Warehouse Waste Reduction Level and Its Impact on Warehouse and Business Performance

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Abstract: Warehouses considered as having a strategic role in supporting the overall competitiveness of the supply chain through achieving improved efficiency. Accordingly, lean thinking have recently found its way in the warehouse operations. The aim of this paper is to propose and test a model to assess the level of waste reduction practices and its impact on warehouse and business performance, and to encourage scholars to develop models to assess lean thinking and waste reduction in warehouse operations. A Delphi technique used in order to develop related questionnaires to measure the degree of waste reduction in the different warehouse activities. The results suggested the existence of a positive relationship between waste reduction activities and business performance and warehouse operational performance. Finally, this paper provides practical implications for warehouse and supply chains managers and directions for future researchers in this field.

Keywords: Lean Thinking, Waste, Warehouse Efficiency, Warehouse Performance, Delphi

1. Introduction

Toyota identified seven major types of waste in manufacturing and business processes (Ohno 1988; Womack & Jones 2003; Villarreal et al., 2009). These include overproduction, waiting, unnecessary transport, incorrect processing, excess inventory, unnecessary movement and defects. Bicheno & Holweg (2009) view waste as anything other than the minimum activities and materials necessary to get the job done immediately, right the first time and to the satisfaction of the customer. The Japanese word 'Muda' (Naylor, Naim & Berry 1999), or waste is a focus point in Lean thinking and production which strives to reduce a system's waste (Womack, et al., 1990; Warnecke & Huber 1995). Toyota started this concept about 50 years ago, when several tools and techniques were introduced to eliminate waste in a process such as: Value stream mapping, 5s technique, just-in-time production, continuous improvement programs, Kanban systems, continuous flow production and quick changeover methods.

The implementation of Lean tools or techniques in a service environment requires the service to be seen as a process of steps adding value to the work in progress (Swank 2003). Warehouses are being recognized as having such value-adding steps, kitting, pricing, labelling and product customization (Gu, Goetschalckx, & McGinnis 2010). As a result, the Lean techniques and tools, in recent years, have also found their way into the warehouse environment (Garcia 2003; Gu, Goetschalckx, & McGinnis 2010; Bozer 2012; Sharma & Shah 2015). Within a warehouse environment orders are the products assembled, and Lean in the warehouse focuses on assembling warehouse orders in the most efficient way, minimizing non-value adding activities in receiving, put away, picking, packing and shipping (Myerson 2012). Therefore, to minimize non-value adding activities warehouses have to identify wastes in these activities.

Most research concerning Lean warehousing have investigated Lean principles, methods, tools, and techniques and their relationship to warehouse performance (Garcia 2003; Womack & Jones 2003; Bicheno & Holweg 2009; Gu, Goetschalckx, & McGinnis 2010; Bozer 2012). As can be concluded from reviewed literature, the topic of Lean warehousing has been aimed at discussing the opportunities of applying Lean tools and applications in the warehouse operations in order to save the time and cost of these operations. However, literature still lacks a model to assess the level of waste reduction practices in warehouse environment. In fact, this assessment is essential, as the implementation of any Lean warehousing activities should start by evaluating the status quo of wastes in the system. The objective of this research is hence to address this gap in the literature, and provide a model to assess the level of waste reduction practices and accordingly fill this gap in literature. The contribution from this study provides new theoretical insights that will permit the development of a new instrument to assess the waste reduction practices in the warehouse environment. Results of this instrument can also guide managers in the choice of the proper Lean tools they should apply or adopt to improve their waste reduction practices initiatives. So, this study shall contribute to the identified gap in Lean warehousing research by proposing a model to assess the degree of waste reduction in the warehouse as the journey of Lean starts with assessing the level of waste in the system before using the tools, principles, and concepts of Lean. Therefore, the purpose of this study is to empirically test a framework identifying the relationships among warehouse waste reduction practices, warehouse operational performance and business performance. Warehouse waste reduction practices are defined as the set of activities undertaken by an organization to provide efficiency. The practices of warehouse waste reduction are proposed to be a multi-dimensional concept, including the activities of receiving, put away, picking and dispatching. Furthermore, by offering a validated instrument to measure warehouse waste reduction practices, and by providing empirical evidence of the impact of such practices on performance, it is expected that this research will offer useful guidance for measuring and implementing waste reduction practices in a warehouse operation and facilitate further research in this area. More specifically, this paper attempts to empirically answer two questions:

(1) Do warehouses with high level of waste reduction have greater warehouse performance?

Justification for question (1):

One could argue that "since "waste" by definition is detrimental to a company. So, why would the "waste reductions" NOT help lead to greater warehouse performance? So, If the positive link between waste reductions and warehouse performance is conceptually always true, why is it necessary to be tested?". Most of the research on Lean warehousing was case-based research of implementing waste reduction practices (lean tools) and benchmarking improvements before and after. This study attempts to empirically test this relationship by developing an assessment tool of such practices.

(2) Do warehouses with high level of waste reduction have greater business performance?

Justification for question (2)

One could argue that "given the firms studied are warehousing firms, why would the warehouse operation performance NOT have a positive impact on firm's business performance, because warehousing is its business? Aren't they necessarily or conceptually true, if warehouse=firm? How else should readers interpret this study's results?". Business performance could be improved by different pricing strategies and service levels offered to their customers even if the warehouse is solely its business. So, even if a warehouse as a company does have a low level of waste reduction practices might still have a greater level of business performance than its rivalries who have a high level of waste practices in their warehouses. The reader should interpret the results of this question as implementing waste reduction practices in a warehouse does have a positive impact on business performance and could be used beside other strategies that would improve business performance and compete efficiently and effectively.

There are different types and classifications of warehouses (Frazelle 2002; Bozer 2012) such as raw-material and component warehouses, work-in-process warehouses, finished good warehouses, distribution warehouses, fulfilment warehouses, local or regional warehouses, and value-added service warehouses. Bozer (2012) found that the principles of Lean warehousing do not change by the type of warehouse. Therefore, the results of this study should be applicable to all types of warehouse as much as possible. To meet the aim of the study, the paper begins by reviewing the most relevant literature and describing our theoretical model with proposed hypotheses. The research methodology is described in the third section, which include variable measurement, sampling methods, and data collection procedures. The fourth section displays the results of the empirical study and the hypotheses are discussed. Conclusions and directions for future research are presented in the last section.

2. Literature Review and Research Hypotheses

Figure 1 presents the proposed developed framework in this research. The framework proposes that warehouse waste reduction practices will have an impact on business performance both directly and also indirectly through warehouse operational performance. The warehouse waste reduction practices are conceptualized as a four dimensional waste practices in the stated warehouse activities. A detailed description of the development of the warehouse waste reduction practices construct is provided in the following paragraphs. Warehouse operational and business performance have been operationalized in the existing literature as stated in the following paragraphs. Using the given literature support, the expected relationships among waste reduction practices, warehouse operational and business performance are discussed and hypotheses relating these variables are developed.

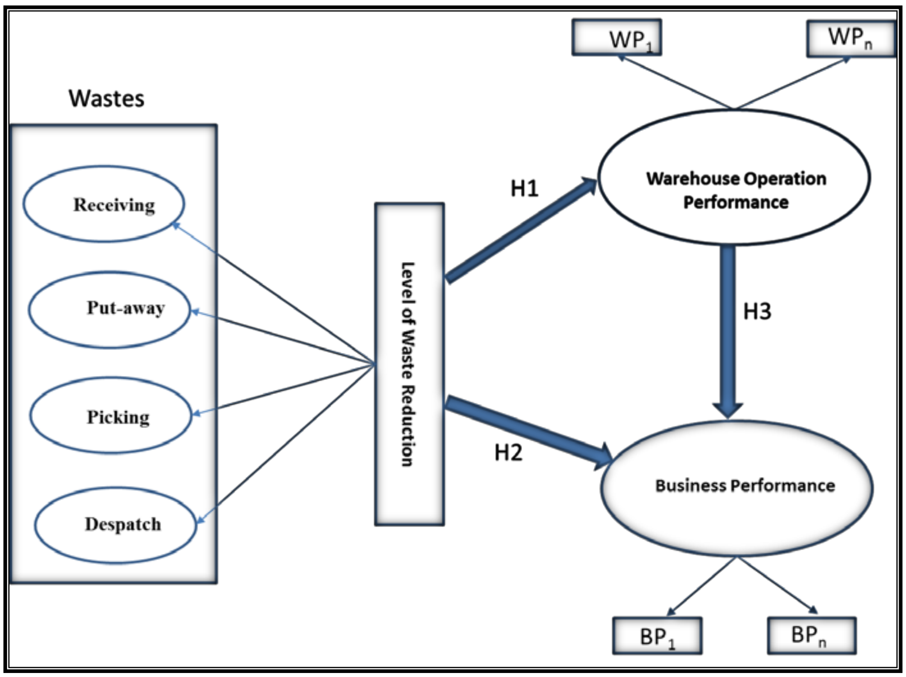

Figure 1. Proposed Model

2.1 Lean Warehousing

Understanding Lean starts with the analysis of waste in the system (Womack and Jones 1996) in order to reduce this waste. Seeking perfection through waste elimination or reduction is therefore core to Lean philosophy since implementation of the Lean principles and techniques aims fundamentally at elimination of non-value-adding work and other forms of waste (Liker 2004; Singh *et al*. 2010; Sawhney *et al*. 2010). Furthermore, as a concept the elimination of waste aims at an optimized use of available resources (Anand & Kodali 2009), and creation of high-quality goods and services at the lowest possible cost (Kumar *et al*. 2013). Therefore, the ultimate goal of Lean is to maximize value-creating activities to waste ration by reducing or eliminating forms of waste identified by Ohno (1988). The origin of waste elimination is associated with the concept of Lean manufacturing (Liker 2004); originally, in the manufacturing sector. However, different service operations have adopted the concept of waste elimination (Karlin & Liker 2005; Womack & Jones 2005; Hicks 2007; Castle & Harvey 2009; Piercy & Rich 2009; Pedersen & Huniche 2011; Laureani & Antony 2011; De Souza & Carpinetti 2014). Therefore, if the elimination of waste fits the service environment, which differs significantly from a standard manufacturing environment, warehouse operations should also be able to adopt the elimination of waste in its operations. Muraira, et al., (2014) asserted that transportation and warehousing operations represent good opportunities for the application of Lean concepts as these activities are classified as waste in Lean philosophy. The Lean approaches to transport improvement have found its way to decrease waste and increase efficiency (Sternberg & Harispuru 2016). Similarly, Sternberg *et al*. (2013) proposed a waste framework for motor carrier operations, and identified five out of the seven Toyota wastes (Ohno 1988) apply to motor carrier operations.

The importance of Lean concepts and their ultimate aim of eliminating waste for warehouse operations have been discussed by several scholars (e.g. Garcia 2003; Hines, Holweg, & Rich 2004; Kumar *et al*. 2006; Gu, Goetschalckx, & McGinnis 2010; Bozer 2012; Gagliardi et al., 2012; Sharma & Shah 2015). Bozer (2012) stated that the most pertinent issues experienced by warehouses in general are known as the seven wastes, and have related these wastes to the five Lean principles (Value, Value Stream, Flow, Pull, Perfection) as explained by Womack & Jones (2003), Shah & Ward (2003), Piercy & Rich (2009), and Shetty et al., (2010) as follows:

1. The storage of excess inventory – This not only minimizes effective storage space in the warehouse, but also has an impact on productivity, as employees may struggle to pick the appropriate order due to excess inventories being stored. This is seen as overproduction. In the warehousing environment, this occurs when an activity is completed before it is needed by the customer. Examples include pre-packing of goods before its required, picking orders too far in advance, thus creating unnecessary congestion and work-in-progress in the despatch area. Lean strives to eliminate overproduction through the Pull principle, where the warehouse only reacts to the customer's rate of demand (Womack & Jones 2003).
2. Unnecessary travel – Warehouse employees spending excessive time traveling within the warehouse to store and pick products. This may require additional employees to cater for the workload. This can be classified as transportation waste. In warehousing, this can be the movement of products or employees. This is seen as a "necessary non-value adding" process that the customer is not willing to pay for. Although it can never be fully eliminated, the warehousing operation should strive to minimize this as far as possible. When products aren't stored in a logical sequence, it forces a picker to travel unnecessary distances when picking an order (Bozer 2012). Lean attempts to minimize transportation waste through their third principle, Flow; by eliminating non-value adding activities.
3. Waiting time – This occurs when employees are ready to continue their work, but the process doesn't allow them to, due to unavailability of products, machines or the system (Bozer 2012). This is categorized as waiting waste. Waiting waste is minimized through the implementation of Lean's third principle, Flow, where delays in the process flow is diminished.
4. Motion – In cases where inventory is not stored at the correct location level, employees need to reach or bend over to pick the items. The reverse is also true, when employees have to store items at ergonomically uncomfortable heights when it can be avoided. This is classified as motion waste. Applying better Flow, the third Lean principle, would strive to eliminate this waste as far as possible, by storing the correct items in their appropriate locations to suit picking and storing needs.
5. Wrong or no Inventory - Warehouses rarely carry the exact inventory required, due to various different reasons. However, storing an excess or shortage of products remains a big challenge for warehouses. A shortage means that customer orders are not filled, while excess inventories restrict the flow of product through the facility. In Lean, this is seen as inventory waste. Along with various other 'tools' like economic order quantity (EOQ) models, minimum-maximum inventory level and inventory optimization, Lean attempts to carry the precise amount of inventory that is needed through the implementation of the Pull principle, by only reacting to the customer's demand. This however remains a big challenge in warehousing, as they need to cater for varying demands.
6. Insufficient processing – This issue occurs when warehouse employees need to re-enter certain information in order to do their daily job. It includes multiple scanning of barcodes (which can be eliminated) or using equipment with additional capacity. Classified as over-processing waste; any duplication of information entry is seen as waste (Bozer 2012). One very important aspect of Lean, Value Streams, can be greatly beneficial to streamline the process and eliminate such wastes (Womack & Jones 2003).
7. Defects and Damages – A major challenge in warehousing is picking the wrong item or wrong quantity. This can lead to under or over supplying the customer, or worse, supplying them with the wrong order. It further leads to more returns that need to be processed (due to incorrect shipment of orders), which means more staff is required. This is classified as the defect waste, which also includes damages within the warehouse. Damage is another challenge within warehousing, where inventory needs to be scrapped if can't be repaired. This directly affects a company's bottom line. Through the correct use of Womack and Jones' fifth and final Lean principle, Perfection, a company can supply its customer with exactly what is required, at a reasonable price, in the correct quantity and at the right time.

   Several studies (e.g. Smith 2003; Kumar *et al*. 2006; Fine, Hannam, & Morra 2009; Myerson 2012; Sharma & Shah 2015) have translated the seven deadly wastes of Lean production into the warehouse environment as follows:

   - Defects: handling and shipment of defective products. Incorrectly packaged goods, damaged products, wrong invoicing, wrong stocks' documentation; etc. Preparing and loading a customer's order with wrong products would lead to stock returns, hence it would involve a re-work.
   - Overproduction: replenishing, packing and picking products not yet needed. Energy and time is spent on producing a product that is not needed by the customer.

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- Waiting: Picked goods waiting for inspection, shipment or packing. People are waiting for pallets to place products on. Products are waiting to be transferred to a pallet or to be moved away. Bulk stacking or palletized stock to be re-arranged before new stock can be placed on it. Also, waiting in the parking lot as truck drivers queue up at the same time.
- Unnecessary motion: unnecessary movement of pickers and packers due to inefficient routing. Handling a product unnecessarily is seen as "double handling", or as a non-value adding activity. Unnecessary movements of people during delivering or supplying times. Also, unnecessary motion of work which involves lots of stretching or climbing on a bulk stack of products. Unnecessary movements in trying to locate equipment (forklifts, hand pallet trucks, etc.) left by other people in non-designated areas.
- Unnecessary inventory: Storing extra or buffer stock in the warehouse is another sign of waste. All inventory comers with a cost. It needs space to store it, people to count it, and managers to monitor it. Also, it could occupy vital space in the warehouse for other products that are actually needed by customers.
- Transporting: inefficient movement of products through inefficient layout and routing. Unnecessary travelling between products' release for loading or unloading and documentation point(s). Collection of print outs or copies of invoice(s) from different offices. Vehicles' parking lots placed far from the unloading or loading bay. Also, empty forklifts traveling through the warehouse.
- Inappropriate processing: unnecessary inspection of picked orders and unnecessary packing. For example, you might assign three quality checks to a picker before passing it to packaging and then require them to perform other quality checks. Moving a pallet with the hand pallet truck for some distance and then handing it over to a forklift for further transportation; is another example of inappropriate processing.

2.2 Lean effect on performance

Various studies have investigated the effect of Lean production on performance (Swank 2003; Shah & Ward 2003; Brandao de Souza 2009; Demeter & Matyusz 2011; Yang Hong & Modi 2011; Jaca *et al*. 2012). Many practitioners and researchers claim that Lean contributes to significant cost reduction, more productive workforce, shorter lead times and better quality (Krafcik 1988; MacDuffie 1995; Holweg 2007; Shah and Ward 2007). Some authors suggest positive link between Lean production and business performance (Callen, Fader, and Krinsky 2000; Mia 2000; Kinney & Wempe 2002; Fullerton, McWatters, & Fawson 2003). In addition, the link between Lean production and operational performance has been excessively researched and confirmed (Crawford *et al*. 1988; Cua, McKone, and Schroeder 2001; Laugen *et al*. 2005). Bowersox *et al*. (2013) asserted that Lean provides the warehousing operations with a competitive edge by ensuring the following:

- On-time delivery and low cost service to its customers through improved efficiency and productivity, together with high quality and accuracy in preparing orders.
- Improved stock integrity and better control over services by preventing picking disruptions, lack of material availability and loss of sales opportunities.
- Accurate levels of information flow and traceability between the warehouse and other legs of the supply chain.
- Management of the ever changing customer requirements and market complexities by adapting to demand changes and remaining flexible to meet seasonal and new customer demands.

The above arguments lead to:

Hypothesis 1: Firms with high levels of warehouse waste reduction practices will have high levels of warehouse operational performance.

The framework developed in this study proposes that warehouse waste reduction practices has a direct impact on the overall financial and marketing performance of an organization. Waste reduction practices is expected to increase an organization's market share and improve overall competitive position. Based on the above, it is hypothesized that:

Hypothesis 2: Firms with high level of waste reduction practices will have high levels of business performance.

Having a high levels of warehouse operational performance generally suggests that an organization can have an efficient operation when compared to its competitors. This efficiency will, in turn, enhance the organization's overall performance. Warehouse operational performance can lead to a high levels of economic performance, thereby increasing profitability and market share. Therefore, a positive relationship between warehouse operational performance and business performance can be proposed.

Hypothesis 3: The higher the level of warehouse operational performance, the higher the level of business performance.

This study proposes a model to assess waste reduction level and its impact on warehouse performance (WP) and business performance (BP) as depicted in Figure 1. Assessment of waste reduction level will be investigated based on the flow of activities along the value stream in the warehouse. In warehousing, the flow of activities can typically follow these steps:

- Receiving – Offloading of inventory and inspection of products to ensure correct quality.
- Put-away – Storing of the product in the suitable location, and making it available for picking to a customer.
- Picking – Once an order has been placed by a customer, the relevant product(s) are picked and prepared for dispatch.
- Dispatch/Shipping – As orders are fulfilled, they are packed and made ready for delivery to the customer.

3. Research Methodology

3.1 Waste reduction level construct

In order to develop related questionnaires to measure the degree of waste reduction in the different warehouse activities (receiving, put-away, picking, and despatch/shipping), a Delphi technique is used. This technique is especially appropriate when expert opinions are often the only source of information available, due to a lack of appropriate literature or information (Rowe & Wright 1999; Blind, Cuhls, & Grupp 2001; Mcleod & Childs 2007). It is not surprising that a number of supply chain researchers have used the Delphi approach (e.g. Akkermans *et al*. 2003; Ogden *et al*. 2005; Melnyk *et al*. 2009; Piecyk & McKinnon 2010; Von der Gracht & Darkow 2010) as research in supply chain management still needs more grounding in order to develop as a discipline. Similarly, as pointed in the literature review, there is a dearth of previous Lean warehouse research addressing types of waste in the different activities in the warehouse. As a result, a panel of experts is needed to shed light on waste reduction practices in the warehouse environment. In addition to literature scarcity, another major reason that makes the Delphi method the most appropriate to develop the waste reduction construct, is the complexity of the subject, which requires the knowledge of the experts in the field who understand the different practices to reduce types of wastes in the warehouse environment. The Delphi technique is well suited as a means and method for consensus-building by using a series of questionnaires to collect data from a panel of selected subjects (Dalkey & Helmer 1963; Dalkey 1969; Linstone & Turoff 1975; Lindeman 1981; Martino 1983). Since we wanted to canvas the views of expert academics and practitioners we needed to devise criteria for selection of experts as well as addressing the issue of the number and size of panels to be used. Some commentators (e.g. Okoli & Pawlowski, 2004) recommend adopting rigorous guidelines for selecting experts to include in the study. In contrast, other researchers prefer to interpret the phrase "expert panel" broadly as the individuals involved in the work. Brill, Bishop, and Walker (2006) used six-years of project management experience as a criterion to identify potential panel lists, rather than seek out project managers deemed to be expert. In the content of our study, practitioners must have a minimum of five-year experience in warehouse operation as managers. As far academics, the study have employed three criteria to identify suitable academics to participate such as: academic qualifications, experience teaching warehousing, and scholarly publication history in Lean thinking and warehouse issues. In deciding who to invite to join the expert panel from the academic community, we utilized our network of German and Jordanian lecturers and consults in the field of warehousing.

There is little agreement in the literature about the size of an expert panel (Keeney et al., 2001). Okoli & Pawlowski (2004) recommended 10-18 on a Delphi panel, and most studies indicated that a minimum panel size of 10-15 was needed (Sitlington & Coetzer 2015). In the content of this study, the expert panel size was 12 participants (50% practitioners and 50% academics). Theoretically, the Delphi process can be continuously iterated until consensus is determined to have been achieved. However, Cyphert & Gant (1971), Brooks (1979), Ludwig (1997), and Custer et al., (1999) point out that three iterations are often sufficient to collect the needed information and to reach a consensus in most cases. Some Delphi studies (McGuire & Cseh 2006) pointed out that the first round is a "brainstorming" stage, where panelists respond to open-ended questions, which serves as the cornerstone of soliciting specific information about a content area from the Delphi subjects (Custer et al., 1999). In this study, the Delphi questionnaire themes were based on identifying as many as waste reduction practices in receiving, put-away, picking, and despatch/shipping activities. After receiving participants' responses, the authors of this study converted the collected information into a well-structured questionnaire. This questionnaire is used as the survey instrument for the second round of data collection. In the second round, each Delphi participant received the structured questionnaire and asked to review the items summarized by the authors based on the information collected in the first round. Accordingly, Delphi participants were required to rate items as to their relevancy and applicability in capturing waste reduction practices in the investigated warehouse activities on four point Likert-type scale. In a Delphi study, a decision rules must be established to both define and determine consensus. Basically, consensus on a topic can be decided if a certain percentage of the votes falls within a prescribed range (Miller 2006). Green (1982) suggests that at least 70 percent of Delphi subjects need to rate three or higher on a four point Likert-type scale and the median has to be at 3.25 or higher. As a result of round two, areas of disagreement and agreement are identified (Ludwig 1997), and consensus begins forming. Items that are deemed to be less than 70 percent by the academic and practitioners are removed from the next round. In the third round and final round, each Delphi participant received a questionnaire that included the items and ratings summarized by the authors in the second round and were asked to revise their judgments. Based on the response of this round, the Kendall's W, also known as Kendall's coefficient of concordance, was used to estimate the level of consensus between the members of panel. According to Schmidt (1997), a value of Kendall's W of 0.7 or higher can be interpreted as strong agreement. The results of Kendall's W are shown in Table 1.

Table 1. Kendall's W for Waste Reduction Practices

	Statistics	Receiving	Put-away	Picking	Dispatch/Shipping
Panel	N	12	12	12	12
	Kendall's W	0.889	0.764	0.712	0.709
	$\chi 2$	36.587	34.380	33.126	32.403
	df	10	5	8	6
	p	0.001	0.04	0.03	0.001

The final items that constitute the waste reduction construct are finalized to be used as our instrument to measure the level of waste reduction in the warehouse environment as shown in Table 2.

Table 2. Waste Reduction Construct

Warehouse Activity Items	**Item Description**
Receiving (R)	
R1	As a warehouse manager, you are involved with purchasing in specifying and agreeing the packaging, items per carton, carton per pallet, and labeling requirement.
R2	You ask your suppliers to send deliveries with the most suitable packaging for you.
R3	You specify a time schedule for the suppliers to make the delivery.
R4	You receive a notification from the suppliers/shipper before a delivery arrives at your warehouse. (ASN = advanced shipping notification)
R5	You are able to plan the correct equipment (forklift trollies, powered trucks, and pallets jacks) to use in unloading before the delivery arrives.
R6	You are able to plan enough labor to unload the delivery before it arrives.
R7	You are able to plan sufficient space to unload the delivery before it arrives. You have always stock-keeping units (SKU) master data available, e.g. for new products, that you are able to store and handle these products appropriately?
R8	You perform cross-docking operations when possible or needed.
R9	It is easy to identify deliveries from suppliers (product, description, pack quantity)
R10	You do carry out inspections and quality checks on most of the goods received. In other words, you do count and identify 100% of the received products.
R11	You usually breakdown deliveries into smaller or lager increments (pallets to cartons or vice versa) for storage based on data collected from customer orders. In other words, you do not require deliveries from your supplier in the normal selling quantity in order to increase the speed of throughput and simplify picking. (You do not order in logistics units)
Put-away (PA)	
PA1	We have a system (computerized or warehouse manager) which allocate product locations prior to offloading and instruct the operator as to where to place the goods.
PA2	You notice any delays in put-away because of labor or equipment being occupied or missing.

Warehouse Activity Items	Item Description
PA3	The rack configuration is flexible enough to accommodate size of pallet received from suppliers.
PA4	The put-away team work adjacently with the picking team.
PA5	You create a time schedule to separate the operations of the put-away and picking team.
PA6	The put-away process follows an ABC-structure of the warehouse (A-articles close to good-in/good-out area; C-articles very far away within an aisle?
Picking (P)	
P1	You slot the heaviest SKUs in weight at the locations nearest to the start points of the pick.
P2	You slot items which are usually sold together next to each other.
P3	You use technologies in picking operations such as pick-to-light, voice picking, etc.
P4	You use double (volume and frequency) ABC categorization in order to slot SKUs
P5	Fastest-moving SKUs are placed in the middle row so that the order picker does not have to spend time bending and stretching.
P6	The picker sort the order while picking.
P7	The picker pick the exact quantity required.
P8	You use a warehouse management system to create an efficient route within the warehouse in the picking process.
P9	A worker can use “interleaving” method by putting away received SKUs and retrieving others required for a pick list in the same trip.
Dispatch/shipping (D)	
D1	There is sufficient space at the loading bay to stage the loads.
D2	Truck arrivals are subject to a system in the shipping area
D3	The picked orders arrive at the loading bay in the sequence in which they will be delivered.
D4	We have grids marked out on the warehouse floor at the dispatch area to replicate the floor area of the largest vehicle.
D5	Vehicles at the dispatch bay do not wait a long time until the dispatch team is ready.
D6	At our warehouse, the checking of vehicle papers at the dispatch bay ensures the match of the SKUs to the right vehicles.
D7	Dispatch operator checks and inspects that picked SKUs and quantities are correct.

3.2 Performance Measurements

Performance measurement underwent a revolution, from pure financial focus to include more comprehensive business characteristics (Neely, Gregory, and Platts 2005). Neely, Gregory, and Platts (2005) noted that although practitioners argued some areas in which performance measurement might be useful, little guidance is given on how appropriate measures can be applied to manage the business. Lean practices is frequently implemented at the shop-floor and is associated with production processes. Hence, the use of non-financial measures, which is not part of traditional accounting systems, seems to be useful in Lean areas (Abdel-Maksoud et al., 2005). Accordingly, this study will use qualitative measures to assess the operational warehousing and business performance constructs.

3.2.1 Warehouse Performance Construct

The major functions of a warehouse are to store products in order to make an assortment for customers, to assemble customer orders, sometimes to add value to the orders by customization activities, to organize transport to the customers, and to ship orders timely, in the way desired by the customer (Gudehus & Kotzab 2012; Bartholdi & Hackman 2011). Warehouse performance therefore, has multiple dimensions. Often, performance is measured in terms of ratios of output and input factors. This study will adopt a tool developed by De Koster (2008) to assess warehouse operations on a qualitative bases as shown in Table 3.

Table 3. Warehouse Performance Construct

Item #	Item Description
WP1	The facility is clean, safe, orderly and well lit.
WP2	The work processes are ergonomically well-thought over.
WP3	The layout prevents major cross flows.
WP4	Material is moved over the shortest/best possible distances.
WP5	Double handling is prevented and appropriate product carriers are used.
WP6	SKUs are stored on their right locations.
WP7	Appropriate (non-) splitting inventory is in bulk and forward pick stock applied.
WP8	There is an effective process management for introducing new SKUs, getting rid of non-movers, and internal relocations.
WP9	The organization of the picking process is well-designed without obvious improvement possibilities.
WP10	Storage and receiving processes are monitored and controlled on-line.
WP11	The response to mistakes and errors is immediate.
WP12	Ratings are for customer satisfaction and shipping errors are displayed.
WP13	The material handling systems are used, the racks and the product carriers in good operating condition and are well-maintained.
WP14	A right balance has been struck between order customization, process flexibility and efficiency.
WP15	Receiving and shipping processes and inventory levels are tuned with suppliers and customers.
WP16	This is a warehouse you would like to work in.
WP17	The air quality is good and noise level is low in warehouse.
WP18	The environment is attractive to work in.

3.2.2 Business Performance Construct

As far as measurement of business performance is concerned, the treatment of the performance construct has been one of the thorniest issues confronting academic researchers (Venkatraman & Ramanujam 1986; Cardinaels & Veen-Dirks 2010; Miller et al., 2013). Literature in the field of business management and organizational performance reveals that there is no consensus among the researchers regarding the measurement of business performance (March & Sutton 1997; Richard *et al*. 2009; Silvestro, 2014). Subjective as well as objective measures have been used by researchers for measuring business performance. However subjective measure of business performance are more commonly used (Naman & Slevin 1993; Jarvis *et al*. 2000; Wall *et al*. 2004; Wiklund & Shepherd 2005; Wood 2006; Ellis 2006; Clercq et al., 2010; Kraus *et al*. 2012). So, this study will measure business performance based on subjective measures as shown in Table 4.

Table 4. Business Performance Construct

Item #	Item description
BP1	We have superior quality of service compared to our competitors.
BP2	Our profitability has exceeded our competitors.
BP3	Our revenue growth rate has exceeded our competitors.
BP4	Our market share growth has exceeded our competitors.
BP5	Our customers are satisfied with our company’s delivery lead time compared to our competitors.
BP6	Our overall competitive position is better than our competitors.

4. Research Sample, Measures and Validation

The research population consisted of firms who owns and operate a warehouse, and organization was the unit of analysis. Despite the various classifications based on different criteria, the essential difference between warehouses is confined to the perspectives of the sources, management and users of the warehouse (Van den Berg & Zijm 1999; Frazelle 2002). On the other hand, what brings them together is set of common operations: receiving, storing, picking and despatching (Tompkins & Smith 1998). The sampling frame consisted of 100 firm drawn from the list of Jordan Chambers of Commerce. Participants for this research have been purposively chosen from a population of warehouse supervisors and managers as the most appropriate respondents because they are most familiar with their organization's practices and performance outcomes. The purposive sampling technique used homogeneous sampling, which aims to achieve a sample whose units share very similar traits and/or characteristics (such as gender, background, occupation). A homogeneous sample is chosen when the research question to be answered is particular to the characteristics of a certain group. In the case of this research, it is a group of warehouse employees. Furthermore, purposive sampling also enables other researchers to determine the generalization possibility of the qualitative research to other situations or phenomena, better known as transferability (Petty et al., 2012). The developed survey tool was administered in three mailings following a modified version of Dillman's (1978) "Total design for survey research". In the first e-mail, a cover letter explaining the purpose of the study and a survey questionnaire was sent. A letter encouraging non-respondents to participate in the research was sent four weeks later. Seven weeks after the initial mailing, a second survey and cover letter were sent to the remaining non-respondents. The resulting sample was made up of 160 usable responses which constituted 80 firms. Early versus late respondents were compared (Armstrong & Overton 1997) and no statistically significant differences were found on any of the study variables. Respondents reported an average of 55 employees with a total of 50 percent of the companies employing between 20 and 30 employees, and the largest firm employed 70.

A survey instrument incorporating waste reduction level, warehouse performance, and business performance was developed specifically to statistically measure the structural portions of the model presented in Figure 1. The survey instrument used in this study measured a total of 57 items: 33 items referred to waste reduction level, 18 items related to warehouse performance, and six items referred to business performance. The respondents were asked to indicate their degree of agreement or disagreement with the statements using five-point Likert scales, where "1" represented "strongly disagree" and "5" represented "strongly agree". Cooper and Schindler (2003) described that the researchers have to ensure whether or not the test measures do actually measure what is to be measured (validity) and maintain consistency of measurement results (reliability). One widely accepted classification of validity is: content validity; criterion-related validity; and construct validity. In this research, content and construct validity were employed. The content validity of a measuring instrument (the composite measurement scales) is the extent to which it provides adequate coverage of the investigative questions guiding the study. The content validity of the instrument used to measure waste reduction level in this research was ensured using the Delphi method as it acclaimed academicians as well as practitioners participated in developing this construct items. As far as the content validity of the warehouse and business performance, it was assured by adopting previous models as indicated previously. Factor analysis was carried out to examine construct validity on each construct separately because of the limitation of sample size (Hair *et al*. 2010). Only items with a factor loading of at least 0.45 were retained (Hair *et al*. 2010). Table 5 exhibits that a number of items were recommended to be omitted. The table shows that factor loadings for all retained constructs ranged from 0.46 to 0.82. Moreover, all constructs explain more than 50 percent of total variance. All the KMO values are greater than 0.50 as recommended by Kaiser (1974), indicating that patterns of correlations are relatively compact, and thus, factor analysis is reliable. In addition, The Bartlett's test is significant at $\alpha = 0.05$ for all the constructs, implying the variables are highly correlated to provide a reasonable basis for factor analysis (Coakes & Steed 2007). Therefore, the constructs used are valid and eligible.

Table 5. Validity and reliability of model constructs

	Receiving	Put-away	Picking	Dispatch/ Shipping	Warehouse performance	Business performance
No. of items in the survey	11	6	9	7	19	6
Deleted items	R 8	None	P 6	None	WP (2,10,14,17)	BP 1
Factor loading for retained items (Range)	(0.795 - 0.551)	(0.678 - 0.512)	(0.820 - 0.691)	(0.643 - 0.527)	(0.795 - 0.460)	(0.801 - 0.670)
KMO	0.72	0.83	0.84	0.86	0.78	0.71
Eigenvalue	2.32	3.52	4.17	4.27	2.51	2.19

	Receiving	Put-away	Picking	Dispatch/ Shipping	Warehouse performance	Business performance
% variance	51.39	71.23	66.82	53.39	51.19	54.27
α of retained items	0.716	0.722	0.786	0.771	0.783	0.831
Mean of retained items	3.64	3.85	2.99	2.15	3.47	3.31

Construct reliability is assessed by using Cronbach's α which is the most frequently measured form of reliability by researchers, that is, the "internal consistency reliability". It is the degree to which instrument items are homogenous and reflect the same underlying constructs. Cronbach's α coefficient was used for estimating internal consistency reliability, and its value ranges from 0 to 1. The generally agreed limit for Cronbach's α is 0.7, although it may decrease to 0.6 in exploratory research (Hair *et al*. 2010). Cronbach's α was used to assess reliability of each construct. The results of reliability test for the model constructs are summarized in Table 5. Cronbach's α value for this study ranged from 0.716 to 0.831. These values of α in excess of 0.7 indicate acceptable internal consistency associated with all the measures. Hence the scales can be considered to be reliable. Furthermore, the mean is reported in Table 5, which indicate a low to moderate adoption of waste reduction practices in the surveyed warehouses.

5. Results and discussion of hypotheses

Bivariate correlation analysis was used to make an initial assessment of the relations between the constructs as shown in Table 6. A composite measure for each construct was represented by the means values as reported in Table 5. For the waste reduction level the mean of the four sub-constructs means was used; found to be 3. The results showed that waste reduction level in warehousing was positively correlated with warehouse performance at $p < 0:01$ percent providing initial support for H1. Similarly, warehousing performance and business performance had a positive relationship at $\alpha = 0.10$ percent initially supporting H3. On the other hand, no significant relationship was found between waste reduction level in warehousing and business performance. This result initially suggested the rejection of H2. However, bivariate correlation analysis does not take into account the effect of other variables when calculating the correlation between two variables. The correlation between waste reduction level and business performance does not inform us of the direct effect of waste reduction practices on business performance, and it doesn't inform us of the indirect effect through the mediating effect of warehouse performance on business performance. In order to overcome this limitation and further investigate the impact of waste reduction level on warehousing and business performance, a structural equation analysis should be performed.

Table 6. Bivariate correlation

	Overall Waste reduction level (n = 80)	Warehouse performance (n = 80)	Business performance (n = 80)
Overall Waste reduction practices (n = 80)	1		
Warehouse performance (n = 80)	0.355*	1	
Business performance (n = 80)	0.021	0.092**	1
Notes: * Correlation is significant at the 0.01 level (one-tailed); ** correlation is significant at the 0.10 level (one-tailed)			

The hypotheses presented in Section 2 were tested using structural equation modelling (SEM). SEM is an appropriate statistical technique when testing a model that is hypothesized a priori; it assesses the relationships among latent constructs that are measured by multiple scale items, where at least one construct is both a dependent and an independent variable (Hair *et al*. 2010). Additionally, SEM allows researchers to estimate the strength of relationships among scale items and latent constructs, while giving the investigator an indication of the overall model fit. Prior to accessing the study's hypotheses, the model's overall fit must be established (Bollen & Long 1993). Table 7 shows the fit statistics for structural model. The Chi-squared statistic (χ^2) was significant. Other fit indices indicated an acceptable fit of the measurement model to the data.

Table 7. Results of the overall model fit

Fit measures	Suggested values	Structural model
Chi-square (χ^2)		221.32
Degrees of freedom (df)		201
p-value	≥ 0.05	0.007
χ^2 / df	≤ 3.00	1.10
RMSEA	≤ 0.10	0.048
NFI	≥ 0.90	0.92
NNFI	≥ 0.90	0.93
CFI	≥ 0.90	0.98
GFI	≥ 0.90	0.98
AGFI	≥ 0.90	0.97

The ratio of χ^2 to degrees of freedom (χ^2/df) and the root mean square error of approximation (RMSEA) were below the recommended maximum of 3.00 and 0.10 values, respectively (Chau 1997). The adjusted goodness of fit index (AGFI) was above the minimum recommended value of 0.80 (Byrne 1994; Hair *et al*. 2010). The remaining indexes, i.e. normed fit index (NFI), non-normed fit index (NNFI), comparative fit index (CFI) and goodness of fit index (GFI) were all above the minimum acceptable level of 0.90 (Byrne 1994; Hair *et al*. 2010). The model resulting from the estimation of the structural model is the one shown in Figure 2. LISREL coefficients between latent variables give an indication of the relative strength of each relationship (Jöreskog & Söbom 1993). The test of the proposed hypotheses is based on the total effects in the structural model (Table 8).

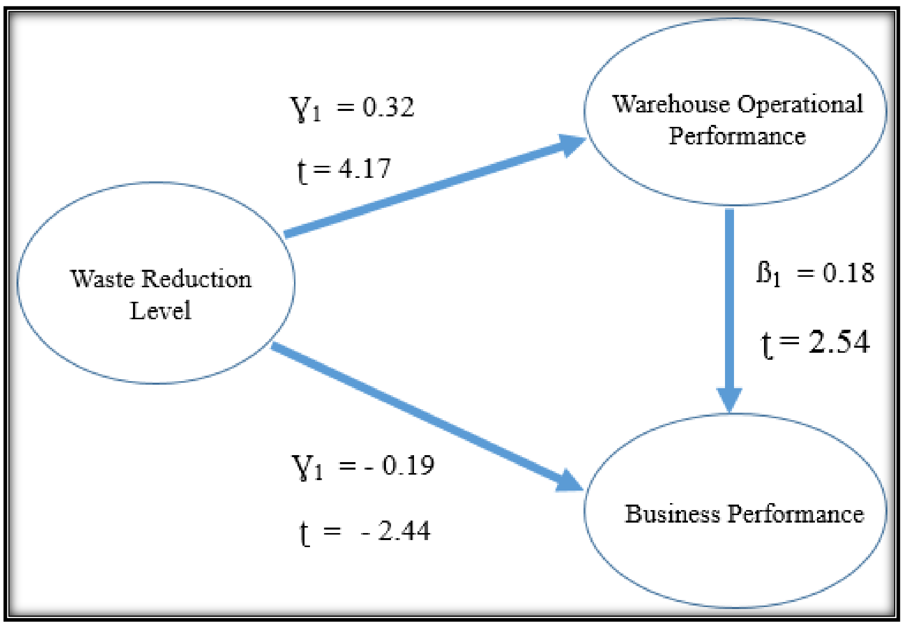

Figure 2. Structural Model Estimated

Table 8. Direct, indirect and total effects

Constructs	Warehouse performance	Business performance
Direct effects (Waste reduction level)	Coefficient = 0.32 t-value = 4.17	Coefficient = - 0.19 t-value = - 2.44 H2 not supported
Indirect effects (Waste reduction level)	Not applicable	Coefficient = 0.04 t-value = 1.86 H2 supported
Total effects (Waste reduction level)	Coefficient = 0.32 t-value = 4.17 H1 supported	Coefficient = - 0.21 t-value = - 2.82 H2 not supported
Warehouse performance	Not applicable	Coefficient = 0.18 t-value = 2.54 H3 supported

A positive significant coefficient estimate (t-values greater than 1.65 are significant at p < 0:05, one tailed) for the hypothesized paths reveals that support is found for each hypothesis. In view of the results, H1 was supported. The path between waste reduction level and warehouse performance was positive and significant (path coefficient = 0.32, t-value = 4.17) indicating that a positive relationship exists between waste reduction level and warehousing performance. This result suggests that warehouse managers that practice ways to reduce waste in the warehouse activities, achieve higher levels of warehouse performance than warehouses with lower levels of waste reduction practices. According to Table 8, waste reduction level had a significant positive indirect effect over business performance (coefficient = 0.04, t-value = 1.86) and thus confirmed H2. On the contrary, the results indicated that waste reduction level had a direct negative effect on business performance (path coefficient = -0.19, t-value = -2.44). Similarly, the total effect of waste reduction level on business performance was also negative and significant (path coefficient = -0.21, t-value = -2.82). Therefore, H2 were not supported. This result was not surprising, based in the fact that all areas of a firm affect business performance, and the efforts of a single area (warehouse activities) could not be sufficient if the other areas of the firm (fleet management) do not support it. Further research is needed to fully understand this relationship. H3 stated that warehousing performance has a positive direct impact on business performance. The structural path between warehouse performance and business performance was positive and significant (path coefficient = 0.18, t-value = 2.54). Hence, H3 was supported. This result implies that when warehousing performance levels increase, there is also improvement in business performance indicators.

This study is important because it is the first empirical research to establish relationships between waste reduction level, warehousing performance and business performance using a structural equation model. Therefore, this research fills a gap between theory and practice in the Lean warehousing area and its impact on warehousing and business performance. The implications of this study are also important because the results suggest that firms can improve their warehousing performance through an increased emphasis in waste reduction practices (elimination of waste).

6. Conclusions and Future Research

Although recent research acknowledges the importance of reducing the inefficient activities from road transportation, there is still a missing link in literature of how waste practices impact the performance of warehouses. The primary aim of this study was to propose a model to assess waste reduction level and investigate its impact on warehouse operation performance and business performance. Specifically, the study asked two questions:

- Do firms with high waste reductions levels have greater warehouse performance?
- Do firms with high waste reductions levels have greater business performance?

Due to scarcity of literature concerning the types of wastes in the warehouse environment, Delphi method was used to propose a measurement tool of waste reduction level. Accordingly, valid and reliable measurement instruments were developed to measure waste reduction level, warehouse operations performance and business performance. Subsequently, the analysis of a sample of 80 firms who own and operate a warehouse was used to examine the research questions. The study showed that, waste reduction level in the warehouse function has a significant positive impact on warehouse operation performance. The research also confirmed the notion that firms with high levels of warehouse operation performance also achieve high levels of business performance. Accordingly, the results of structural equation model testing indicated that there is a positive indirect effect of waste reduction level on business performance. The implications for warehouse managers are clear; efforts to reduce or eliminate types of waste in the warehouse activities improve warehouse operation performance and in turn improve business performance.

The theoretical contribution of this paper is significant. Besides the proposal of the validated instrument and its reported results, the paper also contributes to the application of Lea thinking to reduce ware in the warehouse operations. The intention of this paper was not to investigate the effectiveness of the Lean tools to reduce waste in the warehouse environment. Hence, a future research could address the effectiveness of applying the Lean tools to reduce wastes in the warehouse environment.

Our research fills this gap in literature, and proposes an empirical research model to assess wastes in warehousing operations and its impact on efficiency and provides a perspective from a Middle Eastern country context.

The study has a number of limitations that should be noted. A more stringent test of the relationships among waste reduction level construct, warehouse operation performance and business performance requires a longitudinal study, or field experiment, which could gather information about waste reduction level, warehouse operation performance and business performance on an appropriate time span. Then, the association between the variation of independent factors and the variation of performance could be further investigated. Future researchers are also invited to use the theoretical model developed in this study to test its validity and consequently, raise our knowledge of the lean practices relationship in the service context, particularly in warehousing operations.

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