiency (WOE).

Table 1: Reliability of the Scales

Variables	Abbreviation	No. of Items	Cronbach's Alpha
Dependent Variable (DV)			
Warehouse Operation Efficiency	WOE	4	0.799
Independent Variable (IV)			
Staffing Level of Warehouse	SLW	4	0.766
Skill Set of Employees	SSE	4	0.810
Communication in Supply Chain Network	CSCN	4	0.764
Material Handling Technology	MHT	4	0.870

The demographic information in the table below provides insight into a specific population. 94% (94 people) of the total population surveyed are males, while only 6% (6) are females, as indicated by the gender distribution.

6. Correlation

Correlation is a statistical methodology that quantifies the magnitude of the connection between two variables or the degree to which they are linked. The table shows the correlations between all five variables, giving significant results on their connection. The intensity and direction of the association between two variables are indicated by each correlation coefficient, determined using the Pearson correlation coefficient. Starting with the variable WOE, it displays a significant and positive correlation with SLW ($r = .339$, $p < .001$), SSE ($r = .605$, $p < .001$), CSCN ($r = .565$, $p < .001$), and MHT ($r = .589$, $p < .001$). Examining SLW, it demonstrates a significant and positive correlation with WOE ($r = .339$, $p < .001$), SSE ($r = .498$, $p < .001$), CSCN ($r = .550$, $p < .001$), and a relatively weaker positive correlation with MHT ($r = .310$, $p < .002$). Similarly, SSE reveals significant and positive correlations with WOE ($r = .605$, $p < .001$), SLW ($r = .498$, $p < .001$), CSCN ($r = .688$, $p < .001$), and MHT ($r = .659$, $p < .001$). Likewise, CSCN exhibits significant and positive correlations with WOE ($r = .565$, $p < .001$), SLW ($r = .550$, $p < .001$), SSE ($r = .688$, $p < .001$), and MHT ($r = .621$, $p < .001$). Lastly, MHT shows significant and positive correlations with WOE ($r = .589$, $p < .001$), SSE ($r = .659$, $p < .001$), CSCN ($r = .621$, $p < .001$), and a relatively weaker positive correlation with SLW ($r = .310$, $p < .002$). The correlation coefficients show different levels of positive connection between the variables, with some correlations showing greater ties than others. These correlations are unlikely to have happened by chance alone, according to the significance levels (p-values), demonstrating significant relationships between the variables.

Table 1: Demographics Overview

Demographics		
Gender		
	Frequency	**Percentage**
Male	94	94.0
Female	6	6.0
Total	100.00	100%
Age		
	Frequency	**Percentage**
21-30	15	15.0
31-40	51	51.0
41-50	28	28.0
Above 50	6	6.0
Total	100.00	100%
Education		
	Frequency	**Percentage**
High School	2	2.0
College Graduate	12	12.0
Post-Graduate	24	24.0
University Graduate	62	62.0
Total	100	100.0
Occupation		
	Frequency	**Percentage**
Inventory Managing Staff	32	32.0
Order Managing Staff	44	44.0
Quality Assurance Staff	16	16.0
Warehouse Trainee	8	8.0
Total	100	100.0

Table 2: Correlation

Correlations						
		WOE	**SLW**	**SSE**	**CSCN**	**MHT**
WOE	Pearson Correlation	1	.339**	.605**	.565**	.589**
	Sig. (2-tailed)		.001	.000	.000	.000
	N	100	100	100	100	100
SLW	Pearson Correlation	.339**	1	.498**	.550**	.310**
	Sig. (2-tailed)	.001		.000	.000	.002
	N	100	100	100	100	100
SSE	Pearson Correlation	.605**	.498**	1	.688**	.659**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	100	100	100	100	100
CSCN	Pearson Correlation	.565**	.550**	.688**	1	.621**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	100	100	100	100	100
MHT	Pearson Correlation	.589**	.310**	.659**	.621**	1
	Sig. (2-tailed)	.000	.002	.000	.000	
	N	100	100	100	100	100

6.1 Regression

Regression analysis evaluates the extent of association between a dependent variable and one or more independent variables. It assists in forecasting the value of the dependent variable based on the independent variable(s). The model summary thoroughly analyzes a regression model's statistical performance. In this instance, the model includes a dependent variable (WOE) and multiple predictors (MHT, SLW, CSCN, and SSE).

How well the predictors explain for the observed variability in the dependent variable is shown by the coefficient of determination (R-square). This model's R-square value of 0.448 indicates that the predictors can explain approximately 44.8% of the variance in the dependent variable (WOE). Taking into account the number of predictors, the adjusted R-square provides a more precise estimate of the model's explanatory power. In this case, the adjusted R-square is .425, which considers the number of predictors and offers a more accurate measurement of the model's ability to explain the variation.

The correlation coefficient (R) evaluates the strength and direction of the relationship between the model's predicted values and the actual values of the dependent variable. An R-value of .669 indicates a moderately strong positive relationship between the predicted and actual values. The standard error of the estimate (.57419) represents the average amount of variability observed between the predicted values and the actual values of the dependent variable. A smaller standard error indicates a better fit between the model and the available data, indicating that the predicted values closely match the observed values.

Table 3: Model Summary

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.669[a]	.448	.425	.57419

a. Predictors: (Constant), MHT, SLW, CSCN, SSE

b. Dependent Variable: WOE

The table below provides information regarding the proportion of variability explained by the regression model and the remaining unexplained variance. The sum of squares (SS) for the regression is 25,429, indicating that the predictor variable explains the total amount of variance. The regression has four degrees of freedom (df), corresponding to the number of predictors. The mean square (MS) is calculated by dividing the sum of squares by the degrees of freedom, which yields the value 6.357.

The F-value, calculated as 19,282 by dividing the regression mean square by the residual mean square, is used to evaluate the regression model's overall significance. In this instance, the F-value is highly significant (p 0.001), indicating that the entire regression model substantially affects the dependent variable.

ANOVA is utilized in SPSS to investigate differences in the mean values of the dependent variable, considering the effects of controlled independent variables and the impact of uncontrolled independent variables. The "Residual" row represents the model's unexplained variability. The residual sum of squares is 31,321, which indicates the variability the regression model cannot explain. The residual has 95 degrees of freedom, calculated by subtracting the number of predictors from the total observations. The mean square for the residual is 0.330, which is calculated by dividing the sum of squares by the degrees of freedom. The "Total" row represents the total variation of the dependent variable. The total sum of squares is 56,750, the sum of the sum of squares for regression and residual.

Table 4: ANOVA

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25.429	4	6.357	19.282	.000[b]
	Residual	31.321	95	.330		
	Total	56.750	99			

a. Dependent Variable: WOE
b. Predictors: (Constant), MHT, SLW, CSCN, SSE

The table displays coefficients that illustrate the connections between predictor and dependent variables. It provides unstandardized coefficients, standard errors, standardized coefficients (Beta), t-values, and p-values. Standardized coefficients allow for the comparison of predictor variable importance, while t-values evaluate their significance. The "Correlations" section displays the strength and direction of the zero-order correlations between predictors and the dependent variable.

Table 5: Coefficients

Coefficients							
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Correlations
		B	Std. Error	Beta			Zero-order
1	(Constant)	.479	.434		1.102	.003	
	SLW	.006	.125	.005	.050	.000	.339
	SSE	.335	.137	.288	2.436	.001	.605
	CSCN	.239	.148	.190	1.613	.004	.565
	MHT	.283	.109	.279	2.595	.011	.589

6.2 KMO and Bartlett's Test

The KMO measure determines whether the data is suitable for factor analysis. In this instance, the KMO measure is.826, indicating a level of sampling adequacy that is reasonably high. Typically, a value greater than.6 is acceptable. Bartlett's test of sphericity assesses whether the correlation matrix of the variables differs significantly from an identity matrix, which implies that the variables are interconnected. The test yields an approximate chi-square value of 1247.417, with 190 degrees of freedom. The associated p-value is .000, indicating a significant difference between the correlation and identity matrices. In summary, the KMO measure confirms the suitability of the data for factor analysis, and Bartlett's test highlights the significant interrelationship between the variables.

Table 6: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.826
Bartlett's Test of Sphericity	Approx. Chi-Square	1247.417
	Df	190
	Sig.	.000

6.3 Communalities

The table displays communalities for variables associated with the effectiveness of warehouse operations. Communalities represent the extent to which extracted factors in a factor analysis account for the variance in each variable. For the dependent variable "Warehouse Operations Efficiency," the initial communalities range from 0.615 to 0.772, representing the variance explained by factors before extraction. After extraction, communalities range between.507 and.694, which indicates the variance explained by the extracted factors. Similar patterns are observed for the independent variables "Staffing Level of the Warehouse," "Skill Set of Employees," "Communication within the Supply Chain Network," and "Material Handling Technology."

Initial communalities range from.508 to.763, whereas post-extraction communalities range from.372 to.682. Overall, communalities provide insight into the proportion of each variable's variance explained by extracted factors. Higher communalities indicate a stronger relationship between variables and underlying factors, indicating that the factors account for a greater proportion of the variance.

The results allow us to evaluate whether the hypotheses regarding the associations between Warehouse Operations Efficiency (WOE) and various factors can be accepted or rejected.

- ***H1:*** *The correlation coefficient 0.339 between WOE and SLW indicates a significant positive association (p < 0.01). Therefore, we accept H1, which suggests an association between WOE and SLW.*
- ***H2:*** *WOE and SSE exhibit a strong positive association with a correlation coefficient 0.605 (p < 0.01). Hence, we accept H2, indicating an association between WOE and SSE.*
- ***H3:*** *The correlation coefficient 0.565 between WOE and CSCN signifies a significant positive association (p < 0.01). Therefore, we accept H3, suggesting an association between WOE and CSCN.*
- ***H4:*** *WOE and MHT demonstrate a positive association with a correlation coefficient 0.589 (p < 0.01). Thus, we accept H4, indicating an association between WOE and MHT.*

Table 7: Communalities

Communalities			
		Initial	**Extraction**
	DV: Warehouse Operations Efficiency (Amenta, 2019)		
WOE1	Most of the time, goods are properly sorted in our warehouse to avoid risk of spoilage or damage.	.615	.507
WOE2	The storekeeper is informed of the goods being procured before arrival at the warehouse to reduce unloading time.	.576	.473
WOE3	Most of the time, our warehouse personnel utilize a reasonable warehouse space during the reception of goods.	.651	.530
WOE4	Warehouse personnel is skillful in performing order Picking process without significant errors	772	.694

	IV: Staffing Level of the Warehouse (Knosp et al., 2023)		
SLW1	We have one or more staff whose duties include processing requests for data.	.587	.447
SLW2	We have one or more staff whose duties include aggregating and managing stored data.	.508	.379
SLW3	We have one or more staff whose duties include project management of activities.	.639	.523
SLW4	We have one or more staff whose duties are shared with enterprise IT.	.625	.512
	IV: Skill Set of Employees (Verma et al., 2019)		
SSE1	The employees possess the necessary technical knowledge and expertise for their job roles.	.726	.655
SSE2	The employees demonstrate proficiency in using relevant software and tools.	.709	.634
SSE3	Employees identify the root causes of problems and propose effective solutions.	.720	.587
SSE4	Employees show resilience in the face of setbacks or failures.	.675	.506
	IV: Communication within Supply Chain Network (Ghadge et al., 2020)		
CSCN1	Communication within the supply chain network is clear and effective.	.567	.372
CSCN2	Open and transparent communication among all stakeholders within our supply chain network exists.	.606	.485
CSCN3	Our supply chain partners actively collaborate and share relevant information.	.579	.449
CSCN4	Communication breakdowns are quickly addressed and resolved within our supply chain network.	.648	.567
	IV: Material Handling Technology (Improta et al., 2019)		
MHT1	The technological efficiency is appropriate for the type of storage.	.763	.682
MHT2	The technological safety is high to reduce any danger	.719	.607
MHT3	The reliability of the material handling equipment is satisfactory.	.740	.612
MHT4	The procedural complexity of Material Handling is quite easy and well-organized.	.671	.493

Nevertheless, based on the correlation analysis, all four hypotheses (H1, H2, H3, and H4) are supported, as there are significant associations between Warehouse Operations Efficiency (WOE) and each of the predictor variables (SLW, SSE, CSCN, and MHT).

7. Discussion

There is a significant relationship between Warehouse Operations Efficiency (WOE) and Warehouse Staffing Level (SLW). Maintaining an adequate number of skilled employees is crucial to the efficiency of warehouse operations, as their availability directly impacts productivity and overall operational success (Gutelius &

Theodore, 2019). A previous study found that adequate staffing ensures tasks are completed promptly, resulting in enhanced order fulfillment, decreased errors, and increased customer satisfaction. Inadequate staffing levels, on the other hand, can result in bottlenecks, delays, and operational inefficiencies. Recognizing the strong correlation between WOE and SLW enables businesses to allocate resources strategically, optimize staffing levels, and enhance warehouse performance to achieve maximum efficiency and productivity.

The strong correlation between Warehouse Operations Efficiency (WOE) and Employee Skill Set (SSE) is crucial in ensuring the warehouse's seamless and efficient operation. The competence and expertise of warehouse employees directly affect the overall efficiency and output of warehouse operations. Nantee and Sureeyatanapas (2021) & Naeem, Nguyen, and Weber (2017) indicate that a skilled workforce brings valuable knowledge and proficiency to diverse warehouse management tasks such as inventory management, order processing, and logistics coordination (Naeem et al., 2017; Nantee & Sureeyatanapas, 2021). With a knowledgeable and well-trained workforce, warehouses can streamline processes, reduce errors, and maximize resource utilization.

Inefficiency, errors, and operational obstacles can result from inadequate skills and training. Recognizing the significant relationship between WOE and SSE, organizations can prioritize employee training and development programs to increase skill levels, thereby improving warehouse operations and fostering long-term success in the logistics and supply chain management industry.

The significant relationship between Warehouse Operations Efficiency (WOE) and Communication within the Supply Chain Network (CSCN) plays a crucial role in ensuring warehouse efficient and seamless operation. Effective communication within the supply chain network is essential for the timely and accurate exchange of information among stakeholders such as suppliers, manufacturers, distributors, and customers. Clear and effective communication facilitates coordination, collaboration, and synchronization of activities within warehouse operations, resulting in enhanced inventory management, order processing, and fulfillment. A well-connected supply chain network gives warehouses real-time visibility of inventory levels, demand fluctuations, and customer requirements, allowing them to optimize their operations in response (Rejeb et al., 2019). Inadequate communication or information gaps, on the other hand, can lead to delays, errors, and disruptions in warehouse processes, thereby diminishing overall efficiency. Recognizing the significant relationship between WOE and CSCN enables organizations to prioritize effective communication strategies, implement technology solutions, and cultivate strong relationships with supply chain partners to improve warehouse operations, streamline processes, and achieve higher levels of operational efficiency in a dynamic and competitive business environment.

The correlation between Warehouse Operations Efficiency (WOE) and Material Handling Technology (MHT) is vital in facilitating efficient and streamlined warehouse operations. Material handling technology encompasses the tools, equipment, and systems used for storing, transporting, and handling goods within a warehouse. Advanced MHT solutions can significantly impact warehouse efficiency by increasing productivity, decreasing errors, and optimizing resource utilization.

According to previous research, automation technologies such asconveyor systems, robotic picking systems, and automated guided vehicles (AGVs) can significantly enhance material handling processes' speed, precision, and throughput (Frazelle, 2016; Ramli et al., 2017). In addition, inventory management systems and barcode scanning technologies provide real-time visibility and accurate inventory tracking, thereby minimizing stockouts and maximizing order fulfillment rates. By recognizing the significant relationship between WOE and MHT, warehouses can strategically invest in and employ cutting-edge material handling technologies to streamline operations, increase productivity, and ultimately attain higher efficiency and customer satisfaction.

The study emphasized the need for warehouse optimization to increase output and efficiency. Various factors, such as the number of employees, their skills, supply chain communication, material handling equipment, and inventory management systems, significantly impact a warehouse's performance, according to the research. The study also investigated the connection between warehouse layout and productivity, focusing on inefficient motions, a lack of overflow space, inefficient picking methods, safety concerns, and dead-end sections. In addition, the survey revealed that the need to adapt to technological advancements, resource constraints, and difficulties in gaining supply chain awareness were obstacles to warehouse efficiency. These findings, which support earlier research, highlight the significance of these warehouse operations components. The outcomes also shed light on the precise ways in which these variables affect operational outcomes.

Inadequate personnel levels, for instance, harmed performance and increased expenses, as determined by the study. The competence of the workforce has been found to impact the efficiency of warehouse operations significantly. Moreover, it was demonstrated that synchronizing warehouse activities and reducing costs rely heavily on the supply chain network's communication ability. According to the study, material handling technologies such as handheld scanners and warehouse management systems streamlined inventory control and reduced human error, enhancing productivity. The results also highlighted the benefits of a well-designed warehouse in reducing unnecessary jobs, improving safety, and increasing operational efficiency. This study provides insightful data regarding the efficiency of warehouse operations and the factors that affect them. The results demonstrate the significance of various factors for optimizing warehouse operations, such as workforce levels, employee skill sets, communication, technology, and inventory management systems.

In addition to identifying obstacles to operational effectiveness, the report emphasizes the impact of warehouse layout on productivity. This research contributes to the existing knowledge on warehouse operational effectiveness while developing a theoretical framework for comprehending the fundamental factors at play and proposing practical enhancements. By implementing the techniques outlined in this study, warehouse managers can increase efficiency, reduce costs, and boost customer satisfaction. The study highlights the importance of continuous innovation and adaptability in response to shifting market conditions and technological advancements to achieve and sustain the highest warehouse operational efficiency possible. Future research can improve upon these findings by analyzing the precise effects of specific elements and examining alternative optimization techniques.

8. Implications of the Study

The study's findings support previous research and emphasize the importance of these elements in warehouse operations. These findings shed more light on these variables' precise effects on operational efficiency. For instance, it has been found that insufficient workforce numbers contribute to both higher expenditures and less than ideal operational results. A crucial element for effective warehouse operations also emerged as personnel expertise. The supply chain network's ability to effectively communicate was also shown to be essential for coordinating warehouse operations and reducing costs. By enabling inventory tracking and lowering manual errors, material handling technologies, such as handheld scanners and warehouse management systems, have been shown to increase efficiency. The results further supported the idea that an optimized warehouse architecture can greatly increase operating efficiency by eliminating wasteful effort and boosting safety. This study provides insightful information on the efficiency of warehouse operations and the variables affecting it. The results support the notion that optimizing warehouse operations requires considering elements like workforce levels, employee skill sets, communication, technology, and inventory systems. The report also highlights the influence of warehouse layout on productivity and identifies barriers to operational success.

This study contributes by expanding the knowledge on warehouse operational effectiveness, offering a theoretical framework for comprehending the important elements, and suggesting workable solutions for improvement. Warehouse managers may boost productivity, cut expenses, and raise customer happiness by implementing the techniques uncovered in this study. Overall, this study emphasizes the need for ongoing development and flexibility in response to market dynamics and technological advancements to achieve and sustain the highest possible warehouse operational efficiency. Future research can advance these conclusions by examining the precise effects of many elements and looking into other optimization techniques.

The research's conclusions emphasize the need to keep the right staffing numbers and ensure that workers are equipped with the relevant skills in a warehouse environment. It is advised that businesses conduct a thorough analysis of their workload and operational needs to establish the optimal workforce levels to achieve the most operational efficiency. Additionally, investing in initiatives and training programs focused on improving warehouse employees' abilities can significantly increase their competence and effectiveness. The supply chain network's communication ability is crucial for efficient warehouse operations. Establishing effective channels of communication and protocols between suppliers, manufacturers, distributors, and retailers is therefore advised for organizations. Adopting digital technologies can make information sharing and cooperation more effective. Examples include supply chain management systems and real-time communication tools. A open communication and knowledge sharing culture must also be encouraged inside the supply chain network Material handling technology is essential for optimizing the efficiency of warehouse operations. To implement innovative material handling systems, businesses must evaluate their current warehouse layout and identify areas for improvement. By conducting a cost-benefit analysis, businesses can determine the optimal level of expenditure required to implement these technologies. In addition, thorough training and assistance will be provided to warehouse employees to ensure that the installed technologies are utilized effectively.

9. Recommendations

Several significant recommendations can be made to enhance warehouse operational efficiency. To determine the optimal staffing levels, it is necessary to investigate the warehouse's workload and operations in depth. For this analysis to be accurate, it must account for peak periods, order volumes, and required skill sets. This will ensure that there is always sufficient staff on hand. Investing in training programs and projects focusing on skill development and equipping warehouse employees with the knowledge and abilities they need to perform their jobs competently can also significantly improve their competence and performance. Implementing performance evaluation tools is also crucial because it allows for the early identification and prompt resolution of potential staffing issues. These technologies make it easier to monitor employee productivity, identify problem areas, and provide feedback for future development.

Furthermore, good communication within the supply chain network is essential for efficient warehouse operations. Suppliers, manufacturers, distributors, and retailers must establish clear communication channels and conventions for efficient information flow and coordination. Adopting digital technology can greatly enhance information sharing and collaboration between all relevant stakeholders. Examples include supply chain management systems and real-time communication tools. Additionally, by encouraging collaboration and the exchange of insightful information, building an environment of open communication and knowledge sharing inside the supply chain network can further improve effectiveness and efficiency. Another important element in streamlining warehouse operations is adopting modern material handling technology.

It is essential to assess the current warehouse design and pinpoint places that can be made better to accept cutting-edge material handling systems. The ideal expenditure needed to implement these technologies will be determined by conducting a thorough cost-benefit analysis, ensuring that the advantages outweigh the disadvantages. Giving warehouse employees training and support to ensure their efficient use of the installed equipment is just as crucial. Its potential will be maximized, and it will also improve overall operational effectiveness. By implementing these suggestions, organizations may greatly increase warehouse operating efficiency, resulting in cost savings, increased production, and greater customer satisfaction.

10. Further Research Directions

Future work is recommended to conduct additional research to examine how adopting emerging technologies, such as artificial intelligence and the Internet of Things, affects the efficiency of warehouse operations. Exploring the relationship between warehouse design, layout, and operational efficiency can yield valuable insights. Comparative studies involving various industries or regions can aid in identifying factors specific to certain sectors or locations that impact warehouse efficiency. By doing so, more focused optimization strategies can be developed. These research endeavours will enhance our comprehension of warehouse operations and facilitate ongoing advancements in the field.

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