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OPTIMIZING THE EFFICIENCY AND COST OF ENTERPRISE LOGISTICS WAREHOUSE: FROM THE PERSPECTIVE OF GREEN SUPPLY CHAIN MANAGEMENT

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ABSTRACT

The aforementioned findings possess considerable ramifications for both research and application within the domain of logistics management. Nonetheless, this investigation is not without its constraints. Initially, the implementation of a questionnaire survey could potentially yield subjectivity and recall bias. Furthermore, the utilization of non-probability sampling technique could impede the degree of representativeness within the sample population. Furthermore, this research centered exclusively on logistics warehouses situated in China, thereby constraining the potential applicability of its conclusions to dissimilar geographical domains and sectors. Subsequent research endeavors ought to assess the aforementioned constraints and delve deeper into additional variables that impact the effectiveness and monetary aspects of logistics warehouses. Moreover, a deeper analysis is imperative pertaining to the efficacious execution of green supply chain management and sustainable development tactics in real-world scenarios, with the objective of enhancing the operational output and ecological stability of logistics depots. In summation, this research offers noteworthy insights that are beneficial for the logistics management discipline, and it delineates avenues for forthcoming investigations and potential research advancements. By means of ongoing research and practical implementation, the promotion of sustainable development pertaining to logistics warehouses can be facilitated, ultimately bolstering the creation of ecologically-responsible supply chains.

Keywords: Efficiency of logistics warehouse, cost of logistics warehouse, green supply chain management

Introduction

Background

The widespread phenomenon of globalization has led to an escalation in environmental predicaments on a global scale, as posited by Haiyun et al. (2021). Environmental concerns constitute a prominent and critical area of focus within the domain of supply chain research.

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Policy makers and institutional stakeholders on a global level are placing an increased emphasis on the formulation and implementation of plans designed to protect the environment. This need is being driven by considerations beyond mere regulatory and policy frameworks, and is also shaped by the imperative to foster sustainable economic growth and promote environmentally responsible practices among enterprises (Chakraborty et al., 2023). The effective management of supply chains presents a crucial concern for both small and medium-sized enterprises (SMEs) and multinational corporations, as highlighted in extant scholarly research (Chee Wooi & Zailani, 2010; Hubbard et al., 2011). The concept of supply chain management pertains to a complex network of diverse organizations that collaborate in various activities and processes, spanning from upstream to downstream (Mentzer et al., 2001). The field of supply chain management has extended its scope across the domains of procurement, production, and distribution (Chakraborty et al. 2023).

The rise of carbon peak and carbon neutral strategies, as well as the heightened consciousness toward environmentally conscious initiatives, has resulted in growing recognition for green development. As a result, green supply chain management (GSCM), an offshoot of conventional supply chain management, is increasingly being utilized as a mechanism to advance sustainable practices (Zhang et al., 2023). The emergence of the green supply concept is aimed at tackling environmental concerns within the domain of supply chain management (Sezen & Çankaya, 2018). GSCM is a vital component in the effective management of organizational strategies and operations (Gahlot et al., 2023). According to this particular framework, GSCM is a notion that encompasses numerous processes, such as product design, manufacturing and production technology, operations, material selection, and waste management, with the primary objective of averting environmental pollution(Gahlot et al., 2023). There are several measures that must be taken in order to achieve the desired outcome. Environmental protection has emerged as a significant consideration with respect to addressing pollution, which has become a crucial concern for ensuring efficacy enhancement (Zhang et al., 2023). Adhering to social responsibilities pertaining to environmental safeguarding is an imperative issue that necessitates attention in this context.

The warehouse serves as a foundational component within the field of logistics operations and encompasses multiple requisite tasks, including but not limited to: storage provision, reception of goods, item selection, and facilitation of transport. Warehousing operations represent a significant component in enhancing the effectiveness of logistical provisions (Kolinski & Sliwczynski, 2015; Abdul Rahman et al., 2023). Jin et al. (2016) purport that the level of service and customer satisfaction are contingent upon the efficacy and quality of storage. One potential function of warehouse facilities is to serve as a buffer mechanism that can effectively manage and control the movement of goods within a supply chain system (Abdul Rahman et al., 2023). Conversely, storage facility activities may present a bottleneck scenario in certain regions, which results in considerable impediments to the conveyance of goods and the standard of logistical services (Kodawski et al., 2017). By enhancing the efficiency, efficacy, and precision of logistical network operations, fulfillment facilities can reliably and expeditiously provide services that guarantee the timely delivery of products to end-consumers, thus ensuring their satisfaction (Abdul Rahman et al., 2023). Furthermore, the relocation of the warehouse is contingent upon the exigencies of the business and the policies of urban development. The optimization of storage efficiency and the acceleration of response speed within the logistics chain are contingent upon the placement of the warehouse. An illustration of the aforementioned can be observed in the geographical location of a logistics organization situated within the vicinity of Tangshan which lies along G112, the primary circular roadway surrounding Tangshan city. In order to comply with the stipulations of municipal planning and to address its individual development demands, the selection of a novel warehouse location is deemed requisite. To resolve the issue of enterprise location, utilization of the Analytic Hierarchy Process (AHP) is employed for the purposes of analysis and decision-making. The present analysis yields the proposition of an optimal site selection, alongside pertinent recommendations, intended to mitigate operational expenses and augment the financial gains of enterprises (Bingqing & Liting, 2020). The current era presents a propitious moment for strategic opportunities in the enhancement of logistics efficiency. An illustration of the trend is the escalating request for logistics services in China attributable to the amelioration of the populace's quality of life. The emergence and evolution of scientific and technological advancements have significantly contributed to enhancing the efficiency and effectiveness of the logistics industry. Maximizing opportunities to enhance efficiency, the advancement of logistical practices holds great potential in promoting economic growth and sustainability. According to Wang et al.(2022), the enhancement of logistics efficiency possesses the potential to fortify domestic consumption, foster industrial advancement, enhance economic efficacy, and advance sustainability.

Warehousing plays a critical role in the logistics chain. However, challenges continue to arise in the form of erroneous item registration, improper placement of goods, and suboptimal movement of personnel following warehousing procedures. Every error committed results in escalated expenses pertaining to the logistics of a business. To prevent errors of similar nature, numerous organizations have implemented automated recognition systems, effectively resolving the aforementioned issues as witnessed in the study conducted by Kučera (2019). Shu et al. (2018) conducted a comprehensive investigation into the effects of environmental factors on plant growth. The current study aimed to address the issue of the exorbitant expenses associated with cold chain logistics and proposed a customer-centric inventory path optimization framework using satellite models. The chief objective of this framework was to curtail logistics costs while simultaneously enhancing operational efficiency to guarantee customer satisfaction. Furthermore, the advent of intelligent warehouses has brought about a reduction in storage expenses and an enhancement in operational efficacy. The concept of intelligent warehousing pertains to an emerging automated warehouse that is grounded upon the fundamentals of artificial intelligence technology. The mobile robot used in warehouse logistics has integrated route and path planning technology that offers advantages such as reduced running time and energy consumption, diminished wear and tear, and lowered production expenses. Additionally, it has the potential to decrease the required investment capital (Duan, 2018).

Currently, scholarly investigations regarding GSCM predominantly center around issues relating to sustainability and environmental concerns. The holistic implementation of sustainable practices within the supply chain, commonly referred to as GSCM, along with the efficacious management of logistics warehousing, is an area that remains inadequately investigated. Specifically, the possible associations between the costs of logistics warehousing and its efficiency, as well as the influence of GSCM on these measures, warrant further exploration within the literature. The overarching objective of this paper is to investigate the interdependencies and optimization strategies between GSCM, logistics warehouse cost, and logistics warehouse efficiency. This research endeavor is motivated by the existing research gap in this domain, with an aim to advance our understanding of the topic. This article presents a set of research inquiries, namely: (RQ1) In what ways does the implementation of GSCM affect logistics warehousing in terms of efficiency and cost? (RQ2) To what extent do the efficiency and cost of logistics warehouses impact the implementation of green supply chains? (RQ3) What is the optimal approach to optimizing the operation process of logistics warehouses to achieve the objective of GSCM? The present study aims to investigate the relationships between green supply chain management, logistics warehouse expenses, and performance. Furthermore, the study intends to offer recommendations for enhancing practices in order to realize cost savings and augment operational efficacy within logistical warehousing.

The remaining structure of this article is as follows. Building on prior research, Section 2 offers a literature review on the efficiency and cost of logistics warehouses, as well as GSCM, and proposes a structural framework based on assumptions. Section 3 presents the research methodology, including data collection and analysis, detailing the data collection process and the tools used for data processing. Section 4 encompasses demographic analysis, model construction, and analysis, establishing the relationships between logistics warehouse cost, efficiency, and GSCM. Section 5 summarizes the paper. Section 6 discusses policy recommendations. Finally, Section 8 identifies future research directions

Literature Review

Efficiency of logistics warehouses

Distribution center effectiveness has presently ended up a competence center or a vital weapon among organizations. Productive distribution centers can rapidly meet client needs and make strides in company execution (Jermsittiparsert et al., 2019). Hsieh & Tsai (2006) clarified that the sensible utilize of capacity assignment techniques can utilize the slightest capacity space. They utilize eM-plant computer program as a recreation examination device to create a distribution center plan database, distribution center format, capacity allotment, picking course arranging, picking thickness and arrange combination sorts will be optimized, coordinates and arranged within the distribution center framework. Bassan et al. (1980) compared two racking setups in homogeneous or apportioned stockrooms. Taking care of costs as well as costs related with stockroom space and perimeter are taken into consideration. From these, expressions for ideal plan parameters were created. The comes about appear that a few common inclination rules can be defined for the two formats inspected, depending on the proportion between the related costs. Jermsittiparsent et al. (2019) took Indonesian supply chain ventures as the inquiry about target and utilized the factual strategy of Partial Least Squares Structural Equation Modeling (PLS-SRM) to test the information. The discoveries highlight that legitimate stockroom plan can viably move forward stockroom productivity in Indonesian supply chain companies. In expansion, successful stock and material flow, administration will increment the stock proficiency of warehousing (Moons et al., 2019). Material flows can evaluate how materials are utilized, reused and misplaced in present day social orders (Graedel, 2019). Muchaendepi et al. (2019) utilized stock administration strategies to assess the stock effectiveness execution of SMEs within the material division in Harare, Zimbabwe. Wiedenhofer et al. (2019) developed the MISO demonstration to together account for material flow, material capital, and utilize stocks of squander. Moons et al. (2019) appeared that supply chains inside healing centers are characterized by complexity, uniqueness, and operational challenges. Illustrations incorporate amazingly costly items and therapeutic gear utilized in working rooms, troublesome stock following due to the criticalness of treatment, and eccentric request for restorative supplies. There are a parcel of squander chain forms in healthcare supply. Working rooms, in specific, have gotten to be a major fetched driver for clinics. Subsequently, viably overseeing these supplies has continuously been a challenge for healing centers. In expansion, Liu et al. (2019) appeared in their inquire about that the utilize of automated guided vehicles (AGV) in shrewd distribution centers or unmanned distribution centers to move forward sorting can move forward distribution center productivity and improve the competitiveness of undertakings. Ding et al. (2021) summarize the most recent inquire about and applications of the Internet of Things (IoT)-based savvy coordinations, counting keen cargo, warehousing, and dispersion within the writing. They affirmed the part and affect of keen coordinations. Based on the above-mentioned writing, this paper puts forward the taking after speculations:

Hypothesis 1: The layout and design of a warehouse can have a substantial impact on its overall efficiency.

Hypothesis 2: The management of inventory and material flow will have a significant impact on the overall efficiency of the warehouse.

Hypothesis 3: The efficiency of a warehouse is substantially impacted by the processes of loading, unloading, and sorting of goods.

Hypothesis 4: The efficiency of a warehouse is significantly influenced by its shipping and distribution processes.

Cost of logistics warehouses

With tall stock levels, the company causes a settled taken a toll for each extra SKU. The distribution center administration framework can make full utilize of assets, progress proficient warehousing administrations and diminish venture coordinations costs (Kučera, 2017). In reality, coordinations costs are frequently influenced by different variables, counting fuel costs, modes of transportation, and supply chain disturbances (OptimoRoute, 2022; Russell et al., 2014). Milewski & Milewska (2023) appear that transportation costs are unequivocally affected by fuel costs and fuel utilization amid transportation. The comes about of the consider appear that the fuel utilization productivity of large-tonnage transportation is changing at a rate of 0.8-1% per year, and cargo rates have moreover expanded, which has caused weakening within the company's productivity. Yugang (2020) clarified that coordination improvement is emphatically related to current vitality utilization. Be that as it may, Wang and Dong (2023) appeared in their consider that the development of the coordinations industry had a positive affect on energy utilization. In spite of the fact that there's prove that there's a relationship between vitality utilization and coordinations costs, there are clashing ponders on the relationship between the two. Agreeing to past inquire about on labor costs and coordinations costs, Dima et al. (2010) presents a scientific show for the taken a toll of coordinations coming about from squander administration, which includes the arrangement of coordinations costs coming about from labor. Stock taken a toll is an vital thought in coordinations, because it incorporates the fetched of labor included in warehousing and overseeing stock. The affect of stock holding costs on ideal supply chain arrangement and dispersion frameworks development can too have suggestions for labor fetched (Bolaños-Zúñiga & Vidal-Holguin , 2020). Based on the investigate on the relationship between squander treatment taken a toll and natural remediation taken a toll and coordinations fetched. Dima et al. (2010) show a scientific show for the taken a toll of coordinations coming about from squander administration. Zwolińska and Michlowicz (2011) presents the in general costs produced inside the squander administration framework of a full generation cycle steel process, which have been gathered by objects agreeing to the criteria of fundamental coordinations forms realized inside the squander administration framework. In any case, Rihn (2022) recommends that squander pulling clients are seeing their bills go up due to higher yearly cost increments, landfill tipping charge increments, and the tall taken a toll and complexity of transportation. Maleka et al. (2017) prescribes that firms ought to center more on minimizing squander era to diminish costs. In expansion, the most components of coordinations costs are transportation costs, stock holding costs, and capacity costs. Stock carrying costs are the entire fetched of stock transportation and capacity costs. Authoritative fetched variables directly affect factors related to cargo and stock holding costs (Wantanakomol, 2021). Coordinations administration is the greatest figure influencing stock holding costs, since stock capacity may be a vital condition for a commerce to easily encourage fabricating or deals. In any case, abundance stock may lead to issues such as tall capacity costs, item disintegration or out of date quality, and taken a toll sunk (Sebatjane & Adetunji, 2021). Hence, based on the above-mentioned writing outline, this paper puts forward the taking after theories:

Hypothesis 5: The relationship between energy consumption and logistics costs is significant.

Hypothesis 6: There exists a significant correlation between labor costs and logistics costs.

Hypothesis 7: There exists a significant link between the cost of waste disposal and environmental remediation and logistics costs.

Hypothesis 8: Inventory holding costs will have a noticeable impact on logistics costs.

Green supply chain management

Green supply chain administration is ordinarily characterized as joining green considering and natural issues into the whole supply chain operation, such as item plan, fabricating handle, warehousing, dissemination, etc. Warehouse management adopts green standards to play down the negative impact on the supply chain environment. In stockroom operations, to play down benefit time levels because it is closely related to higher costs (Ene et al., 2016). RAHAL and ZENNIR (2021) examined the affect of the execution of GSCM on Unilever in Algeria on its operational productivity, and the comes about appeared that GSCM is a successful apparatus to upgrade natural affect and maintainability, and the usage of GSCM can move forward asset effectiveness and diminish generation costs. Aliyev et al. (2022) affirmed that green supply chain administration advancement can improve operational adequacy, diminish asset squander and diminish generation costs. Stekelorum et al. (2021) given a modern approach to decide the setup of inner and outside GSCM hones to move forward the operational and monetary execution. Furthermore, Iqbal et al. (2020) displayed a supply chain demonstrate and affirmed that the gotten ideal length of the arranging skyline gives ideal generation time and minimizes vitality utilization. Natural execution is emphatically affected by eco-efficiency and eco-brand orientation through three primary GSCM hones: dissemination and transportation, warehousing and green building, and invert coordinations. Progressing natural execution encompasses a positive affect on financial execution (Laguir et al, 2021). Combining natural issues with supply chain administration to ponder organizational execution appears that making strides the environment can increment organizational efficiency. Based on the rundown of the over writing, this ponder puts forward the taking after speculations:

Hypothesis 9: incorporating measures of GSCM will have a significant impact on the overall efficiency of warehouse operations.

Hypothesis 9(a): the adoption of GSCM practices among logistics enterprises will have a positive impact on logistics warehouse layout and design.

Hypothesis 9(b): logistics enterprises implement GSCM practices with the aim of enhancing their inventory management and accelerating the flow of materials.

Hypothesis 9(c): the implementation of GSCM within logistics enterprises may engender expedited loading, unloading, and sorting of goods.

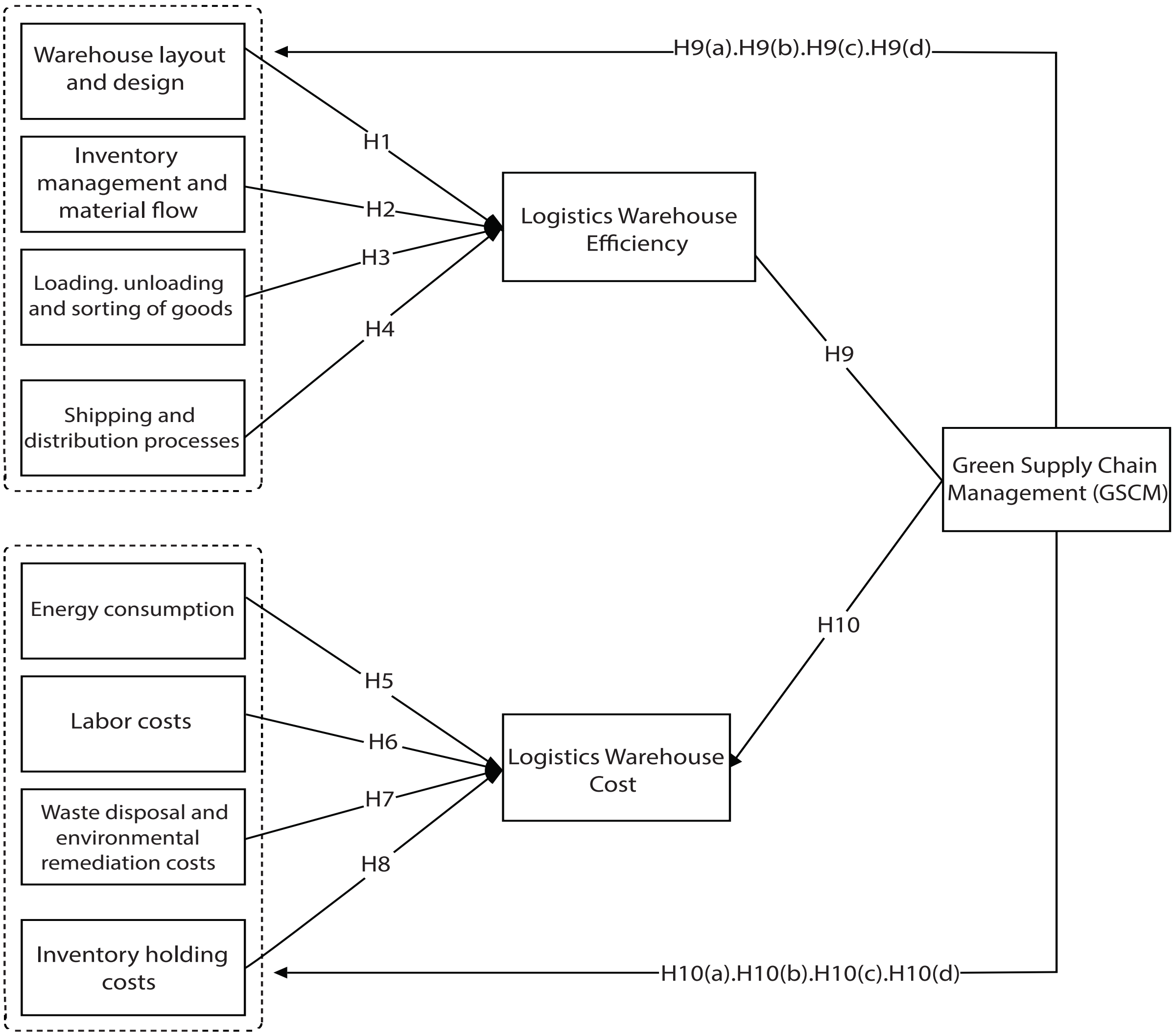

Figure 1. Structure Framework

Hypothesis 9(d): logistics enterprises can expedite the transportation of goods and improve the distribution process by implementing GSCM.

Hypothesis 10: GSCM will substantially impact cost of logistics warehouse.

Hypothesis 10(a): the implementation of GSCM can facilitate logistics enterprises to efficiently regulate energy consumption.

Hypothesis 10(b): the incorporation of GSCM practices can enable logistics companies to aptly supervise their labor costs.

Hypothesis 10(c): the adoption of GSCM by logistics companies may serve as a potential facilitator for promoting efficient waste disposal and mitigating associated environmental governance expenditures.

Hypothesis 10(d): posits that logistics firms implement environmentally GSCM practices in order to efficiently manage inventory holding expenses.

2. Structure framework with research hypothesis

This study is grounded in ten primary conjectures, which were developed based on assessments of logistics warehouse efficacy, expenditure, the correlation between green supply chain management and logistics warehouse effectiveness, as well as the correlation between green supply chain management and logistics warehouse expenditure. The study employs GSCM as the dependent variable and identifies "energy consumption," "labor costs," "waste disposal and environmental remediation costs," and "inventory holding costs" as independent variables. Moreover, the study formulates four additional hypotheses under the headings of H10(a), H10(b), H10(c), and H10(d). This study examines the connection between GSCM and several aspects of warehouse operations, including "warehouse layout and design", "inventory management and material flow", "loading, unloading and sorting of goods", and "shipping and distribution process". The variables of warehouse layout and design, inventory management and material flow, loading, unloading and sorting of goods, as well as the shipping and distribution process, are posited as independent factors for investigation in the present study. These variables are denoted as H9(a), H9(b), H9(c), and H9(d), respectively.

3. Research Methods

The present investigation entails the identification and assessment of measurable priorities and objectives through the implementation of statistically sound methods for data analysis. As a result, the application of quantitative methodologies is deemed necessary. The acquisition of data in the field of scientific research involves the implementation of structured surveys and the utilization of a thorough and stringent methodology. The present study employs the approach of a questionnaire-based survey. To enhance the dependability of data and mitigate the margin of error in data interpretation, the present study endeavors to procure survey instruments directly from employees employed in logistics warehouses located in China. During the course of data acquisition, the present investigation engaged laborers employed across a number of logistics storage facilities situated within the territorial boundaries of China.

Measurements

Construct	No. of items
The efficiency of logistics warehouse	5
Cost of logistics warehouse	5
Logistics Warehouse Efficiency and Green Supply Chain Management	5
Logistics Warehouse Cost and Green Supply Chain Management	5

Table 1. The distribution of the questionnaire

This research employs a questionnaire-based survey comprising 20 measurement items that have been standardized to a five-point scale. The Likert scale necessitates respondents to select their own opinions, characterizing the extent to which they are affected. The scale allocates a range of values from 1, signifying "not affected at all," to 5, signifying "completely affected." The utilization of a closed questionnaire for data collection can be perceived as a methodological approach with certain limitations. The confinement of respondents to a predetermined set of response options can yield valuable and pertinent data. The utilization of this methodology enables the assessment of autonomous examples of attributes drawn from a broader populace (Men et al., 2023). Table 1 denotes the distribution of every questionnaire.

Data collection and analysis

The present investigation recruited logistics warehouse operatives who were employed by SF Express, JD Express, Yunda Express, and Cainiao Yizhan in China. The aforementioned positions comprise individuals serving as logistics warehouse managers and personnel with varying levels of proficiency. It is justifiable to opt for these logistics firms as participants in the present investigation. The aforementioned companies are publicly traded entities and rank among the leading corporations in China. The management and governance of e-commerce logistics and logistics warehouses have been found to exhibit a considerable level of efficacy. The technological advancements in the logistics warehouse industry surpass those of other domestic logistic enterprises. This study encompasses a diverse group of individuals holding various titles within logistics companies, specifically including logistics warehouse managers, logistics supervisors, logistics administrators, logistics coordinators, and logistics distributors, based on their respective roles and responsibilities. A significant number of logistics company managers exhibit reluctance to participate in questionnaire-based surveys, consequently impeding the implementation of stringent sampling techniques for data collection purposes. The method referred to as non-probability sampling is utilized for selecting convenience samples. All participants gave their informed consent, and all information was treated with confidentiality and solely utilized for academic pursuits.

To ascertain the dependability and credence of the data, this investigation employs the reliability assessment and validity assessment for data analysis. Additionally, this investigation employs the path method and the Statistical Package for Social Sciences (SPSS) software program. The statistical software version 26 was employed to examine the gathered data and ascertain their completeness and accuracy. The data was subjected to descriptive analysis utilizing the software tool, SPSS. This investigation has the potential to enhance the efficacy and mitigate the expenses of logistics warehouses, while simultaneously facilitating the sustainable advancement of environmentally-friendly logistics.

4. Results

Demographic analysis

The present section presents the demographic data of the study participants, including variables such as gender, age, employment position, and salary. A total of 553 questionnaires were disseminated throughout the designated population and we subsequently obtained precise information from 408 fully completed surveys, denoting a comprehensive response rate of 73%. The data gathered exhibits representativeness with regard to the entire population. Based on the collected data, it was determined that a proportion of 51.7% of the participants were male, and 48.3% of the participants were female. The age bracket of 26-35 years represented the largest segment of participants in the study. Subsequent to the aforementioned, respondents within the group of ages 36 to 45 exhibited a similar trend. This research encompassed the sampling of a population drawn from varied occupational groups within logistics warehouses. This sample included individuals in the roles of logistics warehouse managers, supervisors, administrators, coordinators, and delivery clerks. The distribution of personnel in the logistics industry reveals that the logistics administrators hold the predominant position, while the logistics warehouse managers rank second, representing 35.5% and 24.8% of the workforce, respectively. The salary of individuals primarily lie within the range of 10,001-15,000 yuan, which constitutes 39% of the total population under consideration.

Measurement and structural model

Cronbach's alpha coefficient	Standardized Cronbach's alpha coefficient	Number of items	Number of samples
0.888	0.887	20	408

Table 2. Cronbach's α coefficient

The computation of the aforementioned Cronbach's Alpha coefficient is conducted as a means of evaluating the scale's reliability, wherein a technique is adopted for ascertaining and statistically computing Cronbach's Alpha. This metric yields an approximation of the proportion of variance in test scores that can be ascribed to the variability of authentic scores. The Cronbach's coefficient alpha for the 20 items under study is 0.888, signifying a high degree of internal consistency in 88.8% of the items. As delineated by Sattler, an index score of 0.60 is the minimum threshold and is deemed unsound, while a score of 0.70 is deemed comparatively trustworthy. On the other hand, scores of 0.80 and 0.90 are deemed satisfactory. It is commonly accepted in social science research scenarios that a reliability coefficient of 0.70 or above is deemed "acceptable." Subsequently, the second stage involved in data analysis is to evaluate whether the sample size employed in the study is suitable for the number of variables contemplated. In this respect, the KMO and Bartlett's Test were employed. To ensure the success of factor analysis, it is imperative that the sample adequacy of KMO measures exceeds a threshold of 0.5. Bartlett's test represents an additional metric used to assess the magnitude of the association among variables.

KMO value		0.873
Bartlett test for sphericity	Approximate Chi-square	4422.23
	df	190
	p	0.000***
Note: ***, **, * represent the significance levels of 1%, 5%, and 10% respectively		

Table 3. KMO test and Bartlett's test

Upon conducting an analysis of the KMO and Bartlett test, the obtained value of 0.873 is deemed as "acceptable" in the context of various social science research endeavors.

Table 4 elucidates the utilization of Pearson correlation analysis as a subsequent stage in the data analysis procedure, emphasizing the factors that exert influence.

In empirical research, investigations concerning two continuous variables commonly involve an analysis of the linear relationship between these variables utilizing the Pearson correlation coefficient, denoted as R. According to Cleophas et al. (2018), the coefficient "R" serves as a metric for gauging the power of correlation and ranges between a negative value of -1 and a positive value of +1. The statistical analysis demonstrates that the variables "Efficiency of Logistics Warehouse," "Warehouse Layout and Design," "Inventory Management and Material Flow," "Loading, Unloading, and Sorting of Goods," and "Shipping and Distribution Process" possess a significant relationship with a statistical significance level of $P<0.05$, as presented in the aforementioned table. The present study examined the relationship between the "Efficiency of logistics warehouse" and various operational factors, including "Warehouse layout and design," "Inventory management and material flow," "Loading, unloading, and sorting of goods," "Shipping and distribution process," and " GSCM". The resulting findings reveal statistically significant positive correlations between the aforementioned factors and the "Efficiency of logistics warehouse".

	Efficiency of logistics warehouse	Warehouse layout and design	Inventory management and material flow	Loading, unloading, and sorting of goods	Shipping and distribution process
Warehouse layout and design	0.295(0.000***)	1(0.000***)			
Inventory management and material flow	0.259(0.000***)	0.62(0.000***)	1(0.000***)		
Loading, unloading, and sorting of goods	0.238(0.000***)	0.614(0.000***)	0.632(0.000***)	1(0.000***)	
Shipping and distribution process	0.267(0.000***)	0.662(0.000***)	0.648(0.000***)	0.635(0.000***)	1(0.000***)
	Cost of logistics warehouse	Energy consumption	Labor costs	Waste disposal and environmental remediation costs	Inventory holding costs
Energy consumption	0.261(0.000***)	1(0.000***)			
Labor costs	0.39(0.000***)	0.613(0.000***)	1(0.000***)		
Waste disposal and environmental remediation costs	0.329(0.000***)	0.606(0.000***)	0.661(0.000***)	1(0.000***)	
Inventory holding costs	0.322(0.000***)	0.668(0.000***)	0.63(0.000***)	0.704(0.000***)	1(0.000***)
	Green Supply Chain Management	Energy consumption	Labor costs	Waste disposal and environmental remediation costs	Inventory holding costs
Energy consumption	0.319(0.000***)	1(0.000***)			

Labor costs	0.37(0.000***)	0.591(0.000***)	1(0.000***)		
Waste disposal and environmental remediation costs	0.377(0.000***)	0.587(0.000***)	0.584(0.000***)	1(0.000***)	
Inventory holding costs	0.364(0.000***)	0.605(0.000***)	0.643(0.000***)	0.589(0.000***)	1(0.000***)
	Green Supply Chain Management	Inventory management and material flow	Warehouse layout and design	Loading, unloading, and sorting of goods	Shipping and distribution process.1
Inventory management and material flow	0.314(0.000***)	1(0.000***)			
Warehouse layout and design	0.288(0.000***)	0.591(0.000***)	1(0.000***)		
Loading, unloading, and sorting of goods	0.377(0.000***)	0.663(0.000***)	0.578(0.000***)	1(0.000***)	
Shipping and distribution process	0.341(0.000***)	0.595(0.000***)	0.646(0.000***)	0.657(0.000***)	1(0.000***)
	Efficiency of logistics warehouse	Cost of logistics warehouse	Green supply Chain Management		
Cost of logistics warehouse	0.718(0.000***)	1(0.000***)			
Green Supply Chain Management	0.749(0.000***)	0.7(0.000***)	1(0.000***)		

Table 4. Correlation coefficient.

The findings indicate notable associations among the variables of "Cost of logistics warehouse," "energy consumption," "labor cost," "Waste disposal and environmental remediation costs," "Inventory holding costs," and "GSCM," as evidenced by significance levels of $P<0.05$. A positive correlation has been identified between the variables of "Cost of logistics warehouse" and "energy consumption", "labor cost", "Waste disposal and environmental remediation costs", "Inventory holding costs", and "GSCM". A significant correlation exists between the "cost of logistics warehouse" and "GSCM" as well as the "cost of logistics warehouse". The study found that GSCM exhibited a linear and statistically significant positive correlation with various cost factors, such as "energy consumption", "labor costs", "waste disposal" and "environmental remediation costs", "inventory holding costs", warehouse layout and design", "inventory management and material flow", "loading, unloading, and sorting of goods", as well as "shipping and distribution processes". Thus, the null hypothesis can be rejected.

Tables 6, 7, and 8 employ path analysis for the purpose of investigating the outcomes pertaining to the interdependent association between the two variables. Based on the findings presented in Table 5, it is evident that a GFI value greater than 0.9 indicates a superior model fit. Furthermore, the Root Mean Square Error of Approximation (RMSEA) was found to be below the threshold value of 0.1, while the Root Mean Square Residual (RMR) was below 0.05. Additionally, both the Comparative Fit Index (CFI) and the Non-Normed Fit Index (NNFI) yielded values greater than 0.9, indicating a high degree of model fit. The aforementioned indicators collectively demonstrate that the model possesses a commendable degree of fitness. The statistical model demonstrated a statistically significant result at a significance level of $P<0.05$.

X^2	df	**P**	**chi-square degrees of freedom ratio**	**GFI**	**RMSEA**	**RMR**	**CFI**	**NFI**	**NNFI**
-	-	>0.05	<3	>0.9	<0.10	<0.05	>0.9	>0.9	>0.9
1777.075	77.000	0.000***	23.079	0.450	0.233	0.244	0.456	0.450	0.258
Note: *, **, * represent the significance levels of 1%, 5%, and 10% respectively**									

Table 5.Model Fitting Index

Descriptions for key indicators	
GFI (Goodness of Fit Index)	It mainly uses the coefficient of determination and regression standard deviation to test the degree of fitting of the model to the sample observations. Its value is between 0 and 1, and the closer to 0, the worse the fit. If CFI≥0.9, the model fit is considered to be good.
RMSEA (Root Mean Square Approximation Error)	In general, RMSEA is below 0.08 (the smaller the better).
RMR (Root Mean	This indicator measures the fit of the model by measuring the average

Square Residual)	residual error related to the prediction and the actual observation. If RMR<0.1, the model fit is considered good.
CFI (Comparative Fit Index)	When comparing the hypothetical model with the independent model, the value of this index is between 0 and 1. The closer to 0, the worse the fit, and the closer to 1, the better the fit. In general, if CFI≥0.9, it is considered that the model fits well.
NNFI (Non-normative Fitting Coefficient)	the larger the value, the better, and the fitted model performs better.
CFI (Comparative Fitting Index)	
Source: Huamin, G.(1988) Brief Introduction to Path Analysis and Its Application [J]. Practice and Understanding of Mathematics, 37-45.	

Table 6. Descriptions for key indicators

The results presented in Tables 7 and 8 indicate that the variables of "Warehouse layout and design", "Inventory management and material flow", "Loading, unloading, and sorting of goods", "Shipping and distribution process", "Energy consumption", "Labor costs", "Inventory holding costs", and "Waste disposal and environmental remediation costs", along with the pairwise associations between these variables and " GSCM", exhibited statistically significant effects. The phenomenon of "energy consumption" raises concern due to its deleterious effects on the "Cost of logistics warehouse". The field of " GSCM" has a significant influence on two key factors related to logistics warehouse performance: namely, the efficacy and cost of such facilities. Notably, the statistical analysis yields correlation coefficients of 0.710 and 0.595 for these respective determinants. Whilst it may be observed that a correlation exists amongst the extant variables, specifically X ostensibly impacting Y, it is noteworthy that the degree of correlation between said variables is comparatively deficient.

X	→	Y	unstandardized coefficient	standardized coefficient	SE	CR	P
Warehouse layout and design	→	Efficiency of logistics warehouse	0.055	0.189	0.035	0.318	0.000***
Inventory management and material flow			0.075	0.141	0.042	0.431	0.033**
Loading, unloading, and sorting of goods			0.079	0.079	0.035	2.277	0.023**
Shipping and distribution			0.069	0.14	0.042	1.017	0.040**

process							
Energy consumption	→	Cost of logistics warehouse	-0.069	-0.069	0.035	-1.990	0.047**
Labor costs			0.204	0.199	0.037	5.555	0.000***
Inventory holding costs			0.107	0.098	0.046	2.322	0.020**
Waste disposal and environmental remediation costs			0.060	0.056	0.049	0.286	0.000***
GSCM	→	Cost of logistics warehouse	0.610	0.595	0.040	15.310	0.000***
		Inventory management and material flow	0.254	0.314	0.038	6.686	0.000***
		Shipping and distribution process	0.303	0.341	0.041	7.320	0.000***
		Labor costs	0.370	0.370	0.046	8.032	0.000***
		Inventory holding costs	0.400	0.407	0.045	8.990	0.000***
		Waste disposal and environmental remediation costs	0.343	0.337	0.047	7.241	0.000***
		Warehouse layout and design	0.314	0.322	0.046	6.874	0.000***
		Loading, unloading, and sorting of goods	0.343	0.350	0.045	7.541	0.000***
		Energy consumption	0.306	0.296	0.049	6.256	0.000***
		Efficiency of logistics warehouse	0.701	0.710	0.039	18.051	0.000***

Note: a. *, **, * represent the significance levels of 1%, 5%, and 10% respectively**
b.SE: standard error

c.CR: combined reliability. In pathway, it is generally checking that X affects Y in a positive or negative way.

Table 7. Path node covariance relationship

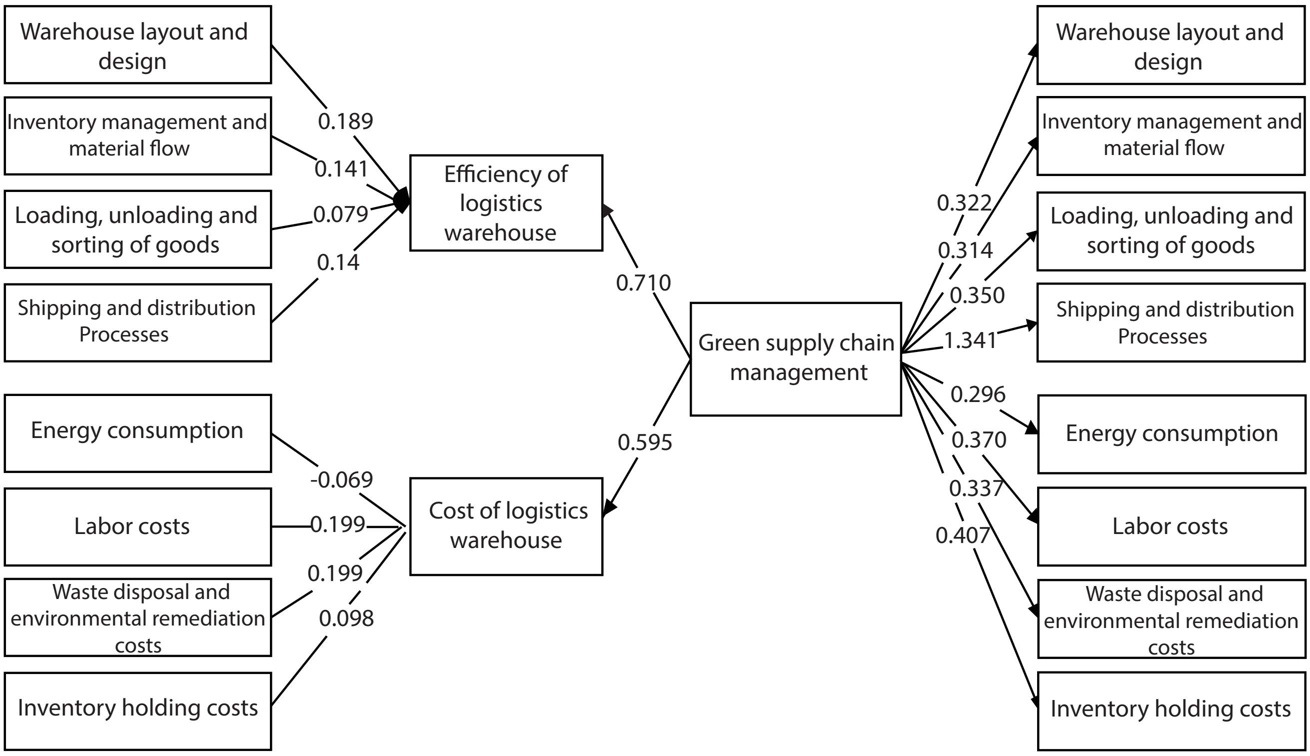

Table 8. Model path

4. Discussion

The study elucidates the interrelationships and impacts between different operational and cost factors, as well as the realm of GSCM, on the efficacy and financial implications of logistics warehouse facilities. The findings demonstrate noteworthy associations and impacts that hold statistical significance, thereby imparting valuable analytical perspectives for scholars and professionals involved in the domain of logistics management.

The present study employed Pearson correlation coefficients to examine the association between the efficiency of logistics warehouses and various factors includingwarehouse layout and design, inventory management and material flow, loading, unloading, and sorting of goods, shipping and distribution process, and GSCM.

The results indicate that there exist positive and significant relationships between the operational factors and the efficiency of logistics warehouses. Therefore, our findings suggest that enhancing these factors could lead to an overall improvement in the efficiency of logistics warehouses.

This study has exhibited noteworthy connections amongst factors of cost, specifically, "Cost of logistics warehouse," "energy consumption," "labor cost," "Waste disposal and environmental remediation costs," "Inventory holding costs," and " GSCM". The positive correlations observed between the "Cost of logistics warehouse" and aforementioned factors suggest that amplified energy consumption, labor costs, waste disposal, and inventory holding costs are drivers of higher logistics warehouse expenses overall. It is imperative for organizations to contemplate these factors and investigate potential approaches to enhance cost management within their logistics operations.

Path analysis facilitated a comprehensive comprehension of the interdependent connections among variables. The present study utilized goodness-of-fit indicators, specifically GFI, RMSEA, RMR, CFI, and NNFI, to assess the degree of fitness of the statistical model. The results of these measures pointed towards a commendable level of fit between the model and the data. This implies that the proposed model effectively incorporates the interrelationships between the variables that are being examined. The findings of the study underscore the noteworthy impact of GSCM on the effectiveness and economic feasibility of logistics warehouse infrastructures. The results of the study suggest that the incorporation of environmentally and socially responsible practices within supply chain management is vital, as evidenced by the moderate correlations observed between GSCM and critical factors such as energy consumption, labor costs, waste disposal, inventory holding costs, and operational elements. It is recommended that institutions prioritize the incorporation of environmentally-friendly initiatives and sustainable practices in order to enhance the effectiveness of logistics warehouse operations and minimize expenses.

It is noteworthy to recognize that although statistical significance was detected in the correlations and effects, certain variables demonstrated a comparatively inadequate level of correlation. This evidence suggests the possibility that there exist additional factors or variables that were not accounted for in the current investigation, which could potentially influence the efficacy and expenditures of logistics warehouses. In order to enhance the analytical models used to assess logistics warehouse performance, it is imperative for future research to evaluate further factors that could potentially impact this outcome and subsequently integrate them into the existing framework.

This investigation imparts valuable insights concerning the interconnections that exist between operational factors, cost factors, and GSCM within the domain of logistics warehouse administration. The results of this study provide a valuable contribution to the current knowledge base within the discipline, while also yielding opportunities for practical implementation towards the optimization of warehouse efficiency and cost management. Organizations can enhance their logistics performance and contribute to the sustainability of supply chains by prioritizing the optimization of operational factors, cost mitigation, and integration of environmentally friendly practices.

5. Conclusion

This current research endeavored to utilize quantitative research techniques to discern and evaluate quantifiable priorities and goals within the context of enhancing logistics warehouse efficiency while minimizing costs. An investigation employing a questionnaire-based survey was undertaken to gather primary data from employees situated in logistics warehouses of China. In this study, a standardized measurement scale consisting of 20 items was employed, utilizing a five-point Likert scale. The assessment of data reliability and validity, as well as the statistical analysis, were accomplished through utilization of the path method and the software known as SPSS. The present research divulged crucial linkages between efficiency in logistics warehouse operations and green supply chain management, alongside the correlation between the cost incurred in logistics warehousing and green supply chain management. The aforementioned findings possess considerable ramifications for both research and application within the domain of logistics management. Nonetheless, this investigation is not without its constraints. Initially, the implementation of a questionnaire survey could potentially yield subjectivity and recall bias. Furthermore, the utilization of non-probability sampling technique could impede the degree of representativeness within the sample population. Furthermore, this research centered exclusively on logistics warehouses situated in China, thereby constraining the potential applicability of its conclusions to dissimilar geographical domains and sectors. Subsequent research endeavors ought to assess the aforementioned constraints and delve deeper into additional variables that impact the effectiveness and monetary aspects of logistics warehouses. Moreover, a deeper analysis is imperative pertaining to the efficacious execution of green supply chain management and sustainable development tactics in real-world scenarios, with the objective of enhancing the operational output and ecological stability of logistics depots. In summation, this research offers noteworthy insights that are beneficial for the logistics management discipline, and it delineates avenues for forthcoming investigations and potential research advancements. By means of ongoing research and practical implementation, the promotion of sustainable development pertaining to logistics warehouses can be facilitated, ultimately bolstering the creation of ecologically-responsible supply chains.

Data availability statement

The author of this article has expressed his willingness to disclose the underlying data that corroborate their findings, devoid of any unnecessary restrictions.

Conflict of interest

The researcher affirm that the study was executed without any existing commercial or financial affiliations that could potentially result in a conflict of interest.

References

[1] Gahlot, N. K., Bagri, G. P., Gulati, B., Bhatia, L., & Das, S. (2023). Analysis of barriers to implement green supply chain management practices in Indian automotive industries with the help of ISM model. Materials Today: Proceedings.
[2] Zhang, L., Dou, Y., & Wang, H. (2023). Green supply chain management, risk-taking, and corporate value—Dual regulation effect based on technological innovation capability and supply chain concentration. Frontiers in Environmental Science, 11. https://doi.org/10.3389/fenvs.2023.1096349
[3] Liu, Y., Ji, S., Su, Z., & Guo, D. (2019). Multi-objective AGV scheduling in an automatic sorting system of an unmanned (intelligent) warehouse by using two adaptive genetic algorithms and a multi-adaptive genetic algorithm. PloS one, 14(12), e0226161.
[4] Chakraborty, A., Al Amin, Md., & Baldacci, R. (2023). Analysis of Internal Factors of Green Supply Chain Management: An Interpretive Structural Modeling Approach. Cleaner Logistics and Supply Chain, 100099. https://doi.org/10.1016/j.clscn.2023.100099
[5] Bolaños-Zúñiga, L., & Vidal-Holguin, C. J. (2020). The impact of inventory holding costs on the strategic design of supply chains. Revista Facultad de Ingeniería Universidad de Antioquia. https://doi.org/10.17533/udea.redin.20200692
[6] Haiyun, C., Zhixiong, H., Yüksel, S., & Dinçer, H. (2021). Analysis of the innovation strategies for green supply chain management in the energy industry using the QFD-based hybrid interval valued intuitionistic fuzzy decision approach. Renewable and

Sustainable Energy Reviews, 143, 110844. https://doi.org/10.1016/j.rser.2021.110844

[7] Chee Wooi, G., & Zailani, S. (2010). Green Supply Chain Initiatives: Investigation on the Barriers in the Context of SMEs in Malaysia. International Business Management, 4(1), 20–27. https://doi.org/10.3923/ibm.2010.20.27

[8] Hubbard, K. A. B., Adams, J. H., & Whitten, D. D. (2011). Purchasing And Supply Chain Management Practices in Greek Small and Medium Sized Business Enterprises (SMES). International Business & Economics Research Journal (IBER), 7(6). https://doi.org/10.19030/iber.v7i6.3263

[9] Maleka, T., Nyirenda, G., & Fakoya, M. (2017). The Relationship between Waste Management Expenditure and Waste Reduction Targets on Selected JSE Companies. Sustainability, 9(9), 1528. https://doi.org/10.3390/su9091528

[10] Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). DEFINING SUPPLY CHAIN MANAGEMENT. Journal of Business Logistics, 22(2), 1–25. https://doi.org/10.1002/j.2158-1592.2001.tb00001.x

[11] Sezen, B., & Çankaya, S. Y. (2018). Green supply chain management theory and practices. In Operations and Service Management: Concepts, Methodologies, Tools, and Applications (pp. 118-141). Igi Global.

[12] WANG, Y., Sui, X., Liu, D., & Li, F. (2022). Does logistics efficiency matter? Evidence from green economic efficiency side. Research in International Business and Finance, 61, 101650. https://doi.org/10.1016/j.ribaf.2022.101650

[13] Kolinski, A., & Sliwczynski, B. (2015). Evaluation problem and assessment method of warehouse process efficiency. Business Logistics in Modern Management.

[14] Jin, X., Zhong, M., Quan, X., Li, S., & Zhang, H. (2016, July). Dynamic scheduling of mobile-robotic warehouse logistics system. In 2016 35th Chinese Control Conference (CCC) (pp. 2860-2865). IEEE.

[15] Abdul Rahman, N. S. F., Karim, N. H., Md Hanafiah, R., Abdul Hamid, S., & Mohammed, A. (2023). Decision analysis of warehouse productivity performance indicators to enhance logistics operational efficiency. International Journal of Productivity and Performance Management, 72(4), 962-985.

[16] Kłodawski, M., Lewczuk, K., Jacyna-Gołda, I., & Żak, J. (2017). Decision making strategies for warehouse operations. Archives of Transport, 41.

[17] Bingqing, F., & Liting, C. (2020, November). Study on warehouse site selection based on AHP. In 2020 5th International Conference on Information Science, Computer Technology and Transportation (ISCTT) (pp. 276-280). IEEE.

[18] Kučera, T. (2019). Calculation of Logistics Costs of Implementation Innovative Automatic Identification System in the Warehouse. In International Days of Statistics and Economics: conference proceedings. Melandrium.

[19] Shu, B., Pei, F., Zheng, K., & Yu, M. (2021). LIRP optimization of cold chain logistics in satellite warehouse mode of supermarket chains. Journal of Intelligent & Fuzzy Systems, 41(4), 4825-4839.

[20] Duan, L. M. (2018). Path Planning for Batch Picking of Warehousing and Logistics Robots Based on Modified A* Algorithm. International Journal of Online Engineering, 14(11).

[21] Bassan, Y., Roll, Y., & Rosenblatt, M. J. (1980). Internal layout design of a warehouse. AIIE Transactions, 12(4), 317-322.

[22] Hsieh, L. F., & Tsai, L. (2006). The optimum design of a warehouse system on order picking efficiency. The International Journal of Advanced Manufacturing Technology, 28, 626-637.

[23] Jermsittiparsert, K., Sutduean, J., & Sriyakul, T. (2019). Role of warehouse attributes in supply chain warehouse efficiency in Indonesia. International Journal of Innovation, Creativity and Change, 5(2), 786-802.

[24] Moons, K., Waeyenbergh, G., & Pintelon, L. (2019). Measuring the logistics performance of internal hospital supply chains–a literature study. Omega, 82, 205-217.

[25] Wiedenhofer, D., Fishman, T., Lauk, C., Haas, W., & Krausmann, F. (2019). Integrating material stock dynamics into economy-wide material flow accounting: concepts, modelling, and global application for 1900–2050. Ecological economics, 156, 121-133.

[26] Graedel, T. E. (2019). Material flow analysis from origin to evolution. Environmental science & technology, 53(21), 12188-12196.

[27] Muchaendepi, W., Mbohwa, C., Hamandishe, T., & Kanyepe, J. (2019). Inventory management and performance of SMEs in the manufacturing sector of Harare. Procedia Manufacturing, 33, 454-461.

[28] Ding, Y., Jin, M., Li, S., & Feng, D. (2021). Smart logistics based on the internet of things technology: an overview. International Journal of Logistics Research and Applications, 24(4), 323-345.

[29] Kučera, T. (2017). Logistics cost calculation of implementation warehouse management system: a case study. In MATEC Web of Conferences. Vol. 134 (2017): 18th International Scientific Conference-LOGI 2017. EDP Sciences.

[30] Milewski, D., & Milewska, B. (2023). Efficiency of the Consumption of Energy in the Road Transport of Goods in the Context of the Energy Crisis. Energies, 16(3), 1257–1257. https://doi.org/10.3390/en16031257

[31] Yugang H. (2020). How do Energy Consumption, Economic Growth and Logistics Development Interrelate? Journal of Distribution Science, 18(1), 71–83. https://doi.org/10.15722/jds.18.1.202001.71

[32] Wang, X., & Dong, F. (2023). The dynamic relationships among growth in the logistics industry, energy consumption, and carbon emission: Recent evidence from China. Journal of Petroleum Exploration and Production Technology, 13(1), 487-502.

[33] Russell, D., Coyle, J., Ruamsook, K., & Thomchick, E. (2014). The real impact of high transportation costs. Www.supplychainquarterly.com. https://www.supplychainquarterly.com/articles/838-the-real-impact-of-high-transportation-costs

[34] OptimoRoute. (2022, March 28). Logistics Costs: How to Measure & Reduce Them. OptimoRoute. https://optimoroute.com/logistics-cost/

[35] Wantanakomol, S. (2021). The effect of guidelines on reducing logistics costs. Uncertain Supply Chain Management, 9(3), 667-674.

[36] Sebatjane, M., & Adetunji, O. (2021). Optimal lot-sizing and shipment decisions in a three-echelon supply chain for growing items with inventory level-and expiration date-dependent demand. Applied Mathematical Modelling, 90, 1204-1225.

[37] Dima, I., Patyk, M., Florin, R., Novak-Marcincin, J., & A., T. (2010). Logistcs costs estimation in case of industrial waste management.

[38] Zwolińska, B., & Michlowicz, E. (2011). Logistics costs in the waste disposal system on the example of a steel mill. Total Logistic Management, 167-176.

[39] Rihn, G. (2022, August 29). In My Opinion: Coping with ever-increasing logistics costs. Resource Recycling News. https://resource-recycling.com/recycling/2022/08/29/in-my-opinion-coping-with-ever-increasing-logistics-costs/

[40] Ene, S., Küçükoğlu, İ., Aksoy, A., & Öztürk, N. (2016). A genetic algorithm for minimizing energy consumption in warehouses. Energy, 114, 973-980.

[41] RAHAL, F., & ZENNIR, I. (2021). The Impact of Green Supply Chain Management on Operational Efficiency. Case study: Unilever.

[42] Iqbal, M. W., Kang, Y., & Jeon, H. W. (2020). Zero waste strategy for green supply chain management with minimization of energy consumption. Journal of Cleaner Production, 245, 118827.

[43] Aliyev, M., Kansime, K. D., & Hasan, S. M.(2022) TSINGHUA UNIVERSITY

IEDE PROGRAM GROUP PROJECT INNOVATING GLOBAL GREEN SUPPLY CHAIN MANAGEMENT.
[44] Stekelorum, R., Laguir, I., Gupta, S., & Kumar, S. (2021). Green supply chain management practices and third-party logistics providers' performances: A fuzzy-set approach. International Journal of Production Economics, 235, 108093.
[45] Laguir, I., Stekelorum, R., & El Baz, J. (2021). Going green? Investigating the relationships between proactive environmental strategy, GSCM practices and performances of third-party logistics providers (TPLs). Production Planning & Control, 32(13), 1049-1062.
[46] Sahar, D. P., Afifudin, M. T., & Indah, A. B. R. (2020, October). Review of green supply chain management in manufacturing: A case study. In IOP Conference Series: Earth and Environmental Science (Vol. 575, No. 1, p. 012239). IOP Publishing.
[47] Cleophas, T. J., Zwinderman, A. H., Cleophas, T. J., & Zwinderman, A. H. (2018). Bayesian Pearson correlation analysis. Modern Bayesian statistics in clinical research, 111-118.
[48] Huamin, G. (1988) Brief Introduction to Path Analysis and Its Application [J]. Practice and Understanding of Mathematics, 37-45.

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