Original Research Article

INTERNATIONAL JOURNAL OF ENGINEERING BUSINESS MANAGEMENT

International Journal of Engineering Business Management
Volume 16: 1–21

DOI: 10.1177/18479790241266352
journals.sagepub.com/home/enb
Sage

Integrating human factors into the distribution model of goods and fast-moving consumer goods for effective inventory control

Afolabi Ogbeyemi[1,2], Akinola Ogbeyemi[2] and Wenjun Zhang[1,3]

Abstract

Multiple factors contribute to the occurrences of disruptions in workflow management within the e-commerce system that focuses on the distribution of goods and other fast-moving consumer goods (FMCG). These disruptions have particularly affected and increased lead times and caused frequent shipment delays. The causes of these disruptions, especially in the context of distribution of goods and FMCG towards inventory control, have been widely speculated upon in recent years. Given the recent interruptions, the study presented in this paper used a methodology called statistical model analysis (SMA) to study the impact of human factors (HFs) on the system performance in a warehouse distribution system. A case study was taken on a particular company called ABC and XYZ to model the impact of some specific HF such as job fatigue, and job rotation to name a few and to uncover the underlying reasons behind the ongoing disruptions within the distribution system. Specifically, the result of this study aims to provide a data-driven understanding of these issues and one of the contributions of this study is to enhance our understanding of the significance of these HFs, rather than focusing on the equipment and materials as seen in prior research. Through this data-based approach study, stakeholders in operations management, e-commerce, and the supply chain system would be well-informed in many ways to resolve the challenges faced by humans in the system towards enhancing their overall system performance.

Keywords

E-commerce, out-bounding and inbounding, order fulfilment, human factors, B2C, B2B, C2C, C2B

Date received: 23 February 2024; accepted: 15 June 2024

Introduction

The studies of Human Factors (HF) in the field of electronic commerce, commonly known as E-commerce has been poorly considered when making decisions in a distribution environment such as E-commerce. E-commerce refers to the online buying and selling of goods and services, as well as the transfer of funds or data, primarily conducted over the Internet.[1] However, to execute an E-commerce transaction, humans are needed to perform data entry, as well as distribution planning and scheduling which are the two most important operational tasks required in a warehouse system. Therefore, humans are one of the crucial factors to take into consideration in a service system that incorporates distribution and inventory planning, especially when it comes to

[1]School of Mechanical Engineering, Donghua University, Shanghai, China
[2]Division of Biomedical Engineering, University of Saskatchewan, Saskatoon, SK, Canada
[3]Department of Mechanical Engineering, University of Saskatchewan, Saskatoon, SK, Canada

Corresponding author:
Wenjun Zhang, School of Mechanical Engineering, Donghua University, Shanghai, China.
Email: chris.zhang@usask.ca

a holistic supply chain business network.[2,3] A supply chain (SC) system involves overseeing the movement of goods among businesses, procurement, distribution centers (DCs), and logistics.[4,5] In this paper, SC system can be seen as a system that encompasses the various stages, which include the acquisition of different stock-keeping units (SKUs), receiving products, storing inventory, order processing (picking and packing), distribution to last-mile locations (i.e., delivering the products to end-users) which can be seen as one type of E-commerce model, in this case business-to-business (B2B) model as illustrated in Figure 1.[6–9] A B2B model is considered in this work as an important model to explain the E-commerce processes in a specific distribution system. The main purpose of the B2B E-commerce model is to make decisions on how to transact between businesses, typically conducted online, and the B2B model plays a significant role in modern E-commerce, supply chain management and operations.

E-commerce represents a digitalized business model that facilitates transactions between organizations and individuals by utilizing the internet. Also, it encompasses a wide range of activities, including product distribution, sales, purchases, marketing, and customer service, all of which are conducted through electronic interfaces.[13] However, the scope of E-commerce extends far beyond just the acquisition of goods from manufacturers and suppliers, but rather, it involves aspects such as logistics, manufacturing, warehousing, collaboration with retail partners, and most importantly, serving end customers[10,11] which all involves human participation, and to improve products delivery time and increase the quality of products ordered online within the domain of supply chain system.[2,3,12–14] It is very important to incorporate HF early in decision-making and apply them to equipment and job tasks to improve the system performance.

In this paper, the concept of HF would be focused on. HF is defined by the International Ergonomics Association (IEA) Council in 2014,[15] as "the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods of design to optimize human well-being and overall system performance". Therefore, considering HF is crucial in systems designs.[16,17] Also, HF consideration in a service system (for example, supply chain system) could help reduce human errors during operations such as picking, packing, shipping, and enhancing the performance of warehouse operations.

In addition, the use of technologies in E-commerce also played a crucial role in the operations of businesses, especially as consumer preferences shift from traditional brick-and-mortar shopping to online platforms.[1] The use of various technological tools has allowed distribution system to offer high-quality and punctual services to their customers.[18] However, despite the integration of sophisticated

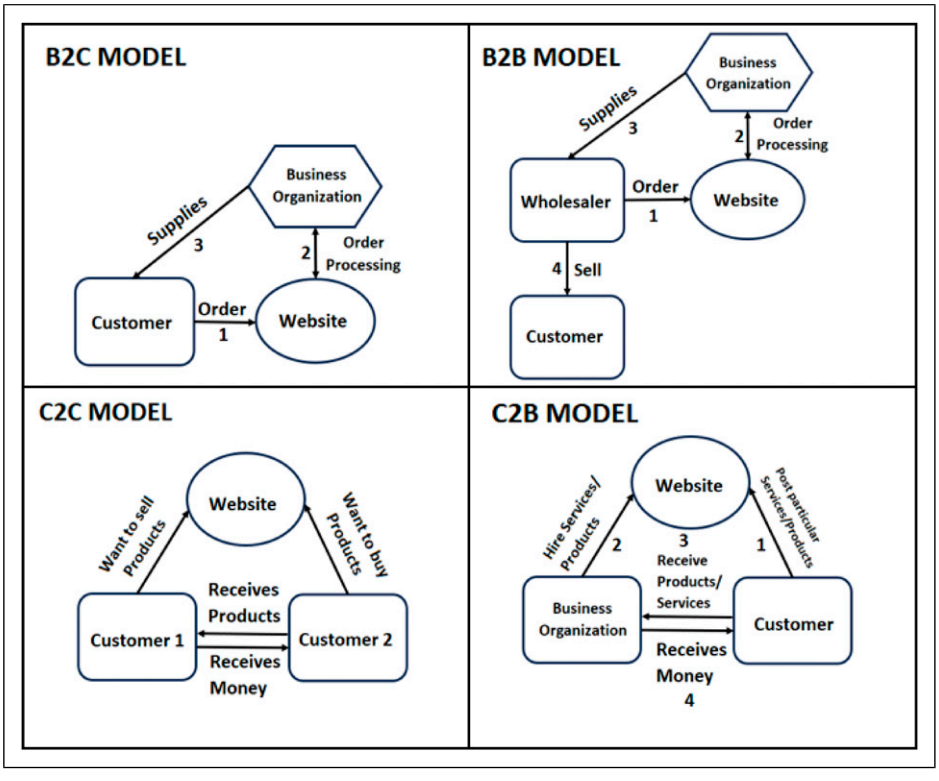

Figure 1. Types of E-commerce models used in E-commerce system.

tools to ensure customer satisfaction, most of the existing studies show that there is still a critical challenge for all other business models, such as traditional brick-and-mortar stores and online shopping platforms as related to HF.[19,20] In addition, most of these service systems[17] aim to provide the highest level of satisfaction to their customers which is influenced by various factors such as service quality from workers, but HF such as workers satisfaction has been neglected in decision making. For example, in a typical service system, worker satisfaction is usually a wide aspect of HF to be considered. It is noted that satisfied employees are more engaged, productive, and less likely to leave their jobs.[21] In fact, some factors contribute to worker satisfaction which includes fair compensation, a safe working environment to mention a few. Although service quality as mentioned earlier is seen as a measure used to assess the excellence of service and determine if users are content with the service they receive.[5] However, customer satisfaction is influenced also by a range of factors, including customer value, customer experience, user experience, brand image, pricing, productivity, trust, and HF such as workers' skills, job rotation, and job fatigue amongst workers.[22–24] Since the skill level of workers is assumed as a fundamental factor affecting job performance in a system, it is assumed that skilled workers are more efficient, and can handle complex tasks with greater ease.[25] For instance, a worker trained in the use of advanced warehouse management system (WMS) can quickly locate items, manage inventory more accurately, and streamline the picking and packing process. However, this assumption does not hold true in many cases.[5] Furthermore, job rotation overtime has been seen as a strategy adopted to mitigate any physical and mental strain in a repetitive task by periodically moving workers between different roles.[26] According to Ogbeyemi et al,[5] job rotation can lead to higher job satisfaction and lower turnover rates in warehouse settings. Also, job rotation has not only helped in reducing monotony but also allows workers in both service system and manufacturing system to develop a broader skill set. For example, a warehouse worker might alternate between tasks such as operating a forklift, managing inventory, and packing orders. So, it is assumed that factors such as job rotation can prevent job fatigue, and reduce the risk of repetitive strain injuries, which at the end would enhance job satisfaction and increasing the skills level. Also, management of some service system have been making use of different techniques,[27] and tools such as robots,[28] to handle heavy lifting and transportation of goods within the system, while the workers focus on tasks that require packing, goods delivery, and decision-making, yet HF have not been fully considered in most service system.

The primary objective of this study is to analyze and explore the impact of certain HFs on the performance of a distribution system that specializes in fast-moving consumer goods (FMCG) in a warehouse, and inventory management provided that HFs have not been considered fully in the real world of inventory system, especially in distribution process in a warehouse.[29] To achieve this aim, specific inquiries were formulated, including investigations into the relationships between the independent variables (such as workers' skills and satisfaction, job fatigue, and job rotation) and the dependent variable (i.e., job performance) in the system. Also, a mixed research approach was employed to gather and analyze data that involves conducting a significance test utilizing a two-way ANOVA. Additionally, the research seeks to ascertain whether each independent variable specifically influences the dependent variable (i.e., job performance) of the warehouse workers and to examine if the independent variables contribute to the ongoing disruption in the distribution system.

The rest of this paper is organized as follows: First, we presents some background knowledge as well as a literature review. Second, a case study is presented to give more details on the problem description. Third, the methodology is presented to demonstrate how the statistical model works. Fourth, we presents the results and discussion, and Finally, the conclusion and suggestions for future research were presented.

Background and literature review

In the domain of E-commerce, there are several challenges encountered during the operations. Hence, it is very important to understand how these challenges could impact both customer behavior (customer goals) and organizational profitability (business goals), while exploring potential solutions. According to Tsagkias et al,[1] some specific challenges include the influence of regulatory and business constraints on E-commerce operations. These constraints often dictate which products can be presented to customers. For example, certain items like hunting knives may not be legally sold online in the UK, and some regions in the US restrict the online sale of alcohol and certain drugs to adults only.

To better understand challenges in E-commerce operations online, most websites implement business rules during the checkout process to control product purchases, displaying products that customers ultimately cannot buy which can lead to a dissatisfying experience. Dayarian and Pazour,[30] discusses several challenges in her research. These challenges include: (a) Cybersecurity: E-commerce businesses cannot afford downtime due to cyberattacks, as each transaction contributes significantly to their financial success. (b) Competition: The E-commerce landscape has become highly competitive, making it challenging for businesses to differentiate themselves from rivals and attract new customers. (c) Order Fulfillment: Timely and accurate order fulfillment is crucial, as delays and incorrect product shipments can result in customer dissatisfaction. (d)

Inventory Visibility: When inventory is not visible, either physically or on the website, customers may turn to other E-commerce platforms, resulting in reduced sales.

Also,[31] focuses on specific challenges related to facilitation and logistics in E-commerce: (a) Undeveloped Legal Infrastructure: Legal regulations enabling E-commerce transactions are essential, and the absence of such infrastructure can hinder E-commerce activities. (b) National Quality Infrastructure: E-commerce consumers demand product traceability and adherence to international standards, which instills confidence, and the absence of these standards may drive customers to competitors. (c) Poor Integration of Postal Services with Border Agencies: Effective coordination between postal services and border agencies is necessary for smooth cross-border E-commerce transactions. (d) Improving In-flight Connectivity: Air freight plays a pivotal role in cross-border shipments, necessitating enhancements in in-flight connectivity. (e) Limited Logistics and Postal Distribution in Remote Areas: Underdeveloped logistics infrastructure in isolated regions of developing countries hinders their ability to benefit from E-commerce.

Nguyen et al.[32] delved into customer satisfaction with last-mile delivery in the E-commerce sector. Their study highlighted factors such as tangibility, reliability, safety, empathy, responsiveness, and perceived value towards the performance of the system. These factors encompass elements that customers directly experience, the reputation and accuracy of service delivery, the ability to respond promptly to customer needs, ensuring safety and peace of mind, and the level of care and attention provided by staff. Also, Bingi et al.[33] emphasized on four major challenges facing the E-commerce industry such as economic, technological, social, and legal. These challenges apply broadly to both B2B and business-to-B2C scenarios. A good way to understand the impact of these factors on E-commerce performance is illustrated in Figure 2.

According to Rahman and Han,[34] an investigation was conducted to validate the elements influencing customer satisfaction within the E-commerce sector. The analyzed factors encompassed network responsiveness, website credibility, payment security, feedback mechanisms, community engagement, and return policies. Additionally, factors like safeguarding personal information, product descriptions, shopping convenience, product quality, pricing, time efficiency, and operational procedures were considered, as shown in Table 1. Table 1 presents the outcomes of a survey conducted for an online retailer, illustrating that the proportion of contented customers significantly exceeds those who expressed dissatisfaction while Figure 3 shows the graphical representation.

In practice, again according to Ogbeyemi et al.[5] the E-commerce industry faces various challenges, notably the labor-intensive inventory tracking methods which must depend on multiple software and spreadsheets. This method is not only time-consuming but also prone to errors, leading to delayed deliveries and a decrease in warehouse efficiency. Additionally, the complexity of inventory management, involving multiple steps like receiving, picking, packing, and shipping, can also result in incomplete, inaccurate, or delayed shipments, as well as inventory losses due to factors like wastage, damage, or theft.[5]

Despite the above reviews, the studies of HF are literally missing from them, therefore, in this paper, we further studied and focused on human-related concepts such as the physical human-machines relationship found in most manufacturing systems[35] for our E-commerce system. HF in the E-commerce industry has witnessed exponential growth, revolutionizing the way business is conducted globally. As technology continues to shape this industry, the role of HF becomes increasingly crucial. Also, several studies have explored the relationship between HF and job performance within the E-commerce settings. Lu and Lin[36] highlighted the impact of stress on performance effectiveness, a concept that resonates with the E-commerce sector, where workers often encounter high-pressure situations. Additionally, worker satisfaction has been recognized as a key determinant of job performance.[37] Employee contentment and motivation have also been shown to positively correlate with enhanced performance, and employees who derive satisfaction from their work may exhibit greater commitment and productivity.[38]

In the E-commerce industry, workers may face demanding schedules and workloads, which as a result increases job fatigue and influences job performance. Job fatigue is often linked to factors such as long hours and repetitive tasks, which can negatively affect job performance.[39] In addition, job rotation has also been proposed as a strategy to enhance job performance.[40] According to Ravenhill and Liu[40] job rotation can provide workers with a broader skill set and reduce monotony. However, the extent to which job rotation positively affects job performance in E-commerce, characterized by specialized tasks and roles, remains a subject of inquiry. Meanwhile, the importance of job skills on job performance is evident in various industries.[17] Skilled workers are often more adaptable and effective in handling complex tasks.[41] Therefore, the concept of HF generally is speculated to be used to broaden skill sets and reduce monotony in a B2B E-commerce system. So, to show the importance of this HF-related concept, a study on the impacts of HF among workers in a distribution warehousing system is required, which would either validate the speculation or not.

Considering the relationship between worker skills and job performance in E-commerce, both are closely related concepts in the workplace. Workers' skills refer to the specific abilities and knowledge that are necessary to perform a particular job or task effectively. These skills may

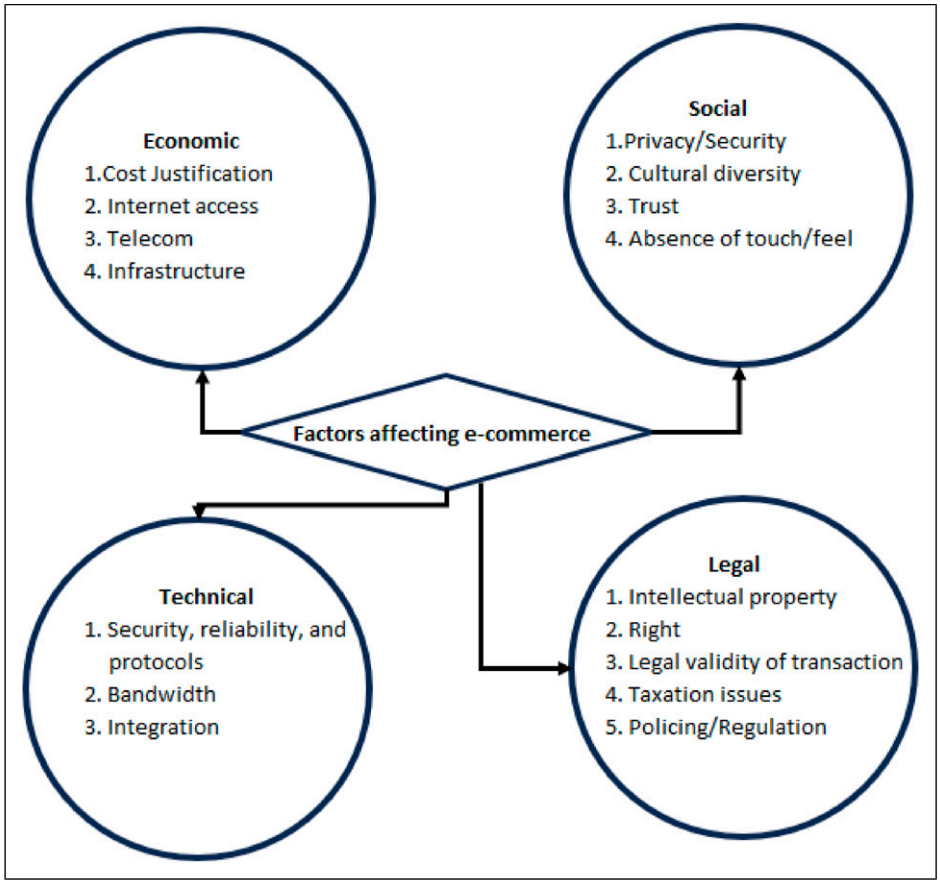

Figure 2. Four major factors affecting E-commerce (adapted from Bingi et al.,[33]).

Table 1. Outcomes of a survey conducted for an online retailer showing customer satisfaction and dissatisfaction.

Factor	Satisfaction (%)	Dissatisfaction (%)
The network speed of response	46.3	14.35
The website image of integrity	39.82	17.59
Payment security	48.6	14.36
Interaction	31.48	22.22
Feedback channels	29.63	22.22
Returns	37.5	26.39
Confidentiality of personal information	32.41	23.15
Operational process	50	11.11
Shopping convenience	26.86	32.41
Save time	63.89	7.41
Product description	41.21	14.82
Product price	63.89	7.42
Product quality	49.53	8.79
Transaction security	47.68	12.97
Personalized	40.27	7.41
Product category	54.63	7.87

Figure 3. Graphical representation of customer satisfaction and dissatisfaction.

include technical skills such as proficiency in computer software, mechanical skills such as the ability to operate machinery, or soft skills such as communication and problem-solving. On the other hand, job performance refers to how well an employee performs in their job. This can be measured by their ability to meet or exceed expectations, achieve targets, produce high-quality work, and contribute positively to their team or organization. However, job performance in a B2B E-commerce is more than completing tasks; it is about contributing positively to the organization's mission and fostering success in a highly competitive area. The markers of job performance include meeting or surpassing set targets, producing high-quality work, and enhancing team dynamics.[42] Employees who excel in these areas are indispensable assets in the B2B E-commerce landscape. However, simply having the required worker skills is not enough to guarantee excellent job performance.[43] An individual's job performance also depends on HFs such as motivation, attitude, work ethic, and ability to work well with others. Any service system will likely have efficiency and increased performance as one of its primary goals. The performance of the job or system is equivalent to that of the individual worker, therefore, workers' performance is understood to be a complicated entity linked to other individualized characteristics, such as skills and workers' satisfaction[44,45] which are both considered to be essential components of workers' performance. The completion of a task within the required completion time by a worker on the warehouse floor is referred to as job performance in this study.

One important factor to also consider in an E-commerce system is job rotation amongst workers in the warehouse. It is also anticipated that its deployment will improve work performance. Job rotation refers to the practice of moving employees between different positions or departments within an organization, to broaden their experience and skill set. According to Song et al[46] job rotation has also been used to sustain and upgrade the various latent skills and experience of workers who have been on the job for a long time. One potential benefit of job rotation is that it can help employees develop a more comprehensive understanding of the organization, as well as a broader range of skills and knowledge. This can in turn lead to greater job satisfaction and motivation, as well as improved performance. However, there are also potential downsides to job rotation. For example, frequent changes in responsibilities can be stressful for some employees and may lead to decreased job satisfaction and performance. One limitation of job rotation is that it may lead to decreased productivity as employees are learning new tasks and becoming familiar with new work environments.[47]

The effect of fatigue among warehouse workers is also an important factor to be considered in the E-commerce system especially in a FMCG sector due to complexity in job schedule. Job fatigue in a service system is caused by task overload, which can lead to workers' injury.[48] There are several factors that can contribute to job fatigue, including long work hours, high job demands, lack of control over work tasks, and a poor work-life balance. Employers can help reduce job fatigue by implementing strategies such as providing flexible work arrangements, encouraging breaks throughout the day, and promoting a healthy work-life balance. On an individual level, there are also strategies that employees can use to manage job fatigue and improve job performance. These may include taking breaks when needed, prioritizing tasks, setting realistic goals, and practicing good sleep hygiene. One limitation of job fatigue is that it can lead to decreased job satisfaction and increased turnover intentions.[49] This can be especially true for employees who experience chronic fatigue, as they may feel that their work demands are not manageable and may seek other employment opportunities. Additionally, job fatigue can result in increased errors and accidents on the job, as employees may be less alert and less able to make good decisions.[50] Another potential limitation of job fatigue is that it can lead to negative health outcomes, such as cardiovascular disease, depression, and anxiety.[51]

Furthermore, the above reviews show that issues such as inaccurate data and limited visibility exacerbate these problems. It is worth mentioning that despite the utilization of advanced management tools in the E-commerce and inventory distribution system today, the challenges regarding HF have not received adequate attention. Remarkably, prior research often overlooks the role of HF when addressing some system challenges such as late delivery and system downtime.[17] Also, many studies preferred to concentrate primarily on system processes and technology, while neglecting the significant impact of human actions within the E-commerce system. This study aims to bridge this gap by incorporating insights from existing literature and considering HFs like worker fatigue, satisfaction, and rotation as crucial elements to address these issues affecting the system performance.

Case study and problem description

Overview of the case study

In this paper, we examine two service systems referred to as ABC and XYZ for the purpose of illustrating this case study. The actual identities of ABC and XYZ will remain undisclosed due to privacy and security considerations.[52] ABC is a service system operating in the domain of E-commerce in West Africa, specializing in the delivery of goods and FMCG through online purchases. On the other hand, XYZ is also an E-commerce service system in West Africa, dealing with a wide range of product categories. In this section, we took companies ABC and XYZ to describe the various challenges faced by both companies and we intend to propose solutions to address these issues.

Over the past decade, West Africa has witnessed the emergence of numerous E-commerce companies. Notably, ABC has distinguished itself as the sole E-commerce company exclusively dedicated to the distribution of FMCG. ABC was established during the COVID-19 pandemic to assist retailers in procuring FMCG and other consumable goods, which were in high demand during that period. In addition, ABC implemented a well-known distribution model called the Hub and Spoke model,[53] to reduce delivery times and enhance customer satisfaction. As shown in Figure 4, the workflow depicts the end-to-end (E2E) process flow of ABC. In Region A, the procurement team collaborates with vendors to purchase products, which are then sent to the warehouse via suppliers. The inbound team receives the products, verifies them against the purchase order (PO), and generates a goods receipt note (GRN) for inventory accuracy and financial reporting. In Region C, the inventory team stores the received products in their designated locations (racks and pallets). In Region B, when a customer places an order on the website, the order processing unit (OPU) team picks and packs the items for the customer's shipment. In Region E, shipments are handed over to the logistics team, loaded into vans, and dispatched for last-mile delivery to customers. In Region D, if a customer rejects any product for any reason, refunds or replacements are processed, and the product is returned to the warehouse. However, the general goal of an E-commerce distribution system is to be able to ensure that the entire process as described in Figure 4 achieves its objective. Therefore, the motivation of this work is to address the challenges faced by ABC by focusing on factors that have not been adequately explored in previous research.

Furthermore, it is worth mentioning that while both service systems share similar operations, the primary focus of this study will be on ABC. XYZ's inclusion is aimed at facilitating a comparative analysis of the challenges encountered by both companies and validating the findings.

Problem description

HFs play a pivotal role in shaping the e-commerce models of both ABC and XYZ. They influence everything from user

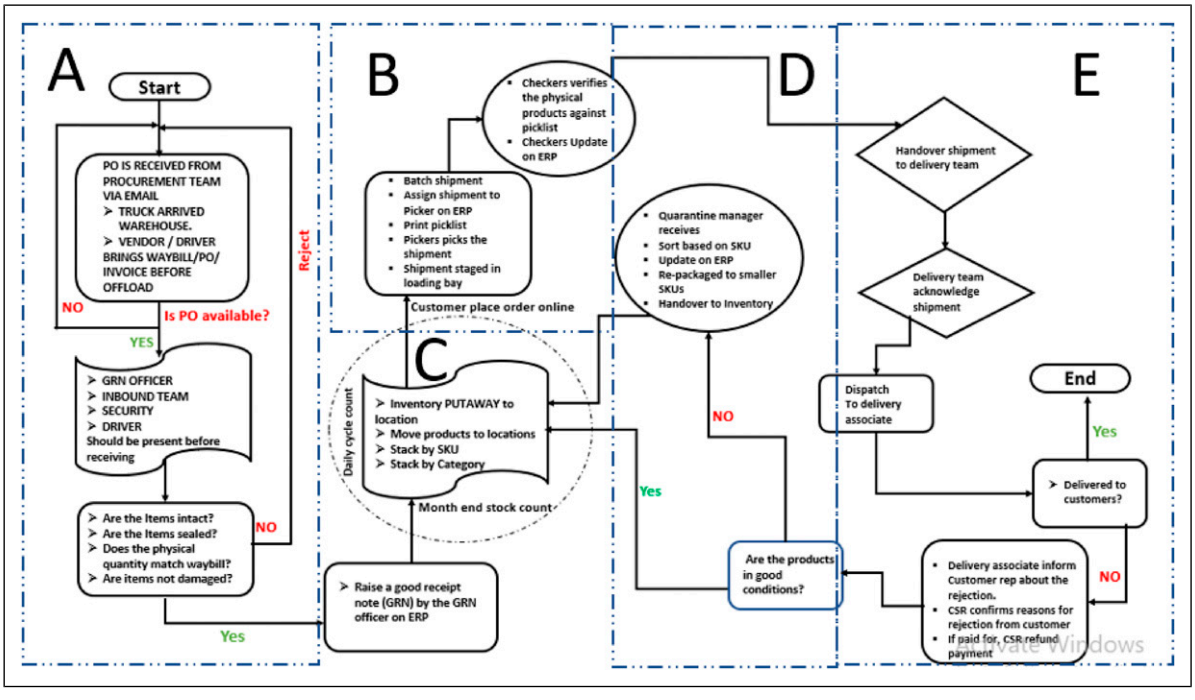

Figure 4. The end-to-end (E2E) E-commerce workflow of ABC.

interface design to order fulfillment processes, ensuring a seamless interaction between workers and automation systems. An effective HF approach enhances the user experience, making it intuitive, efficient, and error-resistant, ultimately boosting customer satisfaction and operational efficiency. By considering ergonomic principles, cognitive load, and user-centered design, both companies can optimize their e-commerce processes, improve user engagement, and reduce errors that might lead to customer dissatisfaction and increased costs. The resilience of ABC and XYZ's e-commerce models relies on their ability to balance profitability and customer satisfaction.

When implementing efficient and user-friendly platforms through HF integration, there is a tendency to improve usage of the system, resulting in higher customer satisfaction and loyalty. Additionally, HF principles can help to streamline operational processes, by reducing errors and enhancing productivity, thus positively impacting profitability. So, ABC's expansion in West Africa during the COVID-19 pandemic has encountered challenges due to factors like ignoring effects from a human perspective, overhead costs, and capital expenditures not being adequately considered. ABC faces a dilemma as it grows, with increasing overhead costs and the need for high productivity. Balancing a productive workforce while optimizing profitability is a delicate task for ABC. ABC's downsizing approach was intended for cost optimization, also when issues such as reduced job satisfaction, increased job fatigue, and disrupted job rotation were observed. This new approach negatively affects ABC's operational efficiency, while impacting order processing, last-mile delivery, and customer satisfaction.

Meanwhile, the critical importance of holistic decision-making in ABC's situation should have been guided by HF principles, while emphasizing on the interconnectedness between workforce dynamics, operational efficiency, and customer satisfaction. However, it was observed that HF and workforce dynamics,[5] resiliency,[2] are closely intertwined and crucial for navigating the complexities faced by both ABC and XYZ. Also, Figures 5 and 6 are used to provide historical knowledge of the monthly net salaries of workers, operational running costs, and the value of orders delivered to customers on a month-to-month basis. For instance, the analysis in Figure 5 illustrates the company's financial performance, when comparing the monthly profits with the operating costs over 6 months. This analysis reveals that the company operated at a loss from May to October, as the monthly profits were less than the operating costs. In contrast, Figure 6 shows a forecast of breaking even if the job performance of ABC increases by 48%. The figure shows the relationship between monthly orders and profits, which indicates the potential for an increase in profitability with higher order volumes. In addition, the visual representation helps in interpreting data towards decision-making over time.

Despite this upward trend in sales, the company struggled to break even due to the substantial operational running costs. These high operational costs indicated that the revenue generated fell below the expected budget. To improve productivity and performance, the company would need to increase projected revenue by approximately 40% to 48%. Achieving this increase implies a need to consider HF principles and adjust the capital expenditures. Also, Figure 6 illustrates a forecast of how the company could reach a break-even point if performance were to increase by 48%. Addressing the operational issues requires a careful adjustment of running costs while taking HF into account to ensure operational efficiency and increased system performance. It's important to note that HF should be a key consideration during cost adjustments to avoid operational downtime.

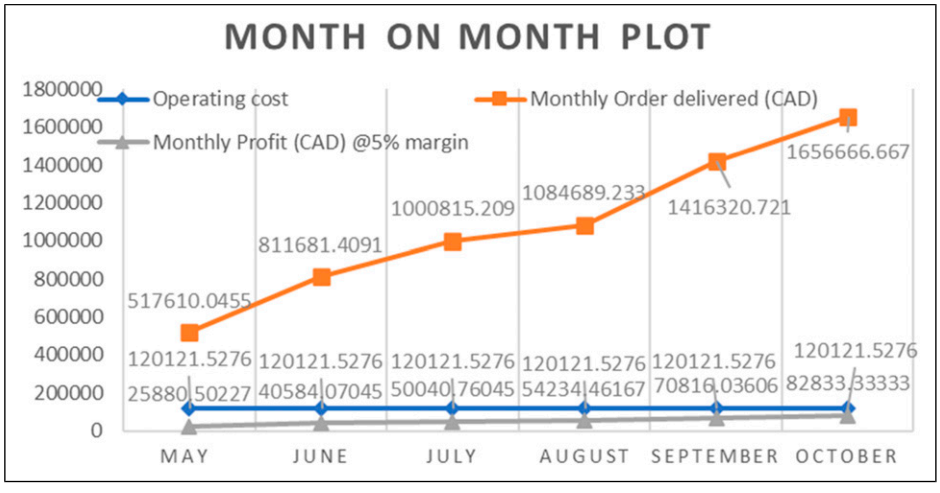

Figure 5. The chart of company ABC running at lost.

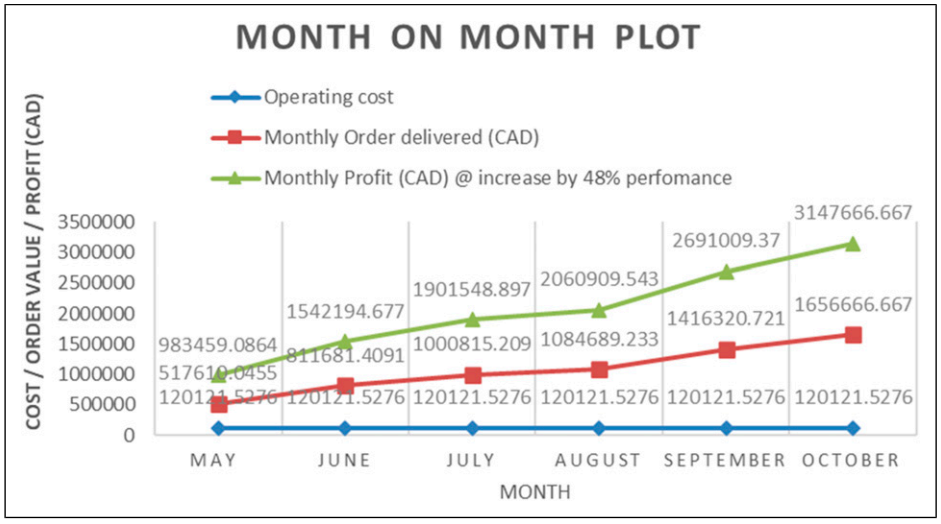

Figure 6. The chart of the revenue increased at 48% performance.

Another important fact to also consider in ABC's operations is that many processes are still manual due to limitations in material handling tools absenteeism amongst warehouse workers, and loss of skilled workers due to sudden resignations. These challenges have led to shortages of manpower and hindered proper capacity planning to achieve ABC's business goals. Late deliveries have also been attributed to issues related to HF and when reflecting on these challenges a significant portion can be traced back to human errors. These errors have resulted in customer-initiated order rejections and subsequent delays in delivering orders to valued clients. So, to maximize the overall performance and efficiency in the e-commerce system such as ABC and XYZ, investigating the impact of some HF on warehouse workers is crucial for improving system performance. Therefore, it is assumed that when HF is considered in practice, it can lead to optimized ecommerce processes, improved profitability, and enhanced customer satisfaction.

Methodology

This paper adopts a method known as statistical model analysis (SMA).[54,55] SMA serves as a crucial modelling tool aimed at outlining the methodology employed in this study to identify some HF among workers within the warehouses of both ABC and XYZ. The method establishes the research hypotheses, forming the fundamental basis for the entire study. Following this, it delves into the research design and the chosen sampling technique on how data was gathered from the target population. Subsequently, it elaborates on the methods and procedures employed for data collection, encompassing the development and pilot testing of the questionnaire.

Research questions

Several e-commerce models have been widely used by so many companies since post-pandemic COVID-19, however, there are several questions about the model, which are to be addressed in this research. This study aimed to examine and investigate how the effect of HF amongst warehouse workers influences job performance. To achieve this goal, the following questions were raised.

- Question 1: What is the significant impact of HF, including workers' skills, workers' satisfaction, job rotation, and job fatigue, on influencing job performance within the modern B2B e-commerce model of companies ABC and XYZ?
- Question 2: What is the significant impact of HF in understanding the levels of job satisfaction, job fatigue, and job rotation among warehouse workers within the modern B2B e-commerce model of companies ABC and XYZ?
- Question 3: What is the combined contribution of each of the independent variables including workers' skills, workers' satisfaction, job rotation and job fatigue to the determination of the dependent variable (i.e., job performance) of the workers within the modern B2B e-commerce model of companies ABC and XYZ?

Research hypothesis

One of the essential tools in research, which underpins investigation-based studies, is the research hypothesis.[55,56] This study's primary objective is to explore and analyze the impact of certain HFs on job performance among warehouse employees in a service system (i.e., ABC and XYZ).

To establish the existence of this relationship and to answer the research questions in this paper, three hypotheses were formulated and tested. Given the presumption that HFs might contribute to the issues discussed in section 3, an extensive work review was conducted to identify pertinent theories and empirical data to substantiate these hypotheses. Furthermore, the hypotheses were scrutinized within the domain of HFs to ensure their suitability for the study. Consequently, the following three hypotheses were crafted.

Hypothesis One. Ho: There is no statistically significant impact between workers' skills, workers' satisfaction, job rotation, and job fatigue on influencing job performance within the B2B e-commerce model of companies ABC and XYZ.

Hi: There is a statistically significant impact of workers skills, workers satisfaction, job rotation, and job fatigue on influencing job performance within the B2B e-commerce model of companies ABC and XYZ.

The first hypothesis posits that there is a statistically significant impact of workers' skills, workers' satisfaction, job rotation, and job fatigue on job performance of the warehouse workers. This hypothesis was developed based on extensive literature review and theoretical considerations.

Hypothesis Two. Ho: There is no statistically significant impact on the levels of workers' satisfaction, workers' skills, job fatigue, and job rotation among warehouse workers within the modern B2B e-commerce model of companies ABC and XYZ.

Hi: There is a statistically significant impact on the levels of workers' satisfaction, workers' skills, job fatigue, and job rotation among warehouse workers within the modern B2B e-commerce model of companies ABC and XYZ

The second hypothesis examines the impact of workers' skills, workers' satisfaction, job rotation, and job fatigue on the level of job performance among warehouse workers. We hypothesized that these HFs significantly influence the current level of job performance in ABC and XYZ.

Hypothesis Three. Ho: The combined influence of workers' skills, workers' satisfaction, job rotation, and job fatigue does not significantly impact the determination of job performance among workers in the B2B e-commerce of companies ABC and XYZ.

Hi: The combined influence of workers' skills, workers' satisfaction, job rotation, and job fatigue significantly affect the determination of job performance among workers in the B2B e-commerce model of companies ABC and XYZ.

Finally, the third hypothesis investigates the combined effect of predictor variables on the determination of job performance. We proposed that these combined factors significantly affect job performance in the distribution system considered in this paper.

Research design

The research design in this paper is used to specify the approach towards fulfilling the research objectives.[57] The research design involved the utilization of a cross-sectional survey design. This design was also selected due to its suitability for gathering data from a sizable population while facilitating data collection at a single point in time.

Sampling technique

This study aimed to include all employees working within ABC and XYZ in West Africa as the target population. To determine the sample size for this study, the sample size determination table according to Krejcie and Morgan,[58] was utilized, which resulted in a calculated sample size of 40. To select participants, a stratified random sampling approach was employed. Firstly, a sample frame was created by compiling a list of e-commerce systems operating in the region. Secondly, these e-commerce systems were categorized into strata based on their respective sizes. Subsequently, a proportional sampling method was applied to choose participants from each section. Lastly, within each section, participants were randomly selected using a simple random sampling technique.

Method of data collection

This study used a questionnaire to collect data on workers' skills, workers' satisfaction, job rotation, and job fatigue among warehouse workers. Participants were informed about the study's purpose and had the opportunity to review and consent to the questionnaire. A total of 40 questionnaires were distributed to employees at both companies, ABC and XYZ, and responses were collected over a 3 – 4 week period. The questionnaire consisted of closed-ended questions with specific response options (i.e., Likert scales), chosen for its convenience in reaching warehouse workers and collecting data on the effect of HF, while data on job performance were obtained from warehouse supervisors.

In addition to the data collection for ABC, the variable, descriptions of the variable, measurement metric and their items rating were depicted through the Measurement metric of rating, as shown in Table 2. In Table 2, the Measurement metric of rating considered four factors (i.e., Workers' Skill, Workers' Satisfaction, Job Rotation, and Job Fatigue) as independent variables to measure the workers' performance and the dependent variable in the first column. The second column shows the description of each factor. The third column represents the measurement metric for each

Table 2. Measurement metric of rating.

Variable	Description	Measurement metric	Items
Workers skills (WS*k*)	Skills possessed by employees	Likert scale (1-5)	Technical skills Analytical skills Communication skills
Workers satisfaction (WS*a*)	Employee satisfaction with their job	Likert scale (1-5)	Satisfaction with workload Satisfaction with compensation Satisfaction with work-life balance
Job rotation (*JRo*)	Frequency and variety of tasks assigned	Likert scale (1-5)	Low: Rarely or never rotated Medium: Periodic rotation between predefined roles or departments High: Frequent rotation across multiple roles or departments
Job fatigue (*JFa*)	Fatigue experienced by employees	Likert scale (1-5)	Level of exhaustion Impact of workload on physical and mental health Frequency of breaks taken
Job performance (*JPerf*)	Overall performance of employees	Regression analysis	Output metrics (e.g., productivity, accuracy)

variable. For example, the metric for the independent variables is the Likert scale [1 -5] and the dependent variable is measured using the regression analysis. Finally, each variable item was described in the fourth column.

Data analysis technique

The study employed a statistical modelling analysis method, which includes a reliability statistics test, descriptive statistics and regression analysis for data collection and analysis. Descriptive statistics such as means, and standard deviations are used to summarize and describe the characteristics of the data among warehouse workers. Furthermore, a reliability statistics test, specifically Cronbach's alpha coefficient, was applied to measure the internal consistency of each variable in the questionnaire used in this study. Cronbach's alpha is widely accepted for evaluating the internal consistency of a questionnaire, while ensuring that the items measure the same construct. To explore the relationship between the independent and dependent variables in this study, Pearson product-moment correlation generated a correlation matrix. The research hypotheses were tested using both Pearson product-moment correlation and multiple linear regression analysis.

Results and discussion

Reliability analysis and pilot testing are crucial steps in developing any research instrument, including questionnaires. In this paper, we examine and investigate how HFs impact warehouse workers and can influence job performance. To realize this, the following steps were taken to ensure the questionnaire's validity and reliability. Reliability analysis assesses the consistency and stability of a research instrument. In this paper, Cronbach's alpha coefficient was used to determine the reliability. This coefficient measures internal consistency, with values ranging from 0 to 1. Generally, a coefficient of 0.7 or higher is considered acceptable for research instruments.[59] The analysis results indicated that the questionnaire exhibited high internal consistency with a Cronbach's alpha coefficient of 0.791, surpassing the acceptable threshold of 0.7 as shown in Table 3. This indicates that the questionnaire is dependable and consistent in measuring the intended constructs. Furthermore, a pilot testing was considered. Pilot testing involves administering the research instrument to a small sample of respondents to identify and rectify any potential issues with the questionnaire. In this study, pilot testing was performed on a group of 9 ABC workers. The results of the pilot testing showed that the questionnaire was easily comprehensible to the participants, enabling them to provide accurate and meaningful responses. While some minor revisions were made to enhance the clarity and wording of a few questions, overall, the reliability analysis and pilot testing confirmed the questionnaire's validity, reliability, and suitability for measuring the constructs of interest.

Table 3. Shows the reliability statistics.

Reliability statistics	
Cronbach's alpha	No of items
.791	9

To answer the research questions in this paper, three hypotheses were tested. Firstly.

(Ho): There is no statistically significant impact between workers' skills, workers' satisfaction, job rotation, and job fatigue on influencing job performance within the B2B e-commerce model of companies ABC and XYZ.

(Hi): There is a statistically significant impact of workers skills, workers satisfaction, job rotation, and job fatigue on influencing job performance within the B2B e-commerce model of companies ABC and XYZ.

The result from the correlation analysis conducted indicated that the four independent variables (i.e., workers' skills, workers' satisfaction, job rotation, and job fatigue) studied in relation to the job performance showed positive relationships. However, it's worth noting that three of these predictors (i.e., independent variables) did not exhibit statistically significant impact on the overall system performance. This suggests that while there is positive relationship between these predictors and job performance, their impact on the overall system performance in the case studies is not statistically significant.

According to Table 4, the analysis for case study 1 (ABC) indicates that the impact of workers' skills on job performance is not statistically significant. Although there is a positive correlation coefficient of 0.249 between workers' skills and job performance, but the associated p-value of 0.145 exceeds the standard significance level of 0.05. Consequently, there isn't substantial evidence to conclude a significant effect of workers' skills on job performance based on this data. This suggests that the data doesn't support the hypothesis that workers' skills significantly influence job performance among workers at ABC.

However, in case study 1 (ABC), the analysis further reveals a positive correlation (r = 0.364) between workers' satisfaction and job performance. This implies that individuals reporting higher workers' satisfaction tend to exhibit better job performance. Also, this correlation is only marginally significant (p = .057), suggesting a possibility that this relationship might have occurred by chance. Notably, the p-value of 0.057 exceeds the conventional significance threshold of 0.05, indicating that the evidence for a significant link between workers' satisfaction and job performance in this sample could vary from time to time. While a positive correlation is observed, it does not attain statistical significance. Therefore, additional analysis with a larger sample size or more data might be necessary for more conclusive insights into the impact of workers' satisfaction on job performance among ABC's workers.

Furthermore, as shown in case study 1 (ABC), the analysis indicates a positive correlation (r = 0.195) between job fatigue and job performance. However, like the previous correlations, this relationship between job fatigue and job performance did not show statistical significance (p = .205). This implies that, based on the sample data, there is no strong evidence to support the idea of a significant link between job fatigue and job performance among workers. It is also possible that the observed correlation could be due to chance, and further investigation or a larger sample size might be necessary to arrive at more definitive conclusions regarding the impact of job fatigue on job performance.

Again, in case study 1 (ABC), the analysis also reveals a positive correlation (r = 0.278) between job rotation and job performance. However, like the other correlations, the relationship between job rotation and job performance did not reach statistical significance (p = .118). This suggests that,

Table 4. Correlation showing the relationship between independent variables and dependent variable for ABC.

	Correlations				
	Job performance	Worker satisfaction	Worker skills	Job fatigue	Job rotation
Pearson correlation					
Job performance	1.000	0.364	0.249	0.195	0.278
Worker satisfaction	0.364	1.000	0.515	0.344	0.529
Worker skills	0.249	0.515	1.000	0.523	0.532
Job fatigue	0.195	0.344	0.523	0.714	0.714
Job rotation	0.278	0.529	0.532	1.000	1.000
Sig. (1-tailed)					
Job performance		0.057	0.145	0.714	0.118
Worker satisfaction	0.057		0.010	0.205	0.008
Worker skills	0.145	0.010		0.069	0.008
Job fatigue	0.205	0.069		0.009	0.000
Job rotation	0.118	0.008			

Table 5. Correlation showing the relationship between independent variables and dependent variable for XYZ.

	Correlations				
	Job performance	Worker satisfaction	Worker skills	Job fatigue	Job rotation
Pearson correlation					
Job performance	1	0.252	0.239	−0.126	−0.099
Worker satisfaction	0.252	1	0.723	−0.081	0.348
Worker skills	0.239	0.723	1	0.056	0.312
Job fatigue	−0.126	−0.081	0.056	1	−0.029
Job rotation	−0.099	0.348	0.312	−0.029	1
Sig. (1-tailed)					
Job performance		0.142	0.155	0.298	0.339
Worker satisfaction	0.142		0	0.367	0.066
Worker skills	0.155	0		0.407	0.09
Job fatigue	0.298	0.367	0.407		0.452
Job rotation	0.339	0.066	0.09	0.452	

based on the obtained results, there is no substantial evidence to suggest a significant link between job rotation and job performance among the workers. The observed correlation could potentially be attributed to chance, and further investigation on a larger sample size may also be necessary to draw more definitive conclusions regarding the impact of job rotation on job performance.

Similarly in Table 5, the analysis for case study 2 (XYZ) shows that the effect of workers' skills on job performance is not statistically significant. Despite a positive correlation coefficient of 0.239 between workers' skills and job performance, the *p*-value linked with this correlation coefficient is 0.155, which surpasses the common significance level of 0.05. Hence, there is insufficient evidence to conclude that a significant relationship between workers' skills and job performance in the examined sample existed. This implies that the data doesn't substantiate the hypothesis that workers' skills have a significant impact on job performance at XYZ.

Also, for case study 2 (XYZ), the examination of the effect of workers' satisfaction on job performance also reveals a positive correlation (r = 0.252) between these variables. This suggests that individuals with higher workers satisfaction tend to exhibit better job performance. However, it's essential to note that this correlation coefficient of 0.252 doesn't reach statistical significance at the conventional level of 0.05. The associated *p*-value of 0.142 is greater than 0.05, indicating a possibility that the observed relationship between workers' satisfaction and job performance could be due to chance. Consequently, the data does not provide strong evidence to support the hypothesis that workers' satisfaction significantly impacts job performance among workers at XYZ. It is important to conclude that the data might be limited in terms of sample size or other factors that could influence the relationship between workers' satisfaction and job performance. Therefore, further analysis with a larger sample or additional data may be required to obtain more definitive results and establish the true effect of workers' satisfaction on job performance among XYZ's workers.

Additionally, in case study 2 (XYZ), we examined the effect of job fatigue on job performance. The correlation coefficient between job fatigue and job performance is −0.126, suggesting a weak negative relationship between these variables. This implies that higher levels of job fatigue are associated with slightly lower job performance. However, it is crucial to note that this correlation coefficient of (r = −0.126) does not attain statistical significance at the conventional threshold of 0.05. The associated *p*-value of 0.298 is greater than 0.05, indicating a lack of strong evidence to show a significant relationship between job fatigue and job performance. Based on these results, we cannot confidently conclude that job fatigue significantly affects job performance among the workers. It is plausible that other unexamined factors or variables may have a more substantial influence on job performance. Therefore, further research incorporating a larger sample size, additional data, and the consideration of other potential factors may be necessary to gain a more comprehensive understanding of the relationship between job fatigue and job performance among workers.

Again, in case study 2 (XYZ), we explore the effect of job rotation on job performance. The correlation coefficient between job rotation and job performance though is −0.099, indicates a weak negative relationship between these variables. This implies that there might be a slight decrease in job performance associated with job rotation. However, it is important to note that this correlation coefficient of −0.099 did not attain a statistical significance at the conventional significance level of 0.05. The associated *p*-value of 0.339 is greater than 0.05, suggesting inadequate evidence to establish a significant relationship between job

rotation and job performance in the given sample. Based on these results, we cannot conclusively state that job rotation significantly affects job performance among workers. Therefore, there are other unexamined factors or variables that may exert a more substantial influence on job performance. Consequently, further exploration with a larger sample size, additional data, and consideration of other pertinent factors may be required to obtain a more comprehensive understanding of the relationship between job rotation and job performance among workers.

Based on the R-values, all the 4 independent variables reveal that there is a positive correlation with the dependent variable. Therefore, the null hypothesis (Ho) is not rejected since the *p*-value is greater than 0.05 while the alternative hypothesis (Hi) is not accepted. This means that the workers skills, job fatigue, job rotation and workers satisfaction all have positive relationship on job performance of the workers, and they are not statistically significant with job performance except workers satisfaction with a marginal significance.

Regarding research question 2, the null hypothesis was devised. (Ho): There is no statistically significant impact on the levels of workers' satisfaction, workers' skills, job fatigue, and job rotation among warehouse workers within the modern B2B e-commerce model of companies ABC and XYZ. (Hi): There is a statistically significant impact on the levels of workers' satisfaction, workers' skills, job fatigue, and job rotation among warehouse workers within the modern B2B e-commerce model of companies ABC and XYZ.

The result from the descriptive statistics as shown in Table 6 was used to indicate the significant impact on the levels of the workers' skills, workers' satisfaction, job rotation, and job fatigue studied in relation to the job performance in ABC. First, the average score of job performance is 3.4450, with a standard deviation of 0.53947. This score suggests that, on average, the HF considered among the participants in system have a moderate level of job performance, and there is some variability in their performance scores. For workers satisfaction, the average score is 3.8500, with a standard deviation of 0.51900. This indicates that, on average, the participants have a relatively high level of satisfaction, and there is relatively less variability in their satisfaction scores compared to the job performance. In terms of workers skills, the average score is 3.6700, with a standard deviation of 0.54008. This further suggests that, on average, the participants have a moderate level of skills, and there is some variability in their skill levels. For job fatigue, the average score is 3.2167, with a standard deviation of 0.55171. This indicates that, on average, the participants experience a moderate level of job fatigue, and there is some variability in their fatigue levels. Lastly, for job rotation, the average score is 3.1900, with a standard deviation of 0.62061. This suggests that, on average, the participants experience a moderate level of job rotation, and there is some variability in their rotation experiences. Overall, these descriptive statistics provide a snapshot of the sample's perceptions of job performance, workers satisfaction, workers skills, job fatigue, and job rotation. They help us understand the average levels and variability of these variables within the sample.

Table 6. Item statistics for study 1 (ABC).

	Descriptive statistics		
	Mean	Std. deviation	*N*
Job performance	3.4450	0.53947	20
Workers satisfaction	3.8500	0.51900	20
Workers skills	3.6700	0.54008	20
Job fatigue	3.2167	0.55171	20
Job rotation	3.1900	0.62061	20

Also, the result from the descriptive statistics as shown in Table 7 was used to indicate the significant impact on the levels of the workers' skills, workers' satisfaction, job rotation, and job fatigue studied in relation to the job performance**.** The mean job performance score is 3.4750, indicating the average level of job performance across the sample. While the standard deviation of 0.57388 shows the variability or dispersion of job performance scores around the mean. Also, the mean workers satisfaction score is 3.4778, representing the average level of workers satisfaction reported by the individuals in the system. The standard deviation of 0.47974 indicates the variability in workers satisfaction scores. Furthermore, the mean workers skills score is 3.5733, indicating the average level of skills reported by the individuals, and the standard deviation of 0.47259 represents the variability in workers skills scores across the sample. In addition, the mean job fatigue score is 3.3333, reflecting the average level of job fatigue reported by the individuals, and the standard deviation of 0.37463 represents the variability in job fatigue scores. Finally, the mean job rotation score is 3.1100, indicating the average level of job rotation reported by the individuals, and the standard deviation of 0.48764 shows the variability in job rotation scores. These descriptive statistics provide an overview of the central tendency and dispersion of the variables in the dataset, allowing us to understand the average levels and variability of job performance, job satisfaction, job skills, job fatigue, and job rotation.

Based on the mean values and the standard deviation values, all the 4 independent variables reveal that there is an impact on the levels of each of the predictors on the dependent variable. Therefore, Ho in this case is rejected since the mean scores of the independent variables are greater than the expected average score of 2.50 while the Hi is

accepted. This means there is an impact on the levels of workers' satisfaction, workers' skills, job fatigue, and job rotation among warehouse workers within the modern B2B e-commerce model of companies ABC and XYZ

Regarding research question 3, the null hypothesis was devised. (Ho): The combined influence of workers' skills, workers' satisfaction, job rotation, and job fatigue does not significantly impact the determination of job performance among workers in the B2B e-commerce of companies ABC and XYZ. (Hi): The combined influence of workers' skills, workers' satisfaction, job rotation, and job fatigue significantly affect the determination of job performance among workers in the B2B e-commerce model of companies ABC and XYZ.

The analysis of the variance component of the multiple linear regression analysis in Table 8 was used to test and make inferences on hypothesis three to answer research question three. The results from the analysis as presented in Table 8 show that the independent variables (i.e., worker satisfaction, worker skills, job rotation, and job fatigue,) did not combine to influence the dependent variable (i.e., job performance of the warehouse workers) ($F(4,15) = 0.631$, $p = .648$). The results shows that the four independent variables only account for 14.4% of the variance in the job performance, which is also not significant. This result implies that the job performance of the warehouse workers could be slightly influenced by these four factors while other factors would highly account for 85.6% variation towards job performance. Since, the F-value is very small at (p-value = .648), therefore the null hypothesis (Ho) is accepted, and the alternative hypothesis (Hi) is rejected. This implies that the workers' satisfaction, workers' skills, job fatigue, and job rotation may not contribute towards the job performance of the workers.

In addition, Table 9 provides a side-by-side comparison of the correlation coefficients and p-value for each variable between ABC and XYZ. In ABC, the correlation between worker skills and the other variable(s) being studied is positive (0.249), suggesting a potential relationship. However, with a p-value of 0.145, the correlation is not statistically significant at conventional significance levels (typically $p < .05$). Also, there is a moderate positive correlation (0.364) between workers' satisfaction and the other variable(s) under investigation. Though the p-value of 0.057 indicates that the correlation is marginally significant, meaning it's close to the conventional threshold of significance but doesn't quite meet it. Additionally, the correlation coefficient between job fatigue and the other variable(s) is positive at 0.195, suggesting a potential association. However, with a p-value of 0.205, the correlation is not statistically significant, indicating that this relationship may be due to chance. Finally, we tested a positive correlation (0.278) between job rotation and the other variable(s) studied, but it's not statistically significant at the conventional threshold of significance ($p < .05$).

In XYZ which is like ABC, there's a positive correlation between worker skills and the other variable(s) under investigation, but it is not statistically significant at the

Table 7. Item statistics for (XYZ).

	Descriptive statistics		
	Mean	Std. deviation	*N*
Job performance	3.4750	0.57388	20
Workers satisfaction	3.4778	0.47974	20
Workers skills	3.5733	0.47259	20
Job fatigue	3.3333	0.37463	20
Job rotation	3.1100	0.48764	20

Table 8. The effect of HFs and its prediction on job performance of workers in ABC.

Model summary[a]

Model	R	R square	Adjusted R square	Std error of the estimate	R Square change	Change statistics				Durbin-watson
						F Change	df1	df2	Sig.F change	
1	0.379	0.144	−0.084	0.56175	0.144	0.631	4	15	0.648	2.457

ANOVA[b]

Model		Sum of squares	df	Mean square	F	Sig
1	Regression	0.796	4	0.199	0.631	0.648
	Residual	4.733	15	0.316		
	Total	5.529	19			

[a]Dependent variable: Job performance.
[b]Predictors: (Constant) Job_Rotation, Workers'_Sstisfaction, Workers'_Skills, Job_Fatigue.

Table 9. Comparison of the correlation coefficients and *p*-values for each variable between study 1 (ABC) and study 2 (XYZ).

Variables	Study 1 (ABC)	Study 2 (XYZ)
Worker skills	Correlation: 0.249, *p*-value: 0.145 (not statistically significant)	Correlation: 0.239, *p*-value: 0.155 (not statistically significant)
Worker satisfaction	Correlation: 0.364, *p*-value: 0.057 (marginally significant)	Correlation: 0.252, *p*-value: 0.142 (not statistically significant)
Job fatigue	Correlation: 0.195, *p*-value: 0.205 (not statistically significant)	Correlation: −0.126, *p*-value: 0.298 (not statistically significant)
Job rotation	Correlation: 0.278, *p*-value: 0.118 (not statistically significant)	Correlation: −0.099, *p*-value: 0.339 (not statistically significant)

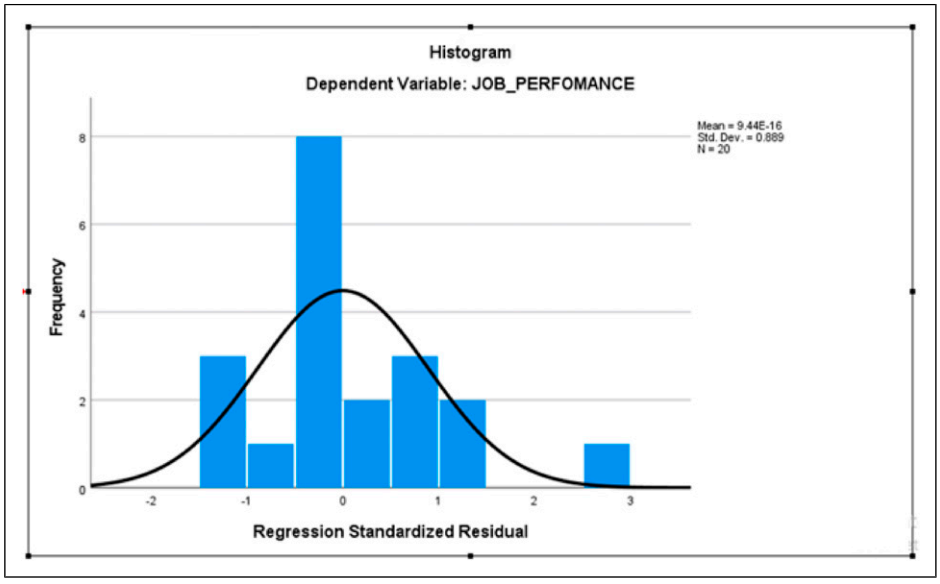

Figure 7. Simple histogram and standardized residual plot.

conventional level. Also, there is a positive correlation between workers' satisfaction and the other variable(s), but it is not statistically significant at the conventional level. Interestingly, there is a negative correlation between job fatigue and the other variable(s), however, it is not statistically significant at the ($p < .05$) level. Also, we tested a negative correlation between job rotation and the other variable(s) being studied, but as with the others, it is also not statistically significant.

Regarding the analysis performed in Table 9, workers' satisfaction seems to be the most consistently correlated variable across ABC and XYZ, with a moderately positive correlation in Study 1 and a slightly lower positive correlation in Study 2. However, worker satisfaction reaches marginal significance in Study 1. Also, job fatigue and job rotation show inconsistent correlations across the studies and are not statistically significant in either study but worker skills show consistent positive correlations across both studies but are not also statistically significant.

Although there are some patterns of correlation between these variables, however, they generally fail to reach statistical significance, suggesting that the relationships observed may be due to random chance rather than true associations. Therefore, further research with larger sample sizes or different methodologies may be needed to confirm or refute these findings.

In addition, according to Figure 7, the histogram of standardized residuals visually represents the distribution of these residuals. It reveals that most data points are centered around the mean (0.000) with a standard deviation of 0.889. This suggests that the residuals, which represent the differences between actual and predicted job performance, are close to zero, indicating a reasonably good fit of the model to the data. This plot helps us evaluate the adequacy of the regression model. An ideal plot would have a symmetric, bell-shaped curve. Deviations from this ideal shape could indicate the presence of outliers or errors in the model.

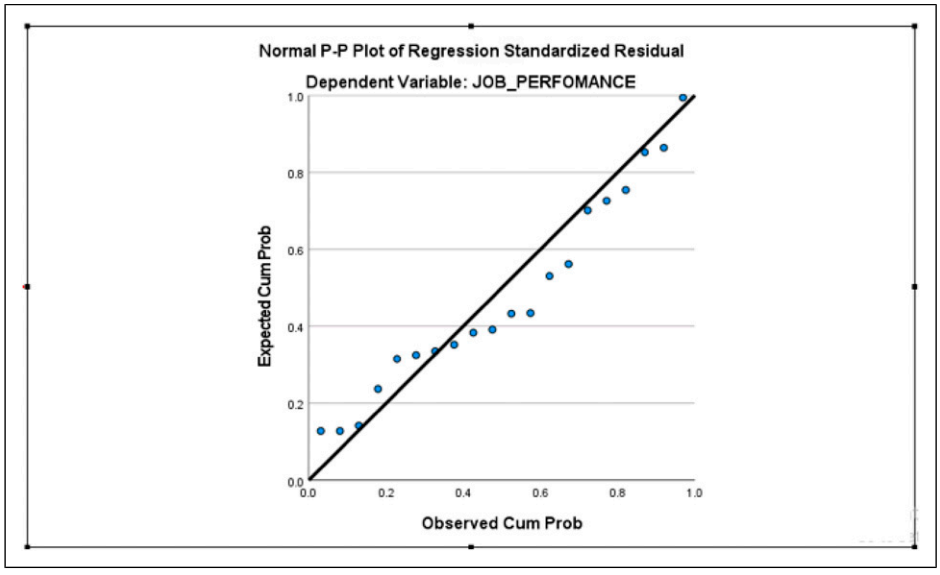

Figure 8. Normal P-P plot of regression standardized residual for Job performance.

According to Figure 8, the Normal P-P plot helps evaluate the distribution of standardized residuals for Job Performance. If the points closely adhere to the 45-degree line, the normality assumption is met. However, the Normal P-P indicate that the residuals of the regression model are normally distributed.

Conclusion, recommendation, and future work

This study aimed to investigate the complex relationships among warehouse workers—HF job rotation, job fatigue, workers' satisfaction, workers' skills, and job performance—between these factors in the operational contexts of two different organisations, ABC and XYZ. To achieve this goal, we developed and put through a rigorous testing process that served as a framework for our inquiry into how job rotation, job fatigue, workers' satisfaction, and workers' skills affect job performance. First hypothesis: In the contemporary B2B e-commerce model of businesses ABC and XYZ, there is no statistically significant effect of HF on job performance. This includes workers' skills, workers' satisfaction, job rotation, and job fatigue. Strong evidence was shown by the empirical findings to the contrary. A statistically significant relationship between these independent variables and the dependent variable was found by the investigation. This finding emphasizes the significant impact these HFs can have on warehouse employees' ability to execute their jobs. This is consistent with the literature, which highlights the relationship between worker productivity and well-being. Although the result implies that other factors not considered in this study may have a more substantial influence on the overall system performance.

Hypothesis 2. In the contemporary B2B e-commerce model of companies ABC and XYZ, there is no statistically significant effect of HF on the levels of job satisfaction, job fatigue, and job rotation among warehouse workers. Understanding how the workers' skills, workers' satisfaction, job rotation, and job fatigue interact through the descriptive analysis can significantly emphasize the complexity of employee performance. This underscores the need for a comprehensive approach to work and job design to achieve optimal job performance. Organisational decision-makers must recognize that a variety of dynamic elements interact to drive job performance rather than a single factor acting alone.

Hypothesis 3. The assessment of job performance among employees in the B2B e-commerce of companies ABC and XYZ is not considerably impacted by the combined influence of workers' skills, workers' satisfaction, job rotation, and job fatigue. This study found that while individual characteristics did not all have a substantial impact on job performance, they all have a significant combined effect. This emphasizes the notion that improving job performance requires a harmonious alignment of workers' skills, workers' satisfaction, job rotation, and job fatigue. Moreover, it suggests that companies should implement plans that deal with these elements in their entirety rather than concentrating on specific elements. The results indicate that HFs have a critical role in determining job performance.

Consequently, the study emphasises on how important it is for companies to put their employees' health and

wellbeing conditions first, particularly those in the transportation and warehousing unit. Higher job performance is certain when a skilled and contented staff is provided with opportunities for job rotation while minimising job tiredness. In other words, the need for sophisticated technology or software tools for warehouse planning and shipping scheduling in ABC and XYZ should probably consider the effect of HF among the users of the technology or tool in the system. In addition, the findings from the correlation coefficients and *p*-values for each variable in study 1 (ABC) as shown in Table 7 depicts that all the HF variables have a positive relationship with the performance of the system, and they all contributed to explain variations in job performance. However, in study 2 (XYZ), job fatigue and job rotation have a negative relationship job performance when considered independently. Therefore, the results in the comparison table show that satisfaction among workers in ABC is an integral part of the inventory system and management of any inventory control system should increase the awareness of equal workload when incorporating job rotation in warehouse planning and shipping scheduling. Additionally, this study revealed that in the absence of considering some of these factors into inventory system, there may be some disruption in the entire E-commerce system or distribution system due to dissatisfaction of workers. Also, the findings in this study will be used by warehouse and inventory managers in their decision-making process and policies to consider the workers well-being in terms of job satisfaction and safety. Consequently, this study also underscores the need for businesses, especially in the warehouse and logistics sector, to prioritize the well-being and work environment of their employees. Furthermore, investing in continuous training programs would ensures that employees are up to date with the latest technologies and practices, which not only boosts their performance but also increases their job satisfaction.

A satisfied and skilled workforce, offered opportunities for job rotation while mitigating job fatigue, will undoubtedly lead to higher job performance. In conclusion, this research not only supports the hypotheses we set forth but also provides empirical insights into the dynamic significance between HF and job performance in diverse organizational settings.

One of the limitations of this study is that the current study was conducted with a relatively small sample size. Therefore, it is recommended to expand the sample size to enhance the generalizability of the findings. A larger sample would provide a more robust analysis and improve the accuracy of the results. Also, there are several future studies under plan. Firstly, there is a need to consider additional variables that may have an impact on job performance such as remuneration, social factors etc. For a fact, factors such as organizational culture, leadership style, and work-life balance could also be included to provide a more comprehensive analysis. Secondly, there is a need to supplement the quantitative analysis with qualitative research methods such as individual interviews or focus groups interview. In general, this would help gather in-depth insights into the experiences and perceptions of the participants, while providing a richer understanding of the correlation between the variables. Thirdly, in future similar research as this, there is a need to consider different industries or sectors,[27,60] to determine if the correlation between the variables hold true across various contexts. This would provide valuable insights into the generalizability of the findings and their applicability in different organizational settings.

The findings from this study can be used in recommending to future researchers to consider comparative analysis in their work. A comparative analysis between different groups or subgroups based on demographic factors or job characteristics can provide insights into potential variations to determine the correlation between variables. One contribution of this study is to significantly advance research in the fields of Operations Management (OP) and Supply Chain Management (SCM), especially in the context of e-commerce. Also, policymakers in OP and SCM can use the findings in this study in their decision-making process and policies. In addition, this study could help OP and SCM managers to be aware of how variables are correlated. Also, the results have shown important factors that determine work performance. For example, the job fatigue does not exhibit a statistically significant link with job performance in warehousing systems, although workers' skills, workers' satisfaction, and job rotation have been found to have a positive effect on system performance. This discovery advances the understanding of the variables affecting employees' job success and system performance. In conclusion, to improve job performance in any service system, the significance of taking workers' skills, and satisfaction, and job rotation into process design is needed. Also, more research is necessary to determine the consequences of job fatigue and how it can affect an employee's ability to execute their job. Finally, future work should add empirical evidence to support the correlation between certain variables such as specific warehouse environment (e.g., automation levels, task complexity), especially during the application of other techniques in decision-making,[61–63] when considering both subjective and objective management optimization technique to develop sustainable and resilient warehousing systems. Another important future work is on the optimal design of the interface of such an e-commerce system, which has two parts: operator-computer interface and user-computer interface. In literature, technologies for developing interfaces are available,[64,65] but they need to be updated to the modern era of information, which is characterized by big data, privacy and security awareness, mobile systems, and AI.[66–68]

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs

Akinola Ogbeyemi https://orcid.org/0000-0002-2183-2522
Wenjun Zhang https://orcid.org/0000-0001-7973-8769

References

1. Tsagkias M, King TH, Kallumadi S, et al. Challenges and research opportunities in E-commerce search and recommendations. *SIGIR Forum* 2020; 54(1): 1–23. DOI: 10.1145/3451964.3451966.
2. Wang J, Dou R, Muddada RR, et al. Management of a holistic supply chain network for proactive resilience: theory and case study. *Comput Ind Eng* 2018; 125: 668–677. DOI: 10.1016/j.cie.2017.12.021.
3. Wang JW, Muddada RR, Wang HF, et al. Toward a resilient holistic supply chain network system: concept, review and future direction. *IEEE Syst J* 2016; 10: 410–421. DOI: 10.1109/JSYST.2014.2363161.
4. Rubio S and Jiménez-Parra B. Reverse logistics: overview and challenges for supply chain management. *Int J Eng Bus Manag* 2014; 6: 12. DOI: 10.5772/58826.
5. Ogbeyemi A, Odeyemi J, Igenewari O, et al. A human factor approach to distribution network design for e-commerce in supply chain system: a case study. *Enterprise Inf Syst*. 2023; 17: 12. DOI:10.1080/17517575.2023.2200767
6. Pedeliento G, Andreini D, Bergamaschi M, et al. Brand and product attachment in an industrial context: the effects on brand loyalty. *Ind Market Manag* 2016; 53: 194–206. DOI: 10.1016/j.indmarman.2015.06.007.
7. Peltier JW, Dahl AJ and Swan EL. Digital information flows across a B2C/C2C continuum and technological innovations in service ecosystems: a service-dominant logic perspective. *J Bus Res* 2020; 121: 724–734. DOI: 10.1016/j.jbusres.2020.03.020.
8. Onion Bill. *B-to-b E-commerce Challenges: creating support in the organization*. Cleveland, Ohio: Briteskies, 2012, 1–3.
9. Zhang Y, Fang Y, Wei KK, et al. Repurchase intention in B2C E-commerce - a relationship quality perspective. *Inf Manag* 2011; 48(6): 192–200. DOI: 10.1016/j.im.2011.05.003.
10. Ghezzi A, Mangiaracina R and Perego A. Shaping the E-Commerce logistics strategy: a decision framework. *Int J Eng Bus Manag* 2012; 4(1): 13. DOI: 10.5772/51647.
11. Stritto GD and Schiraldi MM. A strategy-oriented framework for food and beverage e-supply chain management. *Int J Eng Bus Manag* 2013; 5(1): 50. DOI: 10.5772/57167.
12. Kusrini E, S and Masruroh NA. Good criteria for supply chain performance measurement. *Int J Eng Bus Manag* 2014; 6(1): 1–7. DOI: 10.5772/58435.
13. Wang JW, Ip WH, Muddada R, et al. On petri net implementation of proactive resilient holistic supply chain networks. *Int J Adv Manuf Technol* 2013; 69: 427–437. DOI: 10.1007/s00170-013-5022-x.
14. Zeng W, Tse MYK and Tang M. Supply chain quality management: an investigation in the Chinese construction industry. *Int J Eng Bus Manag* 2018; 10: 184797901881061. DOI: 10.1177/1847979018810619.
15. Council IEA. *Definition and domains of ergonomics*. Geneva, Switzerland: International Ergonomics & Human Factors Association, 2014. https://www.iea.cc/whats/index.html
16. Ogbeyemi A. *The effect of human factors on job performance among workers in a small manufacturing enterprise*. MS Thesis. Saskatoon, CA: Department of Mechanical Engineering, University of Saskatchewan, 2019.
17. Ogbeyemi A, Lin W, Zhang F, et al. Human factors among workers in a small manufacturing enterprise: a case study. *Enterprise Inf Syst* 2020; 15(6): 888–908. DOI: 10.1080/17517575.2020.1829076.
18. Wolff J. How is technology changing the world, and how should the World Change Technology? *Global Perspect*. 2021; 2(1): 27353. DOI:10.1525/gp.2021.27353
19. Murphy CB (2022) Brick and mortar stores. https://www.investopedia.com. https://www.investopedia.com/terms/b/brickandmortar.asp#:~:text=our-editorial-policies,What-Is-Brick-Dand%2DMortar%3F,brick%2Dand%2Dmortar-companies
20. Reinartz W, Wiegand N and Imschloss M. The impact of digital transformation on the retailing value chain. *Int J Res Market* 2019; 36(3): 350–366. DOI: 10.1016/j.ijresmar.2018.12.002.
21. Pérez-Campdesuñer R, De-Miguel-Guzmán M, Sánchez-Rodríguez A, et al. Exploring neural networks in the analysis of variables that affect the employee turnover in the organization. *Int J Eng Bus Manag* 2018; 10: 184797901877273. DOI: 10.1177/1847979018772738.
22. Hamzah MI, Ramli FA and Shaw N. The moderating influence of brand image on consumers' adoption of QR-code e-wallets. *J Retailing Consum Serv* 2023; 73: 103326. DOI: 10.1016/j.jretconser.2023.103326.
23. Parker SH. Human factors science: brief history and applications to healthcare. *Curr Probl Pediatr Adolesc Health Care* 2015; 45(12): 390–394. DOI: 10.1016/j.cppeds.2015.10.002.
24. Kim H, Kim T and Shin SW. Modeling roles of subjective norms and eTrust in customers' acceptance of airline B2C ecommerce websites. *Tourism Manag* 2009; 30(2): 266–277. DOI: 10.1016/j.tourman.2008.07.001.
25. Fachrunnisa O and Hussain FK. Blockchain-based human resource management practices for mitigating skills and

competencies gap in workforce. *Int J Eng Bus Manag* 2020; 12: 184797902096640. DOI: 10.1177/1847979020966400.
26. Luozzo SD, Starnoni F and Schiraldi MM. On the relationship between human factor and overall equipment effectiveness (OEE): an analysis through the adoption of analytic hierarchy process and ISO 22400. *Int J Eng Bus Manag*. 2023; 15. DOI: 10.1177/18479790231188548
27. Adeyemi B, Ogbeyemi A and Zhang W. Combining simple motion measurement, lean analysis technique and historical data review for countering negative labor cost variance: a case study. *Int J Eng Bus Manag* 2021; 13: 184797902110236. DOI: 10.1177/18479790211023617.
28. Sadangharn P. Acceptance of robots as co-workers: hotel employees' perspective. *Int J Eng Bus Manag* 2022; 14: 184797902211136. DOI: 10.1177/18479790221113621.
29. Yu HY, Ogbeyemi A, Lin WJ, et al. A semantic model for enterprise application integration in the era of data explosion and globalisation. *Enterprise Inf Syst*. 2021; 17: 4. DOI:10.1080/17517575.2021.1989495
30. Dayarian I and Pazour J. Crowdsourced order-fulfillment policies using in-store customers. *Prod Oper Manag* 2022; 31(11): 4075–4094. DOI: 10.1111/poms.13805.
31. Huria A. *Facilitating trade and logistics for E- commerce building blocks, challenges and ways forward*. Washington, DC: The World Bank, 2019, pp. 1–113.
32. Nguyen TV, Chau Nguyen B, Hang Cao T, et al. Factors affecting customer satisfaction with the last-mile delivery service of the food and beverage industry E-commerce in hanoi city. *Journal of Contemporary Issues in Business and Government* 2021; 27(5): 83–100, DOI: 10.47750/cibg.2021.27.05.008.
33. Bingi P, Mir A and Khamalah J. The challenges facing global E-commerce. *Inf Syst Manag* 2000; 17(4): 22–30. DOI: 10.1201/1078/43193.17.4.20000901/31249.5.
34. Rahman H and Han L. *Customer satisfaction in E-commerce a case study of China and Bangladesh*. Sweden: University West, 2011, pp. 1–61.
35. Zhang WJ and Lin Y. On the principle of design of resilient systems – application to enterprise information systems. *Enterprise Inf Syst* 2010; 4(2): 99–110.
36. Lu CY and Lin YY. Organizational support, work stress, and employee performance. *Manag Decis* 2018; 56(9): 2061–2075.
37. Bowling NA, Khazon S, Meyer RD, et al. Situational strength as a moderator of the relationship between job satisfaction and job performance: a meta-analytic examination. *J Bus Psychol* 2015; 30(1): 89–104.
38. Harter JK, Schmidt FL and Hayes TL. Business-unit-level relationship between employee satisfaction, employee engagement, and business outcomes: a meta-analysis. *J Appl Psychol* 2002; 87(2): 268–279.
39. Lyubykh Z, Gulseren D, Premji Z, et al. Role of work breaks in well-being and performance: a systematic review and future research agenda. *J Occup Health Psychol* 2022; 27(5): 470–487. DOI: 10.1037/ocp0000337.
40. Ravenhill M and Liu B. Job rotation: analysis and applications. *Int J Prod Res* 1997; 35(7): 2029–2051.
41. Salas E, Tannenbaum SI, Kraiger K, et al. The science of training and development in organizations: what matters in practice. *Psychol Sci Publ Interest* 2012; 13(2): 74–101.
42. Ángeles López-Cabarcos M, Paula Vázquez-Rodríguez and Lara Quiñoá-Piñeiro. An approach to employees' job performance through work environmental variables and leadership behaviours. *Journal of Business Research*. 2022; 140: 361–369. https://doi.org/10.1016/j.jbusres.2021.11.006
43. Sarmiento R, Beale J and Knowles G. Determinants of performance amongst shop- floor employees: a preliminary investigation. *Manag Res News* 2007; 30(12): 915–927.
44. Judge TA, Thoresen CJ, Bono JE, et al. The job satisfaction-job performance relationship: a qualitative and quantitative review. *Psychol Bull* 2001; 127(3): 376–407.
45. Michael JH, Evans DD, Jansen KJ, et al. Management commitment to safety as organizational support: relationships with non-safety outcomes in wood manufacturing employees. *J Saf Res* 2005; 36(2): 171–179.
46. Song M, Kawakami T and Stringfellow A. A cross-national comparative study of senior management policy, marketing-manufacturing involvement, and innovation performance. *J Prod Innovat Manag* 2010; 27(2): 179–200.
47. Dineen BR, Ash SR and Noe RA. A web of applicant attraction: person-organization fit in the context of Web-based recruitment. *J Appl Psychol* 2013; 98(5): 917–927.
48. Jaber MY and Neumann WP. Modelling worker fatigue and recovery in dual-resource constrained systems. *Comput Ind Eng* 2010; 59(1): 75–84.
49. Riggio RE. *Introduction to industrial/organizational psychology*. London, UK: Pearson Higher Ed, 2013. DOI: 10.4324/9781315620589.
50. Williamson A, Lombardi DA, Folkard S, et al. The link between fatigue and safety. *Accid Anal Prev* 2011; 43(2): 498–515.
51. Lindström M, Hanson BS and Östergren PO. Work-related exhaustion and telomere length: a population-based study. *PLoS One* 2014; 9(5): e108599.
52. Power DJ, Heavin C and O'Connor Y. Balancing privacy rights and surveillance analytics: a decision process guide. *Journal of Business Analytics* 2021; 4(2): 155–170. DOI: 10.1080/2573234x.2021.1920856.
53. Loriaux M. Power/play. *Europe Anti-Power* 2018; 34(3): 18–32. DOI: 10.4324/9781315620053-2.
54. Mak MKY and Ip WH. An exploratory study of investment behaviour of investors. *Int J Eng Bus Manag* 2017; 9(9): 184797901771152. DOI: 10.1177/1847979017711520.
55. Habib M. An exploratory analysis of educational management for the universities. *Int J Eng Bus Manag* 2011; 3: 19. DOI: 10.5772/50940.
56. Kothari CR and Garg Gaurav. *Research methodology: method & techniques*. New Delhi: New Age International, 2002. https://www.newagepublishers.com/samplechapter/000896.pdf

57. Creswell JW. *Research design: qualitative, quantitative, and mixed methods approach*. Thousand Oaks, CA: Sage publications, 2014.
58. Krejcie RV and Morgan DW. Determining sample size for research activities. *Educ Psychol Meas* 1970; 30(3): 607–610.
59. Hair JF, Black WC, Babin BJ, et al. *Multivariate data analysis*. 7th edition. Upper Saddle River, NJ: Pearson Education, 2014.
60. Bajomo M, Ogbeyemi A and Zhang W. A systems dynamics approach to the management of material procurement for Engineering, Procurement and Construction industry. *Int J Prod Econ* 2022; 244(November 2021): 108390. DOI: 10.1016/j.ijpe.2021.108390.
61. Ji C, Lu XW and Zhang WJ. A Bi-objective optimization model for expert opinions aggregation and its application in group decision making. *IEEE Syst J* 2021; 15: 2834–2844. DOI: 10.1109/JSYST.2020.3027716.
62. Ji C, Lu XW and Zhang WJ. Development of new operators for expert opinions aggregation: average-induced ordered weighted averaging operators. *Int J Intell Syst* 2021; 36: 997–1014. DOI: 10.1002/int.22328.
63. Ji C, Dai Y, Lu X, et al. A proportional-integral-derivative inspired model for opinion dynamics in a trust relationship network. *IEEE Trans Syst Man Cybern Syst* 2024; 54: 3056–3068. DOI: 10.1109/TSMC.2024.3357776.
64. Lin Y and Zhang WJ. Towards a novel interface design framework: function–behavior–state paradigm. *Int J Hum Comput Stud* 2004; 61(3): 259–297. DOI: 10.1016/j.ijhcs.2003.11.008.
65. Lin Y, Zhang WJ and Watson LG. Using eye movement parameters for evaluating human–machine interface frameworks under normal control operation and fault detection situations. *Int J Hum Comput Stud* 2003; 59(6): 837–873. DOI: 10.1016/S1071-5819(03)00122-8.
66. Bi Z, Jin Y, Maropoulos P, et al. Internet of things (IoT) and big data analytics (BDA) for digital manufacturing (DM). *Int J Prod Res* 2023; 61(12): 4004–4021. DOI: 10.1080/00207543.2021.1953181.
67. Lin W, Xu M, He J, et al. Privacy, security and resilience in mobile healthcare applications. *Enterprise Inf Syst* 2023; 17: 3. DOI: 10.1080/17517575.2021.1939896.
68. Zhang WJ, Yang G, Lin Y, et al. On definition of deep learning. *2018 world automation congress (WAC)*. Stevenson, WA, USA: IEEE, 2018, pp. 1–5. DOI: 10.23919/WAC.2018.8430387.