

# Assessing lean practices within third-party logistics services providers in Jordan

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**Abstract**— This paper aims to evaluate the effect of Muda (waste) practices on warehouse efficiency within third-party logistics providers (hereafter: 3PLs) operations using Data Envelopment Analysis (hereafter: DEA). The study employs a quantitative method to evaluate the impact of Lean (Muda) practices on warehouse efficiency within 3PL operations. A descriptive and correlational design is used, integrating DEA for efficiency calculation and regression analyses to assess the relationships between Lean practices and performance metrics. Data collection involved structured questionnaires. The study found significant variations in efficiency among the decision-making units (hereafter: DMUs), with a few achieving optimal performance (100%) while many showed inefficiencies below 50%, highlighting substantial room for improvement. Regression analysis confirmed a strong positive correlation between total waste reduction practices with operational efficiency ( $R^2 = 0.894$ ,  $p < 0.001$ ). Among specific stages, waste reduction practices at Put-away, Picking, and Dispatching significantly improved efficiency, while Receiving practices had no meaningful impact. The originality of this study is in its integration of DEA and regression analysis for comprehensively assessing the impact of stage-specific waste reduction practices on 3PL operational efficiency in Jordan, a region with limited prior research.

**Keywords**—Waste Reduction Practices, Operational Efficiency, Data Envelopment Analysis (DEA), Logistics Performance, Third-Party Logistics providers (3PLs)

## I. INTRODUCTION

Warehouse operations are essential for effective supply chain management, impacting the overall efficiency and competitiveness of businesses (Öztürkoğlu, Gue, and Meller 2014; Salhieh and Alswaer 2022). As competition intensifies, supply chains face increasing pressure to enhance efficiency while maintaining high-quality product distribution (Ballou 2010; Liu and Lee 2018; Oláh et al. 2018; Tortorella et al. 2018). The trend of firms outsourcing logistics activities has led to a surge in demand for third-party logistics (3PLs) services, a shift largely driven by the growth of e-commerce and global trade (Jum'a and Basheer 2023). 3PLs provide crucial services such as transportation, warehousing, and distribution, making their management vital for sustaining supply chain operations (Partridge 2008; Min and Joo 2009).

In the competitive landscape, 3PL providers must meet customer demands for rapid, cost-effective, and high-quality service (Jum'a and Basheer 2023; Min and Joo 2009). Unfortunately, warehouses are often perceived as sources of waste due to their extensive operations (Gu, Goetschalckx, and McGinnis 2010; Battista et al. 2014; Abushaikha, Salhieh, and Towers 2018). Challenges such as poor layout design, inventory inaccuracies, and long order processing times hinder operational efficiency, leading to increased costs and reduced service quality (Appelqvist et al. 2016; Pires et al. 2017; Hübner, Kuhn, and Wollenburg 2016; Abushaikha, Salhieh, and Towers 2018).

Toyota identified seven types of waste in business processes: overproduction, waiting, unnecessary transportation, excess inventory, incorrect processing, unnecessary movement, and defects (Ohno 1988; Womack and Jones 2003; Villarreal, Garcia, and Rosas 2009). Bicheno and Holweg (2009) describe waste as anything beyond essential activities needed to complete tasks correctly and on time. Lean thinking seeks to eliminate waste, or 'Muda,' enhancing efficiency in warehouse operations (Womack, Jones, and Ross 1990; Monden 2011; Warnecke and Huber, 1995; Womack and Jones 1996; Agrawal 2010; Tahboub and Salhieh

2019). Identifying and eliminating Muda, such as excessive motion and overstocking, can streamline operations, reduce costs, and improve service quality.

Efficiency can be measured in various ways, with Data Envelopment Analysis (DEA) being one of the most widely used techniques (Pereira et al. 2021). DEA is a nonparametric method for ranking the efficiency of decision-making units (DMUs) like warehouses (Miguel 2024). It evaluates efficiency levels, identifies best practices, and highlights areas for improvement without assuming specific relationships among inputs and outputs (Tahboub and Salhieh, 2019). This method is particularly effective in assessing warehouse efficiency using relevant inputs and outputs (Abushaikha, Salhieh, and Towers 2018; Bag et al. 2018).

Despite extensive research on Lean practices, there is a lack of studies focused on the impact of Muda practices on warehouse efficiency, especially within 3PL operations (Abushaikha Salhieh, and Towers 2018; Salhieh, Altarazi, and Abushaikha 2019; Salhieh and Alswaer 2022; Tahboub and Salhieh 2019). Most previous studies have centered on manufacturing contexts or have employed traditional efficiency metrics, neglecting the unique challenges faced by 3PL warehouses.

This study aims to examine the impact of Muda practices on warehouse efficiency in 3PL operations through DEA. The objectives include identifying key Muda practices affecting efficiency, analyzing their implementation's influence on warehouse performance, filling the literature gap regarding Muda's impact in 3PLs, and providing actionable insights for industry practitioners on reducing waste and improving efficiency using Lean management techniques. The research seeks to answer two critical questions: (1) What are the key Muda practices affecting warehouse efficiency? (2) How does implementing these practices influence the relative efficiency of warehouses?

In conclusion, this study contributes empirical evidence to the understanding of Muda practices' impact on warehouse efficiency in 3PL contexts. It bridges Lean management principles and DEA efficiency measurement, offering a fresh perspective for evaluating and enhancing 3PL warehousing performance. For practitioners, the findings deliver actionable strategies to minimize operational waste and boost overall efficiency, thereby supporting 3PL providers in optimizing their operations through Lean management techniques. The paper is structured as follows: Section 2 reviews literature on Muda practices and DEA, Section 3 outlines the research methodology, Section 4 presents data analysis and results, and Section 5 discusses the implications of the findings

## II. THEORETICAL FRAMEWORK

Third-party logistics (3PLs) providers perform critical supply chain functions, including transportation, warehousing, and inventory control, leveraging expertise, technology, and data to enhance operational efficiency and reduce costs (Allway and Corbett 2002). They also offer additional services such as customs handling and returns management, enabling businesses to focus on core competencies while achieving cost savings, scalability, and global reach (Joo, Keebler, and Hanks 2013; Min and Joo 2009). As e-commerce and global trade expand, 3PLs play a pivotal role in improving logistics efficiency and cost-effective resource management (Partridge 2008). Effective warehouse management significantly enhances supply chain responsiveness and efficiency (Abdul Rahman et al. 2023; Joo, Keebler, and Hanks 2013). To remain competitive, 3PLs must continuously evaluate and improve financial performance, utilizing benchmarking to measure success against industry leaders (Min and Galle 1996). Rising fuel costs, insurance premiums, and increasing customer expectations necessitate lean operations for survival (Min and Joo 2006; Piercy and Rich 2009). Warehousing, storage, and distribution, particularly inventory management and order fulfillment, are key activities of 3PLs. This study examines critical warehouse operations—receiving, put-away, order picking, and dispatching—and their impact on efficiency through waste reduction practices, employing DEA to assess warehouse performance.

### A. *Warehouse Operations and Their Role in supply chain management*

Warehouse operations play a pivotal role in supply chain management, bridging production and the end customer. By facilitating storage, picking, packing, and shipping, warehouses enhance overall supply chain performance (Abdul Rahman et al. 2023; Salhieh and Alswaer 2022). Beyond temporary storage, warehouses provide essential services such as product protection, just-in-time (JIT) delivery, and customized customer services (Heragu et al. 2005; Abdul Rahman et al. 2023). Efficient warehouse operations are key to optimizing inventory management, order fulfillment, and cost-effectiveness (Abushaikha, Salhieh, and Towers 2018; Salhieh, Altarazi, and Abushaikha 2019). Despite their importance, warehouse operations are prone to inefficiencies, including bottlenecks that delay product movement and disrupt service logistics (Kodawski et al. 2017b). Effective warehouse management enhances customer satisfaction, reduces operational costs, and strengthens competitiveness by streamlining processes and shortening response times (Bartholdi and Hackman 2016; Abdul Rahman et al. 2023). Picking, as one of the most resource-intensive processes, can be improved by strategically placing high-demand items in accessible locations and employing efficient picking strategies (Gu, Goetschalckx, and McGinnis 2007; Le-Duc and De Koster 2005).

Warehouse efficiency is defined as achieving maximum output with minimal resource utilization, including time, labor, energy, and materials (Pereira 2021). Optimizing resources, systems, and processes eliminates unnecessary costs and maximizes profitability (Abushaikha, Salhieh, and Towers 2018). Key performance indicators (KPIs) such as labor productivity, energy consumption, and equipment efficiency measure the effectiveness of resource usage (Abushaikha, Salhieh, and Towers 2018). Operational efficiency specifically refers to fulfilling orders with the least resources (Miguel 2024; Salhieh, Altarazi, and Abushaikha 2019).

Data Envelopment Analysis (DEA) is a non-parametric tool widely used to measure warehouse efficiency. DEA evaluates multiple inputs (e.g., time, energy, equipment) against multiple outputs (e.g., items picked, orders dispatched, processing times) to identify best practices and improvement areas (Abushaikha, Salhieh, and Towers 2018; Bag et al. 2018; Pereira et al. 2021). This analysis distinguishes high-performing from low-performing warehouses, guiding organizations toward optimization. To address inefficiencies, many organizations adopt Lean management principles, particularly Muda (waste reduction practices). These practices focus on eliminating non-value-adding activities in processes like receiving, put-away, picking, and dispatching. By leveraging Lean strategies, warehouses minimize waste, simplify processes, and improve efficiency. This approach reduces costs, enhances responsiveness, and boosts supply chain competitiveness, solidifying the warehouse's role in supply chain success.

### B. *Lean Management and Muda in Warehouse Operations*

The lean methodologies, which come from Toyota's production system, are based upon the elimination of Muda (Womack and Jones 2003; Holweg 2007; Villarreal, Garza-Reyes, and Kumar 2016; Shah and Khanzode 2017). Lean thinking focuses on reducing seven types of Muda: This includes overproduction, unnecessary transportation, waiting, improper processing, excess inventory, unnecessary movement, and defects (Ohno 1988; Womack and Jones 2003; Vinodh, Kumar, and Vimal 2014; Dotoli et al. 2015). The initial application of Lean principles was related to manufacturing, but later they have been extended to service sectors, like warehousing (Gu, Goetschalckx, and McGinnis 2010; Cagliano et al. 2011).

According to Myerson (2012), lean warehousing intends to lower the waste in receiving, put away, picking, and shipping activities. This study has examined the impact of Lean tools on warehouse performance, identifying challenges related to the seven Muda types and the five core Lean principles: Value, Value Stream, Pull, flow, and Perfection (Womack and Jones 2003, Shah and Ward 2003, Piercy and Rich 2009). Using Lean warehouse management can reduce costs, improve stock control and boost responsiveness to customer needs (Bowersox et al. 2007; Tahboub and Salhieh 2019). Warehouse operations have been traditionally thought to be labor intensive and waste-producing practices in which waste reduction (Muda) have been performed in Lean management (Abushaikha, Salhieh, and Towers 2018; Battista et al. 2014).

MUDA in the 3PLs warehouses can take place in all of the processes such as receiving, put away, picking, and dispatching. The receiving process is inefficient in many ways: overstocking, unnecessary worker movement, delays due to poor scheduling or damaged goods. With poor layouts, there can be excessive travel, delayed work due to inefficient equipment, or misplaced items in put away. Waste may be due to: unnecessary movement, picking errors, and redundant checks. Lastly in shipping, inefficient packing and loading, wrong shipments, and too much packaging waste slow down the process. With Lean practices, organizations find ways to reduce waste, lower costs, and hence increase profitability by optimizing the use of their resources (Abedin and Siddique 2024; Pereira et al. 2021). Therefore, it has been shown that Lean methodologies reduce Muda, thereby improving operational efficiency and performance in warehouses (Sriraman 2023; Hosen et al. 2025).

### *C. Data envelopment analysis (DEA) in Efficiency Measurement*

Operational efficiency is used as an indicator for warehouse performance in this study, and DEA is used as a nonparametric approach to measure the decision-making units (DMUs) efficiency. Originally introduced by Charnes et al (1978) DEA has been widely used as a method of calculating relative efficiency and benchmarking performance across industries (Sufian 2011; Borges, Camanho, and Portela 2011; Phadnis and Kulshrestha 2012; Beriha, Patnaik, and Mahapatra 2011) The technique is suitable for various fields which include banking (Thanassoulis 1999), health care (Valdmanis 1992) and logistics (Min and Joo, 2006,2009), because the technique compares many inputs and outputs of similar entities.

DEA assigns a score of one to the most efficient DMUs and scores between zero and one to less efficient ones (Charnes, Cooper, and Rhodes 1978). By comparing the resources used by the relatively less efficient units with resources referred to by the most efficient, this method enables firms to detect the areas where it can improve (Sherman and Ladino 1995).

DEA has been applied in logistics by Min and Joo (2006, 2009) to assess the efficiency of the leading 3PLs firms, to detect inefficiency and obtain benchmarking. Nevertheless, Zhou et al. (2008) adopted DEA to examine the performance of 3PLs firms in China, and Panayides et al. (2009), Al-Eraqi, Mustafa, and Khader (2010) also utilized it to appraise the efficiency of international seaports.

The advantages of DEA over other traditional efficiency metrics like the ability to measure performance across multiple dimensions, assess relative efficiency, and identify best practice without requiring predetermined input output weights. DEA is a versatile and effective tool to measure operational efficiency in several industries, by providing insights on inefficiency and finding benchmarks for improvement (Min and Joo 2009; Salhieh et al. 2018).

### *D. Proposed Framework to Evaluate the Impact of Muda Practices on Warehouse Efficiency*

Although a great number of studies have been conducted on lean and Muda practices in manufacturing, few research exists regarding their impact on 3PLs warehouse operations (Abushaikha, Salhieh, and Towers 2018; Salhieh, Altarazi, and Abushaikha 2019; Salhieh and Alswaer 2022; Tahboub and Salhieh 2019). Although elaborate research has been conducted on Lean methodologies and efficiency measurements in 3PLs warehouses, there remains an evident gap in empirical studies pertaining to the impact of Muda in 3PLs warehouses through DEA. Prior studies are focused on manufacturing or based on traditional efficiency metrics without considering the special inefficiencies in 3PLs warehousing.

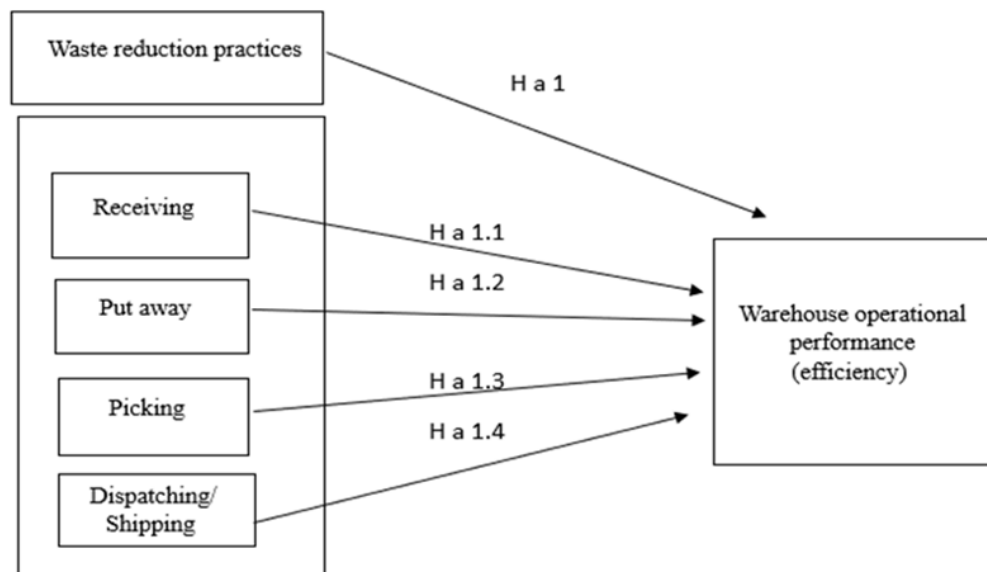
This study's main goal is to assess Muda practices' impact on warehouse efficiency within 3PLs operations through DEA. The study aims to: (1) identify the key Muda practices affecting warehouse efficiency; (2) analyze the effect of these practices on the relative efficiency of warehouses; (3) fill the gap in the existing literature by providing empirical evidence on the influence of Muda practices in 3PL warehouses; and (4) offer practical insights to help industry professionals minimize operational waste and improve efficiency using Lean management strategies.

To achieve these goals, the study poses the following questions: (1) What are the critical Muda practices that impact warehouse efficiency? (2) How does the application of these practices affect the relative efficiency of warehouses?

This study contributes to the literature by offering empirical evidence on the effect of Muda practices in 3PL warehouse efficiency. It bridges Lean management principles with DEA efficiency assessment, providing a novel approach to evaluating and enhancing 3PL warehouse performance. For industry professionals, the findings provide actionable insights to reduce waste and improve overall efficiency, supporting 3PL providers in optimizing operations through Lean management. According on the literature, this study suggests a theoretical framework as shown in Figure 1 (Salhieh & Alswaer, 2022; Salhieh et al., 2019; Min & Joo, 2006, 2009), to answer the study questions and achieve the objectives.

**Ha1: The implementation of Muda reduction practices in receiving, put-away, picking, and dispatching significantly improves warehouse efficiency in 3PL operations.**

- This hypothesis examines whether adopting Lean practices aimed at reducing waste (Muda) across key warehouse activities positively influences the overall operational efficiency of 3PL warehouses.



**Figure 1:** Framework of the study

### III. METHODOLOGY

This section explains the research methodology employed to evaluate the impact of Lean (Muda) practices on warehouse performance within 3PL operations. By integrating Lean management principles, particularly the elimination of waste (Muda), with DEA efficiency measurements, the study aims to give a comprehensive evaluation of warehouse efficiency. The approach used was a quantitative approach to analyze the relationship between logistics elements and warehouse performance, as outlined below.

The study targeted 212 3PLs registered with the Jordanian Logistics Association, of which 34 companies participated in the study. Following guidelines by Churchill and Iacobucci (2010), the unit of analysis was the organization.

### A. Data collection instrument validity and reliability

The primary data were collected through closed-ended questions in structured questionnaires, specifically targeting managers, supervisors, and operational workers. The questionnaire was divided into three sections, and non-probability sampling was used to ensure that the appropriate personnel (e.g., managers and supervisors) were included.

According to (Kallio et al., 2016; Rattray & Jones, 2007), Three design methods exist for measuring items or questions. These include the adoption of questions from other questionnaires, the adaptation of questions from other questionnaires, and the creation of new questions. They suggested that utilizing or modifying existing research questions can be more effective than creating new ones, provided that the necessary data can still be gathered to address the research questions and achieve the intended objectives.

In this research, the questions have been adopted and adapted from various sources for the four Waste reduction practices as seen in Table 1 (Receiving, Put away, Picking, Shipping/Dispatching):

- Receiving was measured using (Gamage et al., 2012; Salhieh et al., 2019; Sarwar and Haider, 2008; Skeldon et al., 2014; Srinivasan et al., 2016; Salhieh & Alswaer, 2022)eleven-item scale. Employees were asked to evaluate the extent of the waste reduction practices of the firm at the receiving stage. Responses were recorded on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree).
- Put away was measured using (Gamage et al., 2012; Salhieh et al., 2019; Sarwar and Haider, 2008; Skeldon et al., 2014; Srinivasan et al., 2016; Salhieh & Alswaer, 2022)four-item scale. Employees were asked to evaluate the extent of the waste reduction practices of the firm at the Put away stage. Responses were recorded on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree).
- Picking was measured using (Gamage et al., 2012; Salhieh et al., 2019; Sarwar and Haider, 2008; Skeldon et al., 2014; Srinivasan et al., 2016; Salhieh & Alswaer, 2022)seven-item scale. Employees were asked to evaluate the extent of the waste reduction practices of the firm at the Picking stage. Responses were recorded on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree).
- Dispatching was measured using (Gamage et al., 2012; Salhieh et al., 2019; Sarwar and Haider, 2008; Skeldon et al., 2014; Srinivasan et al., 2016; Salhieh & Alswaer, 2022)six-item scale. Employees were asked to evaluate the extent of the waste reduction practices of the firm at the Dispatching stage. Responses were recorded on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Secondary data from industry reports were used to supplement the findings. The sample was chosen purposively to ensure a balanced representation of all warehouse functions, from receiving to shipping.

Structured interviews and observational walkthroughs were conducted with warehouse managers, allowing for real-time evaluation of operational stages (receiving, put-away, picking, and dispatching). This methodology ensured the collection of accurate data, particularly in relation to Lean practices (Section 2) and performance indicators (Section 3) of the questionnaire.

Validity refers to the extent to which an instrument measures what it is supposed to measure without bias, as explained by Vogt and Johnson 2016. Validity also requires reliability, which is defined as the instrument's consistency in measuring the target variables across different uses (Vogt and Johnson 2016). To assess internal consistency reliability, Cronbach's alpha will be used. As per (Hair Jr. et al. 2017), Cronbach's alpha estimates reliability based on the inter-correlations between variables. A value above 0.7 is typically considered acceptable (Saunders 2009). For construct validity, exploratory factor analysis (EFA) will be conducted, retaining items with a factor loading of at least 0.45 (Hair, Ortinau, and Harrison 2010). Bartlett's test and the Kaiser-Meyer-Olkin (KMO) measure will be used to confirm data suitability for EFA, with KMO values above 0.50 indicating sufficient correlation between items. By following this comprehensive approach, the study aims to achieve credible and generalizable conclusions on the impact of MUDA practices on warehouse performance within 3PL operations within the investigated context.

**Table 1: Waste reduction practices validity and reliability**

construct	items	Factor loading for Retained Items	Cronbach's $\alpha$	Bartlett's test	p-value	KMO
Receiving stage	R1	0.562	0.835	133.154	0.000	0.736
	R3	0.800				
	R4	0.645				
	R6	0.545				
	R7	0.862				
	R8	0.660				
Put away stage	R11	0.863	0.678	8.598	0.000	0.606
	PA2	0.647				
	PA3	0.786				
Picking stage	PA4	0.761	0.701	14.308	0.026	0.692
	P4	0.625				
	P5	0.739				
	P6	0.613				
Dispatching	P7	0.812	0.786	28.917	0.000	0.743
	D1	0.703				
	D2	0.917				
	D6	0.809				

The analysis demonstrates good reliability and construct validity for the items measuring waste reduction practices across the four warehouse stages. The Cronbach's alpha values and significant Bartlett's test results show that the instrument is internally consistent and that the data is suitable for factor analysis. The KMO values further confirm the adequacy of the data for drawing meaningful conclusions about the impact of MUDA practices on warehouse performance within 3PL operations. These findings provide a solid foundation for generalizing the conclusions about waste reduction practices and their influence on performance in the studied context. Furthermore, a descriptive and correlational research design was employed. The descriptive component aimed to analyze existing Lean practices, while the correlational aspect explored the relationships between logistics activities and warehouse efficiency. The Lean framework focused on Muda (waste elimination), and the performance of the warehouses was measured using DEA, which allowed for a multi-dimensional efficiency analysis by comparing various input and output variables.

Collected data were subjected to DEA for efficiency analysis, single linear regression was used to evaluate the connection between Lean practices and performance metrics. Multiple regression analysis further assessed how variations in Lean practices affected warehouse efficiency. Statistical analysis was conducted using SPSS, while Excel was used for data organization.

#### *B. Data Envelopment Analysis (DEA) and Warehouse Efficiency Inputs and Outputs*

DEA is a non-parametric method used to assess the relative efficiency of DMUs (such as warehouses) through linear programming. This approach enables immediate evaluation of multiple inputs and outputs and is more suitable for such complex environments as warehousing (Joo, Keebler, and Hanks 2013; Min and Joo, 2006, 2009; Salhieh et al. 2018). Boyd and Färe (1984) introduced DEA, which compares every DMUs weighted sum of outputs to its weighted sum of inputs with reference to a frontier established with the most

efficient DMUs, thereby producing efficiency scores from 0 to 1, with 1 indicating optimal efficiency (Chatterjee and Chaudhuri 2022; Yin and Ran 2021). In warehousing operations, DEA aids in measuring operational efficiency, helping managers identify best practices, inefficiencies, and areas for improvement (Tahboub and Salhieh 2019). This study will apply DEA to assess the efficiency of warehouses operated by 3PL providers. According to the literature review on DEA, this study has selected and decided to focus on specific input and output variables that can be accurately collected and analyzed. Focusing on input variables such as the number of full-time employees (FTEs), warehouse size (in square meters), level of automation, and stock-keeping units (SKUs), along with output factors like daily order lines picked and the percentage of error-free orders shipped. Using DEA Solver, the study will compute efficiency scores. Using the DEA Solver software, efficiency scores were calculated, with scores closer to 1 indicating higher efficiency. This method provided a robust framework for comparing warehouse performance across the sample. Table 2 provides the descriptive statistics of inputs and outputs variables.

### C. Descriptive statistics

This section outlines the descriptive statistics of the key constructs related to evaluating the performance of various logistics processes. These statistics encompass measures of central tendency, dispersion, and distribution.

Measures of Central Tendency consist of the mean, median, and mode, which provide insights into the average and most common values within the dataset.

Measures of Dispersion include the minimum, maximum, and standard deviation, which indicate the range and variability of the data points.

Measures of distribution cover skewness and kurtosis, which help to assess the shape and characteristics of the data distribution.

The descriptive statistics existing here focus on four logistics activities identified in the literature: Receiving, Put Away, Picking, and Dispatching. The statistics reported for these activities include the sample size, minimum and maximum values, mean, and standard deviation in Table 2 providing a comprehensive overview of their performance metrics. Also, the descriptive statistics of the DEA inputs and outputs in Table 3.

**Table 2: Descriptive Statistics of Constructs (Receiving, Put away, Picking, Dispatching) for regression analysis**

Construct	N	Minimum	Maximum	Mean	Std. Deviation
Receiving	34	2.00	4.43	3.4671	0.60359
Put away	34	2.33	4.44	3.7165	0.55200
Picking	34	1.75	4.33	2.8860	0.69034
Dispatching	34	2.67	5.00	4.0351	0.58473

**Table 3: Descriptive statistics for DEA variables (inputs and outputs variables)**

	minimum	maximum	mean	SD	Variable type
FTEs	9	98	39.35	20.38	Input
warehouse size	750	20000	5092.94	4948.73	Input
level of automation	1	5	3.23	0.98	Input
SKUs	60	20000	1528.82	3041.47	Input
daily order lines picked	7	100	23.76	15.07	output
percentage of error-free orders shipped	95%	100%	98%	0.016	output

#### IV. RESULTS AND DISCUSSION

##### A. Data Envelopment Analysis (DEA) Results

This section shows the results of the DEA conducted to evaluate the efficiency of the logistics processes within the surveyed organizations. The DEA results presented in Table 4 provide the efficiency scores for 34 DMUs, expressed as percentages. These scores reflect how effectively each DMU performs relative to best practices within the group, with a score of 100% indicating maximum efficiency. The analysis reveals significant variations in efficiency among the evaluated entities.

##### Key Findings:

- **Highly Efficient DMUs (100% Efficiency):** DMU2, DMU14, DMU26, and DMU33 achieved the highest efficiency score of 100.00%, indicating that they operate at optimal efficiency.
- **Near-Efficient DMUs (85%+ Efficiency):** DMU1, DMU9, and DMU29 fall into this category, demonstrating commendable performance with scores above 85%.
- **Moderately Efficient DMUs (50-85% Efficiency):** DMU10, DMU22, DMU23, DMU27, DMU28, DMU32, and DMU34 are classified as moderately efficient, with scores ranging between 50% and 85%.
- **Less Efficient DMUs (<50% Efficiency):** The majority of the DMUs are in this category, with DMU7 recording the lowest efficiency score of 31.84%, followed closely by DMU5 at 32.99% and DMU31 at 32.53%. DMU3 (40.94%) and DMU4 (36.88%) also exhibit relatively low efficiency levels, suggesting these units may need to reassess their operational processes, inputs, or outputs to pinpoint areas of waste or inefficiency.

These findings highlight opportunities for improvement across many DMUs. The presence of both high-performing and underperforming units underscores the potential for enhancing operational efficiency on a broader scale. Organizations should focus on identifying specific areas for improvement to elevate overall performance within the supply chain.

**Table 4: Data Envelopment Analysis (DEA) results**

DMU number	Score
DMU1	96.94%
DMU2	100.00%
DMU3	40.94%
DMU4	36.88%

DMU5	32.99%
DMU6	47.13%
DMU7	31.84%
DMU8	33.83%
DMU9	94.71%
DMU10	61.82%
DMU11	37.82%
DMU12	37.74%
DMU13	48.96%
DMU14	100.00%
DMU15	49.98%
DMU16	40.11%
DMU17	40.11%
DMU18	37.56%
DMU19	51.82%
DMU20	33.19%
DMU21	41.03%
DMU22	72.11%
DMU23	75.77%
DMU24	40.11%
DMU25	35.95%
DMU26	100.00%
DMU27	52.17%
DMU28	48.22%
DMU29	85.81%
DMU30	41.78%
DMU31	32.53%
DMU32	54.77%
DMU33	100.00%
DMU34	74.96%

### *B. Regression Analysis Results and Hypothesis Testing*

This section aims to present and outline the regression analysis done in the study, using simple and multiple regression techniques. The analysis starts with a simple regression analysis to examine the relationship between the total waste reduction practices (independent variable) and efficiency scores (dependent variable). Finally, the results were used to test the hypothesis of the study about whether these practices explicitly affect efficiency significantly. Then, the main hypothesis is tested, and a multiple regression analysis is performed to see how individual waste reduction practices affect the efficiency score.

In this way, it enables a better understanding of how every practice contributes to overall operational efficiency. The results from both analyses present insights into how effective waste reduction practices are and what strategies could further improve efficiency through targeted intervention. In the following tables, detailed results including regression coefficients and model fit will be provided.

### C. Total Waste Reduction Practices: Simple Regression (Linear Regression Model)

For this analysis, regression is utilized to assess how well independent variables can predict the dependent variables, assuming a linear relationship. Key statistical measures such as R-squared, R squared, t tests, F tests, and ANOVA tests were provided with SPSS to determine the significance of relationships and predictive power of the model. Accordingly, simple regression analysis was conducted with efficiency as the dependent variable and total waste reduction practices (WRP) as the independent variable. The results, summarized in Table 5, present a strong positive relationship between WRP and efficiency, with an R-value of 0.923. The model explains 85.2% of the variation in efficiency, as indicated by an R square of 0.852 and an adjusted R<sup>2</sup> of 0.847. The p-value of 0.000 confirms the relationship is statistically significant. The F-statistic also supports the model's good fit. Additionally, the Durbin-Watson value of 1.652 suggests a slight positive autocorrelation among the residuals, but it is within an acceptable range, indicating that autocorrelation is not strong enough to undermine the regression model.

**Table 5: Simple Regression Model Summary**

Subject	R	R Square	Adjusted R Square	F Change	Sig.F value	P-	Durbin-Watson
efficiency Score	0.923	0.852	0.847	183.999	0.000		1.652

**Ha1:** There is a positive correlation between waste reduction practices and warehouse operational efficiency.

- **Results:**  $R = 0.923$ ,  $R^2 = 0.852$ ,  $p < 0.001$

The results show a statistically significant positive relationship between total waste reduction practices and the efficiency score, indicating that waste reduction practices play a key role in improving efficiency. The R<sup>2</sup> value of 0.852 means that 85.2% of the variability in efficiency can be explained by waste reduction practices. The p-value of less than 0.001 confirms the significance of this relationship. Therefore, an increase in waste reduction practices is linked to higher efficiency, and the alternative hypothesis is accepted, concluding that waste reduction practices effectively predict efficiency.

### D. Waste Reduction Practices (Receiving, Put Away, Picking, Dispatching) (Multiple Regression Models)

This section presents the results of the multiple regression analysis used to assess the impact of various waste reduction practices—specifically receiving, put away, picking, and dispatching—on operational efficiency. The analysis aims to determine how these practices collectively influence efficiency scores and identify which practices are most effective in enhancing warehouse performance. The results, summarized in Table 6.

The multiple regression model shows a strong positive relationship between the independent variables (receiving, put away, picking, dispatching) and the dependent variable (efficiency score), with a high correlation coefficient (R) of 0.945. This suggests that changes in the independent variables closely correspond to variations in efficiency. The model explains 89.4% of the variation in the efficiency score, as indicated by an R<sup>2</sup> value, with an adjusted R<sup>2</sup> of 0.879 confirming the robustness of the model. The p-value of 0.000, below the 0.05 threshold, confirms the statistical significance of the model in predicting changes in efficiency. The standard error of the estimate is 0.08336, indicating high precision in the model's predictions. Additionally, an F Change of 60.982 ( $p < 0.001$ ) shows that the combined effect of the independent variables on the model is significant. While the Durbin-Watson statistic of 1.489 suggests mild positive autocorrelation in the residuals, it remains close to the acceptable value of 2, indicating that autocorrelation is not a major concern for the model's validity.

**Table 6: Multiple Regression Results Summary**

Subject	R	R Square	Adjusted R Square	Std. Error of the Estimate	F Change	Sig.F P-value	Durbin-Watson
efficiency Score	0.945	0.894	0.879	0.08336	60.982	0.000	1.489

The coefficients table in the regression analysis highlights the relationships between the independent variables (Receiving, Put Away, Picking, Dispatching) and the dependent variable, Efficiency Score (Table 7).

**Table 7: Multiple regression coefficients results and multicollinearity tests summary of the independent variables**

Variable	Coefficient	Std. Error	t-Statistic	P-value	Collinearity Statistics VIF
Receiving	-0.022	0.027	-0.819	0.419	3.982
Put away	0.114	0.036	3.188	0.003	4.539
Picking	0.098	0.020	5.011	0.000	2.690
Dispatching	0.052	0.022	2.406	0.023	2.302

The unstandardized constant coefficient is  $B = -0.158$ , representing the baseline efficiency when all predictors are set to zero. Among the predictors, Receiving shows a coefficient of  $-0.022$ , with a p-value of 0.419, indicating an insignificant effect on efficiency. In contrast, Put Away (coefficient = 0.114,  $p = 0.003$ ), Picking (coefficient = 0.098,  $p = 0.000$ ), and Dispatching (coefficient = 0.052,  $p = 0.023$ ) all exhibit positive and statistically significant relationships with efficiency, with Picking showing the strongest and most significant influence ( $p < 0.001$ ). The significance of each predictor is confirmed by its respective p-values and t-values. For Receiving, the p-value of 0.419 and t-value of  $-0.819$  suggest a weak, non-significant effect. For Put Away, the p-value of 0.003 and t-value of 3.188 indicate a strong, significant positive impact. Picking ( $p = 0.000$ ,  $t = 5.011$ ) and Dispatching ( $p = 0.023$ ,  $t = 2.406$ ) both show significant positive effects on efficiency. To assess multicollinearity, the Variance Inflation Factor (VIF) was examined. VIF values less than five for all predictors indicate no significant multicollinearity, ensuring the model's coefficients are reliable and unbiased. This confirms that the independent variables are suitable for inclusion in the regression analysis, as they do not exhibit problematic correlations.

#### *E. Sub-Hypothesis Testing*

This section reports proposed correlation sub-hypotheses based on the results from Table 7. Therefore, tests of hypotheses are based on the reported results of correlations, according to the results of analyzing the data related to the variables of the study, which are presented in Table 6, the results of testing the hypotheses of the study were as follows:

Ha1.1: There is a positive correlation between waste reduction practices at the Receiving stage and the firm's operational efficiency.

The results indicate that waste reduction practices at the Receiving stage have a negligible impact on operational efficiency. The correlation coefficient of  $-0.022$  and the p-value of 0.4190, as shown in Table 7, are not statistically significant, meaning that Receiving practices do not meaningfully contribute to predicting

efficiency. Consequently, the alternative hypothesis is rejected, and it is concluded that waste reduction efforts at this stage do not significantly enhance efficiency. This lack of significance may suggest that current waste reduction practices in Receiving are either ineffective or overshadowed by other factors, such as procedural issues or insufficient staff training. Further analysis of practices at this stage is recommended to identify potential areas for improvement.

Ha1.2: There is a positive correlation between waste reduction practices at the Put-away stage and the firm's operational efficiency.

The results show that waste reduction practices at the Put-away stage have a significant positive impact on operational efficiency, with a coefficient of 0.1140 and a p-value of 0.003, as presented in Table 7. This indicates that improvements in waste reduction at this stage meaningfully enhance warehouse efficiency, controlling for other variables. Therefore, the alternative hypothesis is accepted, confirming that waste reduction practices during Put-away significantly contribute to operational efficiency. Effective waste reduction in this phase, such as minimizing unnecessary inventory movements, can reduce processing time and labor costs, leading to substantial improvements in warehouse operations. This finding highlights the importance of optimizing practices in the Put-away stage and encourages organizations to focus resources on strategies that improve efficiency in this phase.

Ha1.3: There is a positive correlation between waste reduction practices at the Picking stage and the firm's operational efficiency.

The results show that waste reduction practices at the Picking stage have a significant positive impact on operational efficiency, with a coefficient of 0.0980 and a p-value of 0.000, as indicated in Table 7. This suggests that improvements in waste reduction at the Picking stage substantially enhance warehouse efficiency. Therefore, the alternative hypothesis is accepted, confirming that waste reduction practices at Picking effectively explain operational efficiency. The significant relationship highlights that optimizing order picking techniques, such as using automated equipment and streamlined picking paths, can improve processing speed and customer satisfaction. These findings emphasize the importance of continuously evaluating and improving picking strategies to achieve significant efficiency gains.

Ha1.4: There is a positive correlation between waste reduction practices at the Dispatching/Shipping stage and the firm's operational efficiency.

The results show that waste reduction practices at the Dispatching/Shipping stage significantly enhance operational efficiency, with a coefficient of 0.052 and a p-value of 0.023, as shown in Table 7. This confirms that waste reduction efforts at this stage meaningfully contribute to improving warehouse efficiency. Therefore, the alternative hypothesis is accepted, indicating that waste reduction in Dispatching/Shipping plays a key role in explaining operational efficiency. Effective practices in this phase, such as optimized packaging, efficient shipping routes, and better carrier coordination, can lead to reduced shipping costs, faster delivery times, and improved service levels. These findings (Table 8) emphasize the importance of incorporating waste reduction strategies throughout the entire order fulfillment process, not just in storage and picking, to maximize operational optimization.

**Table 8: Results Hypothesis Testing**

Hypothesis Number	Hypothesis	Result	p-value
Ha1	There is a positive correlation between waste reduction practices and warehouse operational efficiency.	Accepted	< 0.001
Ha1.1	There is a positive correlation between waste reduction practices at the Receiving stage and the firm's operational efficiency.	Rejected	0.419

Ha1.2	There is a positive correlation between waste reduction practices at the Put-away stage and the firm's operational efficiency.	Accepted	0.003
Ha1.3	There is a positive correlation between waste reduction practices at the Picking stage and the firm's operational efficiency.	Accepted	0.000
Ha1.4	There is a positive correlation between waste reduction practices at the Dispatching/Shipping stage and the firm's operational efficiency.	Accepted	0.023

## V. CONCLUSIONS

The findings of this study emphasize the significant contribution of waste reduction practices in improving the operating efficiency of 3PLs in Jordan. It analyzes the effects of waste reduction practices over the Receiving, Put-away, Picking, and dispatching stages to integrate input and output factors that drive logistics performance within an integrative framework. Regression analysis combined with DEA has shown a positive influence between waste reduction practices and operational efficiency, specifically the Put-away, Picking, and dispatching stages. The findings emphasize that waste reduction practices significantly impact input factors used in this study FTEs, warehouse size, automation levels, and SKU diversity, while also driving improvements in key output factors, including daily order lines picked and shipment accuracy. The combination of these practices is central to optimizing resource allocation, improving throughput, reducing errors, and enhancing customer satisfaction.

Specifically, in the Receiving Stage, practices such as specifying packaging requirements and leveraging Advanced Shipping Notifications (ASN) contribute to better space utilization and more efficient labor planning, ultimately improving output metrics. In the Put-away Stage, the use of automated product location systems and flexible rack configurations facilitates more efficient resource allocation, while separating Put-away and Picking scheduling reduces bottlenecks and enhances throughput. The Picking Stage benefits from the application of SKU slotting and advanced picking technologies, which not only enhance labor efficiency but also minimize errors, improving order accuracy and speed. Finally, in the Dispatching Stage, the organization of dispatch areas and the implementation of systematic checks increase shipping accuracy, reduce delays, and further elevate efficiency.

While the Put-away and Picking stages showed the most consistent benefits, the Receiving Stage requires further investigation to identify additional barriers to effectiveness. The mixed-methods approach of this study highlights the need for a holistic, stage-specific waste reduction strategy that aligns both input factors (e.g., labor, automation, warehouse space) and output factors (e.g., order lines, accuracy, throughput) to achieve optimal operational efficiency.

In conclusion, this study not only demonstrates the positive impact of waste reduction practices across key logistics stages but also calls for continuous improvement and adaptation of these practices to optimize 3PLs operations in Jordan. The findings are significant for logistics managers, providing a roadmap for enhancing efficiency through the strategic integration of waste reduction methods. Further investigation, particularly in the Receiving Stage, will be crucial for unlocking additional efficiency gains and refining waste management practices for a more streamlined and effective logistics operation. This study lays the foundation for future research and the practical application of advanced methodologies such as Lean and Six Sigma to further optimize performance within 3PLs, both in Jordan and in similar markets globally. The study is limited by factors such as its sample size and dependence on self-reported data; future research could expand by applying this framework in other regional contexts.

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## Ocena vitkih praks pri ponudnikih logističnih storitev tretjih oseb v Jordaniji

**Izveček** - Namen tega članka je oceniti vpliv praks Muda (odpadki) na učinkovitost skladišč v okviru dejavnosti ponudnikov logističnih storitev t.i. tretjih oseb (3PL) z uporabo analize ovojnice podatkov (DEA). Študija uporablja kvantitativno metodo za oceno vpliva praks vitke proizvodnje (Muda) na učinkovitost skladišč v operacijah 3PL. Uporabljen je deskriptivni in korelacijski dizajn, ki vključuje analizo ovojnice podatkov (DEA) za izračun učinkovitosti in regresijske analize za oceno odnosov med vitkimi praksami in merili uspešnosti. Zbiranje podatkov je potekalo s strukturiranimi vprašalniki. Študija je ugotovila znatne

razlike v učinkovitosti med enotami za odločanje (DMU), pri čemer je le nekaj enot doseglo optimalno uspešnost (100 %), medtem ko so mnoge pokazale neučinkovitosti pod 50 %, kar kaže na precejšnje možnosti za izboljšave. Regresijska analiza je potrdila močno pozitivno korelacijo med praksami zmanjševanja skupnih odpadkov in operativno učinkovitostjo ( $R^2 = 0,894$ ,  $p < 0,001$ ). Med posameznimi fazami so prakse zmanjševanja odpadkov pri skladiščenju, pobiranju in odpremljanju znatno izboljšale učinkovitost, medtem ko prakse sprejemanja niso imele pomembnega vpliva. Izvirnost te študije je v integraciji analize ovojnice podatkov (DEA) in regresijske analize za celovito oceno vpliva praks zmanjševanja odpadkov v posameznih fazah na operativno učinkovitost 3PL v Jordaniji, regiji z omejenimi predhodnimi raziskavami.

**Ključne besede** - prakse zmanjševanja odpadkov, operativna učinkovitost, analiza podatkovnega ovijanja (DEA), logistična uspešnost, logistika tretjih strani (3PL)