Causal Factors of Lean Affecting Transportation and Warehousing for Waste Reduction and Value Added: A Literature Review

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ABSTRACT

The results of many companies can expect to see will differ from that of other companies. It will depend on where you start and what you put into it. Lean manufacturing or lean production is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Basically, lean is centered on preserving value with less work. Lean manufacturing is a management philosophy derived mostly from the Toyota Production System (TPS). It is renowned for its focus on reduction of the original Toyota seven wastes to improve overall customer value, but there are varying perspectives on how this is best achieved. To apply lean concepts in the context of warehouses, this research study focuses on applying the concepts for a general warehouse and refrigerated warehouse operation. Normally, a warehouse is a commercial building for storage of goods. Warehouses are used by manufacturers, importers, exporters, wholesalers, transport businesses, customs, etc. Generally, a cold storage company may provide service for keeping import and export chilled/frozen cargo, freezing, re-packing, and container vanning. A cold storage facility is not only essential for increased production capacity and larger profits, but also important in order to achieve maximum efficiency with minimum non-value added waste. This paper reviews the literature detailing lean manufacturing, general warehouse and refrigerated warehouse, and applying lean concepts in warehouses.

Keywords: Lean Manufacturing, Value Stream Mapping, Warehouse, Refrigerated Warehouse

INTRODUCTION

Lean manufacturing or lean production is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. Working from the perspective of the customer who consumes a product or service, “value” is defined as any action or process that a customer would be willing to pay for. Basically, lean is centered on preserving value with less work. Lean manufacturing is a management philosophy derived mostly from the Toyota Production System (TPS) (hence the term Toyotism is also prevalent) and identified as “Lean” only in the 1990s (Womack, 1990; Holweb, 2006). It is renowned for its focus on reduction of the original Toyota seven wastes to improve overall customer value, but there are varying perspectives on how this is best achieved. The steady growth of Toyota, from a small company to the world’s largest automaker, (Bailey, 2008) has focused attention on how it has achieved this. Lean manufacturing is a variation on the theme of efficiency based on optimizing flow; it is a present- day instance of the recurring theme in human history toward increasing efficiency, decreasing waste, and using empirical methods to decide what matters, rather than uncritically accepting pre-existing ideas. To apply lean concepts in the context of warehouses, this research study focuses on applying the concepts for a general warehouse and refrigerated warehouse operation. Normally, a warehouse is a commercial building for storage of goods. Warehouses are used by manufacturers, importers, exporters, wholesalers, transport businesses, customs, etc. They are usually large plain buildings in industrial areas of cities and towns. They usually have loading docks to load and unload goods from trucks. Sometimes warehouses are designed for the loading and unloading of goods directly from railways, airports, or seaports. They often have cranes and forklifts for moving goods, which are usually placed on ISO standard pallets loaded into pallet racks. A warehouse is typically

divided into functional areas that are designed to facilitate the material flow (Tompkins et al., 2010). The storage area is often divided into a reserve and a forward storage area. The reserve storage area covers typically distant and heavily accessible locations, e.g., the uppermost part of a rack, and is used to ensure the replenishment for the forward storage area (Peter Bodnar, 2013). For the specific refrigerated warehouse, there is a need for more efficient cold storage facilities in order to serve with the food consumption industries. Generally, a cold storage company may provide service for keeping import and export chilled/frozen cargo, freezing, re-packing, and container vanning. A cold storage facility is not only essential for increased production capacity and larger profits, but also important in order to achieve maximum efficiency with minimum non-value added waste. This paper reviews the literature detailing lean manufacturing, general warehouse and refrigerated warehouse, and applying lean concepts in warehouses.

WHAT IS LEAN MANUFACTURING ?

Definitions

Lean manufacturing or lean production, which is often known simply as "Lean", is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination. In a more basic term, more value with less work. Lean manufacturing is a generic process management philosophy derived mostly from the Toyota Production System (TPS) (hence the term Toyotism is also prevalent) and identified as "Lean" only in the 1990s. It is renowned for its focus on reduction of the original Toyota seven wastes in order to improve overall customer value, but there are varying perspectives on how this is best achieved. The steady growth of Toyota, from a small company to the world's largest automaker, has focused attention on how it has achieved this.

Lean principle come from the Japanese manufacturing industry. The term was first coined by John Krafcik in a Fall 1988 article, "Triumph of the Lean Production System," published in the Sloan Management Review and based on his master's thesis at the MIT Sloan School of Management. Krafcik had been a quality engineer in the Toyota-GM NUMMI joint venture in California before coming to MIT for MBA studies. Krafcik's research was continued by the International Motor Vehicle Program at MIT, which produced the international best-seller book co- authored by James Womack, Daniel Jones, and Daniel Roos called The Machine That Changed the World (1990). For many, Lean is the set of "tools" that assist in the identification and steady elimination of waste (muda). As waste is eliminated quality improves while production time and cost are reduced. Examples of such "tools" are Value Stream Mapping, Five S, Kanban (pull systems), and poka-yoke (error-proofing).

There is a second approach to Lean Manufacturing, which is promoted by Toyota, called the Toyota Way, in which the focus is upon improving the "flow" or smoothness of work, thereby steadily eliminating mura ("unevenness") through the system and not upon 'waste reduction' per se. Techniques to improve flow include production leveling, "pull" production (by means of kanban) and the Heijunka box. This is a fundamentally different approach to most improvement methodologies which may partially account for its lack of popularity. The difference between these two approaches is not the goal but the prime approach to achieving it. The implementation of smooth flow exposes quality problems which already existed and thus waste reduction naturally happens as a consequence. The advantage claimed for this approach is that it naturally takes a system-wide perspective whereas a waste focus has this perspective, sometimes wrongly, assumed. Some Toyota staff have expressed some surprise at the tool-based approach as they see the tools as work-around made necessary where flow could not be fully implemented and not as aims in themselves.

Both Lean and TPS can be seen as a loosely connected set of potentially competing principles whose goal is cost reduction by the elimination of waste. These principles include: Pull processing, Perfect first-time quality, Waste minimization, Continuous improvement, Flexibility, Building and maintaining a long term relationship with suppliers, Autonomation, Load leveling and Production flow and Visual control. The disconnected nature of some of these principles perhaps springs from the fact that the TPS has grown pragmatically since 1948 as it responded to the problems it saw within its own production facilities. Thus what one sees today is the result of a 'need' driven learning to improve where each step has built on previous ideas and not something based upon a theoretical framework. Toyota's view is that the main method of Lean is not the tools, but the reduction of three types of waste: muda ("non-value-addingwork"), muri ("overburden"), and mura ("unevenness"), to expose problems systematically and to use the tools where the ideal cannot be achieved. Thus the tools are, in their view, workarounds adapted to different situations, which explains any apparent incoherence of the principles above.

Previous Research on Lean Manufacturing

Ohno (1988)'s concept recognized the scheduling of work should not be driven by sales or production targets but by actual sales. Given the financial situation during this period, over-production had to be avoided and thus the notion of Pull (build to order rather than target driven Push) came to underpin production scheduling. Ohno at Toyota mentioned the concept of Toyota Production System (TPS). It is principally from the TPS, but now including many other sources, that Lean production has developed. While, Womack et al. (1990) published their groundbreaking book on lean production, "The Machine That Changed the World." Initially, lean initiatives focused on examining existing manufacturing processes, then re-working such processes to increase efficiencies. Similarly, Abdullah (2003) addresses the application of lean manufacturing concepts to the continuous production/ process sector with a focus on the steel industry. The goal of this research is to investigate how lean manufacturing tools can be adapted from the discrete to the continuous manufacturing environment, and to evaluate their benefits on a specific application instance. Although the process and discrete industry share several common characteristics, there are areas where they are very different. Both manufacturing settings have overlap, but at the extreme, each has its unique characteristics. This research attempts to identify commonalities between discrete and continuous manufacturing where lean techniques from the discrete side are directly applicable. The ideas are tested on a large steel manufacturing company (referred to as ABS). Value stream mapping is used to first map the current state and then used to identify sources of waste and to identify lean tools to try to eliminate this waste. The future state map is then developed for a system with lean tools applied to it. To quantify the benefits gained from using lean tools and techniques in the value stream mapping, a detailed simulation model is developed for ABS and a designed experiment is used to analyze the outputs of the simulation model for different lean configurations. Generalizations of the results are also provided. Furthermore, Sriariyawat and Zunder (2007) describe the impact of lean production to supply chain. There are some issues that might be considered for suppliers who are going to join or be the partner with Lean manufacturer. Also, the summarize effect of Lean production will be conducted a first round Delphi survey. The future study will gather information of the impacts of Lean production from Delphi expert panel from different regions (Thailand and European countries). Shahin and Janatyan (2010) stated that while Group Technology (GT) has considerable effects on important dimensions of lean production such as production wastes, set up time, quality and inventory management, the relationship between the two subjects has been not been sufficiently addressed in the literature. In this paper, a conceptual model has been proposed for enhancing productivity through the application of Group Technology (GT) in lean production systems. The model includes dimensions of GT and its relationship with lean production goals. Statistical analysis has been conducted and the links in the proposed model have been examined based on a questionnaire. The statistical population included managers of two industrial companies. The results confirm the high correlation between the elements of the proposed model in both companies. Also, the results of the variance analysis imply that except two items of the questionnaire, there is no difference in other items between the two companies.

Moreover, Ross (2003) stated that lean manufacturing has been re-discovered' by many UK manufacturing companies over the past two years. Announcements of its 'death' in the late 1990s as companies' focus moved into topical areas such as enterprise resource replacement (ERP), e-business, supply-chain management and product data management were undoubtedly premature. In a study completed by Codexx earlier this year into 25 medium-sized manufacturing companies based in the UK, 10 of them had an active lean manufacturing programme. A survey of 100 UK manufacturing executives in 2002 for The Manufacturer magazine showed that 45% were seeking to implement lean manufacturing within 12-24 months. Adopt a lean manufacturing strategy but make sure innovation plays a key part. On the other hand, Brown (2005) presented lean manufacturing, which establishes small production "cells," or teams of workers, who complete an entire product from raw material processing through final assembly and shipment, increases health and safety hazards by mixing previously separated exposures to various chemicals (with possible additive and cumulative effects) and noise. The intens ification of work leads to greater ergonomic and stress-related adverse health effects, as well as increased safety hazards. The standard industrial hygiene approach of anticipation, recognition, evaluation, and hazard control is applicable to lean operations. A focus on worker participation in identifying and solving problems is critical for reducing negative impacts. A key to worker safety in lean production operations is the development of informed, empowered, and active workers with the knowledge, skills, and opportunity to act in the workplace to eliminate or reduce hazards.

WAREHOUSES

Definitions

General Warehouse

A warehouse is a commercial building for storage of goods. Warehouses are used by manufacturers, importers, exporters, wholesalers, transport businesses, customs, etc. They are usually large plain buildings used for commercial purposes for storage of goods in industrial areas of cities and towns. They usually equipped with loading docks to load and unload goods from trucks. Sometimes warehouses load and unload goods directly from railways, airports, or seaports. They often have cranes and forklifts for moving goods, and are placed on ISO standard pallets loaded into pallet racks. The warehouse can also be preferred for distribution purposes. But since nothing the warehouse do with the item gives it more value in monetary terminology, little handling of the item as possible is to be preferred (Tostar, Martin and Per Karlsson, 2013). A warehouse requires labor, capital (land and storage and-handling equipment) and information systems, all of which are expensive. For most operations the answer is no. Warehouses, or their various cousins, provide useful services that are unlikely to vanish under the current economic scene (Bartholdi, John J. and Steven T. Hackman, 2014).

Stored goods can include any raw materials, packing materials, spare parts, components, or finished goods associated with agriculture, manufacturing, or commerce.

Some of the most common warehouse storage systems are:

- Pallet rack including selective, drive-in, drive-thru, double-deep, pushback, and gravity flow
- Mezzanine including structural, roll formed, rack supported, and shelf supported
- Cantilever Rack including structural and roll formed
- Industrial Shelving including metal, steel, wire, and catwalk
- Automated Storage and Retrieval System (ASRS) including vertical carousels, vertical lift modules, horizontal carousels, robotics, mini loads, and compact 3D

Traditional warehousing continuously is declining since the last decades of the 20th century, with the gradual introduction of Just in Time (JIT) techniques. The JIT system promotes product delivery directly from suppliers to consumer without the use of warehouses, but in some cases like of offshore outsourcing and offshoring in about the same time period, the distance between the manufacturer and the retailer (or the parts manufacturer and the industrial plant) grew considerably in many domains, necessitating at least one warehouse per country or per region in any typical supply chain for a given range of products. Recent retailing trends have led to the development of warehouse-style retail stores. These high-ceiling buildings display retail goods on tall, heavy duty industrial racks rather than conventional retail shelving. Typically, items ready for sale are on the bottom of the racks, and crated or palletized inventory is in the upper rack. Essentially, the same building serves as both warehouse and retail store.

Refrigerated Warehouse

Cold storage may refer to a form of refrigerated storage. The cold storage company may provide service for keeping import and export chilled/frozen cargo, freezing, re-packing, and container vanning. A cold storage facility is not only essential for increased production capacity and larger profits, but also important in order to achieve maximum efficiency with minimum non-value added waste.

Previous Research on General and Refrigerated Warehouse

Duiven and Binard (2002) conducted the research on cold stores or refrigerated warehouses that are facilities where perishable foodstuffs are handled and stored under controlled temperatures with the aim of maintaining quality. Preservation of food can occur under chilled (above zero) or frozen (below zero) temperatures. For some products, other conditions besides temperature control might be required: for living products (e.g. fruit) the moisture content and/or the composition of the surrounding atmosphere has to be changed as well. Controlled-Atmosphere storage of Ultra-Low-Oxygen storage are some of the techniques available. In a later year, Nitin Magoo (2003) stated that refrigerated warehouses play an important link in the storage of food products throughout the year under conditions specially suited to prevent their decay. In doing so, refrigerated warehouses serve as an indispensable link in maintaining the availability of otherwise seasonal food products all year round. A proper humidity and temperature level has to be maintained in the warehouse at all times to make this possible. The operation of the warehouse is an energy intensive process; however, under many electricity pricing tariffs, there are no cost benefits of adopting operating strategies that shift electrical usage to lower price (off-peak) periods, i.e., a demand-shifting strategy. But, with the deregulation of utility rate structures, there has been a gradual shift towards Real Time Pricing (RTP), whereby the electricity price varies every hour. The RTP rate is a typical example of the demand-supply interaction. The RTP structure offers consumers the incentive of reducing their electricity bill if they can shift their loads from high to low price periods. The benefit to the end-user is reduced utility operating costs (even with equal or slightly higher energy usage). The utilities benefit by being able to reduce their cost of electricity generation by stimulating stability in their aggregate demand of electricity through pricing signals.

Nonetheless, Gottlieb (2006) stated that refrigerated warehouse facilities operate in different fashions, depending upon whether they offer public or private refrigerated space. Public general storage facilities typically store food for clients at a stated unit rate. Private general storage facilities exist to facilitate an operator's role- often that of a producer, processor or manufacturer of refrigerated food products. Semi- private facilities store an operator's products in addition to offering storage space to outside clients. All facilities attempt to turn product over quickly, aiming for "just-in-time" delivery. Most refrigerated warehouse facilities have loading docks, and nearly all have interiors divided into cooler space and freezer space. Cooler space temperatures may range from 0 to 50 degrees Fahrenheit, while freezer space temperatures range from -5 degrees Fahrenheit to -30 degrees Fahrenheit. Among all operators, freezer space occupies 78 percent of total warehouse area; cooler space fills the remaining 22 percent. CEC (2007) mentioned that refrigerated warehouses have long been the target of energy efficiency programs run by the IOUs. These programs have generally targeted shell and refrigeration equipment specifications. Shell requirements address wall and ceiling U-values, interior wall U-values, floor U-values for frozen food warehouses, and door U-values. Refrigeration systems requirements address condenser sizing, condenser fan and pump power, condenser fan controls, compressor motor efficiency, compressor capacity control, evaporator sizing, evaporator fan control, and evaporator fan motor efficiency. Refrigerant piping and storage vessels, when located outside, have maximum U-value requirements. Lighting generally defaults to Title 24 requirements for warehouse and/or C&I work area categories. As part of this case study, we carried out secondary research on refrigerated warehouse energy efficiency, conducted interviews with contractors and designers, and conducted detailed energy modeling and economic analysis on a series of potential measures that could be addressed within Title 24. Based on the results of these activities, we propose a set of changes to the Standards.

Pacific Gas and Electric Company (2007) carried out secondary research on refrigerated warehouse energy efficiency, conducted interviews with contractors and designers, and conducted detailed energy modeling and economic analysis on a series of potential measures that could be addressed within Title 24. Based on the results of these activities, we propose a set of changes to the Standards. The proposed changes to Title 24 affect the building shell insulation levels, evaporator fan controls, condenser fan power and control strategies, compressor plant controls and interior lighting levels for refrigerated warehouses. The equipment-related changes deal only with the storage part of the facility; standards for pre-coolers or other clearly process related equipment was not addressed. Whereas, Bledso (2009) proposed the action plan of cold chain and storage. Warehousing and cold storage are the central elements in the food harvest, preservation and distribution system and should not be considered in isolation, but rather as a part of a primary sector commonly referred to as the “Cold Chain.” Constraints in the cold storage and warehousing sector in Azerbaijan go beyond a basic lack of capacity. Where cold storage exists, they also include a knowledge gap in how to build, run, and maintain a storage facility. Preventative maintenance schedules are lacking and rudimentary activities such as daily recording of cold chamber temperatures and humidity controls also seem to be missing. There are also problems of management and marketing of existing warehouse and cold storage facilities, which are often empty due to mismanagement. Finally, the fruit and vegetable sector as a hole lacks fundamental expertise in regards to post harvest handling of their crops. Given the importance of cold storage to many of the fruit and vegetable value chains, this is a sector where PSCEP could have a major impact.

Agricultural Statistics Board (2010) General refrigerated storage capacity in the United States totaled 3.79 billion gross cubic feet on October 1, 2009, an increase of 14 percent since the previous survey was conducted two years ago. While most of the increase from the previous survey was due to increased survey coverage of existing warehouses, some was due to new construction. This was the 46th biennial survey of refrigerated warehouses. The five States with the largest gross general warehouse capacity (million cubic feet) were: California with 495; Florida, 274; Pennsylvania, 227; Georgia, 218; and Texas, 198. In 2011, California Utilities Statewide Codes and Standards Team proposed changes to the Mandatory Requirements for Refrigerated Warehouses, Section 126 of the 2008 California Building Energy Efficiency Standards (the 2008 Standards. Refrigerated warehouses are extremely energy intensive and are fertile ground for additional energy savings and demand reductions. While, Cole (2011) mentioned about two process freezing techniques - contact freezing and air blast freezing. Contact freezers typically have lower operating costs, particularly from the standpoint of the amount of refrigeration required to accomplish the freezing and the cost of the associated energy required to do the freezing. This consideration will define the need for ice production and handling, special cutting, portioning, or other processing and/or cooking machinery. However, Jim Thompson (2011) mentioned that energy use in a cold storage facility is affected by the amount of heat the refrigeration equipment must remove and the efficiency of the equipment. The main sources of heat in a facility for long-term storage are transmission through walls, evaporator coil fans, lights, air leakage, and respiration of the stored commodity. Refrigeration system design has a great effect on energy use. The temperature of the refrigerant fluid after it is cooled in the condenser should be as low as possible. For example, a facility maintaining 32°F (0°C) and a condensing temperature of 125°F (52°C) requires 50 percent more power than one that operates at a condensing temperature of 95°F (35°C).

McMullan (2011) detailed the procedures of non-destructive infrared evaluation on two commercial refrigeration facilities and report the findings of these inspections. The use of non- destructive testing methods to examine the thermal envelope of low and medium temperature refrigerated facilities is the subject of this paper. Commercial refrigeration is similar to the refrigeration that occurs in your household refrigerator. Simply, it is the process of removing heat from an area and transferring that heat to a place where it makes little or no difference. Furthermore, the use of non- destructive infrared imaging of the refrigerated box provides an invaluable dialogistic tool. The presence of any type of breach in the box can create havoc with the refrigeration system. As the system works to remove latent and sensible heat from the cooler, the uncontrolled addition of ambient air can cause a number of problems including additional energy consumption, product loss and thermal envelope damage. Besides, Pineda and Diaz (2011) proposed that liquid-desiccant systems have been extensively studied as a way of reducing the latent load on air conditioning systems. Most of the studies have targeted the removal of moisture from air at ambient conditions. The literature about the use of liquid desiccants in low temperature applications is scarce. In this study, a small-scale liquid-desiccant absorber is installed inside a commercial refrigerated warehouse. Its performance under realistic operating conditions inside a pre-cooling room is analyzed. The results show that the dew point temperature of the air downstream of the absorber is comparable to the evaporator surface temperature suggesting the potential to delay the formation of ice on the cooling coil. An internal heat exchanger is used to lower the temperature of the inlet liquid desiccant flow to the absorber and the regeneration process is performed using only ambient air. The analysis of the reduction in water and energy consumption for a scale dup system is also performed. Nonetheless, Reindl and Mitchell (2011) investigated the possibility to utilize product stored in a refrigerated warehouse as a thermal energy storage media to minimize energy costs under real-time pricing rate structures. Demand shifting, i.e. precooling the warehouse during hours of low electricity prices to a lower temperature and shutting down the refrigeration equipment during high price hours, can yield operating cost savings. The increase in product temperature during equipment shutdown limits the possible floating duration. A computer model of a representative refrigerated warehouse was developed. The model includes the building envelope, the refrigeration systems and a model of the stored product. A thermally massive and a lightweight wall construction were investigated.

LEAN WAREHOUSE

Definitions

The underlying theme of “lean” thinking is to produce more or do more with fewer resources and less waste. Lean manufacturing is a recognized discipline-but the concept is just beginning to take hold in the distribution center. For applying lean concepts in warehousing, it can be applied to the distribution center to cut waste, improve productivity, increase space utilization and meet increasing customer demands. Lean principles can be applied key warehousing functions such as receiving, put- away/storing, replenishment, picking, packing and shipping. Each section concludes with a list of action items which guides the reader from theory to practical steps that can be implemented in the warehouse. It’s a practical approach that will help any warehouses reduce the waste from the operations.

Previous Research on Lean Warehouse

Wanitwattanakosol and Sopadang (2010) proposed a conceptual framework to apply many techniques for implementing lean in the high-variety low-volume (HVLV) environment is presented. Lean production has increasingly being implemented as a potential solution for many organizations. Anyway, the lean formula is applicable directly only to the make-to-stock business, but the make-to-order (MTO) product environment has to adapt lean manufacturing principle. The objective of this paper is to develop a suitable lean manufacturing system for SMEs. This modeling framework is also used to study the performance of the system for improving effectiveness. This paper addresses how to combine lean concept with simulation optimization, the step of this framework to obtain the optimization solution. On the other hand, Womack and Jones (2003) stated that achieving lean warehousing requires a certain mind set. A can-do attitude is the starting point. If you and your staff don't believe that "the perfect order" is attainable, normal error rates will persist. Lean thinking will require a conversion from top-down leadership to bottom-up initiatives. In a lean operation, every worker is an inspector, and everyone is expected to help the company achieve continuous improvement. Lean thinking will not occur in a hierarchical environment. Managers must become coaches rather than tyrants. Employees must be rewarded for being proactive.

According to logistics' view point, Zylstra (2005) conducted a study applying lean concepts to distribution and logistics. The challenges facing Profit-Chain Company were higher total logistics costs subject to financial budget pressures. There are a number of barriers to improve distribution and logistics operations such as freight cost or reliability, customer requirements, forecast accuracy, labor costs, quality, or planning processes that needed to be solved. The results indicated that forecasts are only accurate in the aggregate and over longer periods of time, re-planning as forecasts change takes time and effort, re-planning tends to induce snowball effect, customer service policies are not well documented or formalized, minimizing transportation in isolation can be a faulty objective, and high inventories may not equal responsiveness. Sezen and Erdogan (2009) conducted a study aimed at introducing the lean philosophy in the strategic supply chain management and its process. The lean tools are used to reduce wasteful activities across the supply chain. |The approach of lean brings the enterprises a value stream, which is called a business model. To reach high quality and customer satisfaction; the whole supply chain and each every chain implements the lean principles to have a competitive advantage and to reduce costs. So, the lean production can give the lower costs through eliminating waste.

Garcia (2007) conducted a case study of the ongoing application of pork producer by investigating lean concepts in normal warehouse operation. He assessed the operation using a value stream mapping (VSM) and product families and warehouse data, and identified lean improvements and continuous improvements. The resulted indicated that by proposing the future state using VSM, it was needed to expand warehouse to provide staging areas, most pallets are staged on floor, revise order picking methods, upgrade robotic palletizing systems, schedule and plan improved production, and increase turns of new markets for frozen products. Similarly, Calderone (2008) mentioned that a recent study involving a large HME supplier revealed that their overall order processing cycle time was grossly inefficient. Orders were being worked on less than 40 percent of the time within the total cycle time. Nearly nine percent of the total cycle time was spent on wasteful activities such as removing items from blocked aisles, waiting for a lift truck, searching for products, dealing with backorders, or staff having to deal with interruptions not directly related to picking and shipping. Many orders sat waiting or idle nearly 50 percent of the total cycle time. Sobanski (2009) conducted the research undertaken to fill a gap in the academic literature and in practice by developing a comprehensive lean implementation assessment tool for warehousing operations implementing lean manufacturing principles and techniques. The lean implementation assessment tool developed provides specific, actionable items that can be used in practice to further implement lean production and provide useful information to monitor the initiative's progress and make better resource decisions. Furthermore, the results from the application of the lean implementation assessment tool are analyzed to better understand the practical implementation and underlying factors of lean warehousing. Consequently, the research outcomes are two-fold, both filling the gap in the development of a comprehensive warehousing lean implementation assessment tool and providing insight into the actual implementation of lean warehousing.

In 2011, Dharmapriya and Kulatunga mentioned that according to Lean thinking it can be decided that the efficiency of warehouse operations depends on the layout arrangement, material handling techniques and media of transportation. Therefore, this study attempts to optimize warehouse layout: by allocating an economical place to each type of item while minimizing the honeycombing. However, due to the computational complexity of finding an optimal allocation within reasonable time frame, this is mathematically termed as NP-hard type problems. It has been found in the literature that the heuristic approaches are highly attractive than the traditional approaches for this instances. The Simulated Annealing heuristic was used to determine the optimal allocation of each category once the initial solution is generated by greedy approach. Generating a shortest route to collect all the items of a respective order is also an objective of this study. The route was decided based on the item's rank in the delivery route, distance in between two consecutive types of items and the weight. The improved layout was tested on several case studies and simulation results show that improved layout is beneficial in terms of travel distance (reduced by 30%) and resource utilization. Whereas, Fledderjohann (2011) stated that with a modernization project going on upstream from the warehouse, it was clear the Goodyear plant would require more than a retrofit for the current manual processes used for tire distribution. With the high number of SKUs, manual sorting capabilities had reached capacity, and Goodyear wanted to protect its workforce from the risk of injuries. It was also essential to have a Supply Chain Deployment strategy that offered real advantages to customers. It was also mentioned that in today's lean manufacturing and warehousing environment, it's a competitive advantage to have automation that can sort, temporarily stage, then ship tires directly to customers on demand. It not only reduces labor costs, it also keeps inventory levels low and customer response high. In the same year, Martichenko and Luery stated that the lean thinker believes in standard work as it produces the baseline from which we will improve. Visibility of material flow, inbound logistics, internal warehouse flow, and outbound logistics are critical to the lean warehouse. It is needed to understand the flow of material and be able to determine if we are supporting the "perfect order"; the right quantity, at the right place, at the right time in the right quality. The lean concept of "visual management" allows us to understand the score of the game (operation) so we can make decisions in real time that impact the overall flow of material to the customer. This is counter intuitive to many warehousing operations where the operation simply reacts to what trucks (or orders) show up at the facility on any given day. While, Venkateswaran et al (2011) conducted the research that implements, documents and evaluates the impact of implementing a hybrid 5S strategy versus two traditional 5S on hospital warehouses' operations by using Hybrid 5S that is an integration of inventory management techniques and process improvement tools. The results indicated that Hybrid 5S had the greatest impact compared to the traditional methods. Further measurement is required to maintain a steady increase in inventory turnover. Employee training and top-management involvement needs to be exercised in order to sustain the improvements for long term.

TABLE 1 SUMMARY OF RESEARCH PAPERS ON LEAN IN WAREHOUSE/ DISTRIBUTION/ LOGISTICS

Researcher	Theme and Description
Lean Manufacturing	
Ohno (1988)	A concept of Toyota Production System (TPS) Beyond Large-Scale Production and Lean production
Krafcik (1988)	Lean principles come from the Japanese manufacturing industry in the article, "Triumph of the Lean Production System"
Womack (1990)	Lean production in automotive industry. Lean initiatives focused on examining existing manufacturing processes
Zylstra (2005)	Lean concepts to distribution and logistics. Its aims at improving distribution and logistics operations such as freight cost or reliability, customer requirements, forecast accuracy, labor costs, quality, or planning processes
Sriariyawat and Zunder (2007)	Lean production to supply chain. The study is conducted to investigate the impacts of Lean production from Delphi expert panel from different regions
Pettersen (2009)	Lean production with conceptual and practical issues. He reviewed the literature to delineate what is Lean finds little evidence that the removal of waste is central to Lean yet Taichi Ohno
Sezen and Erdogan (2009)	Lean philosophy in strategic supply chain management and value creating. The approach of lean brings the enterprises a value stream, which is called a business model
Wanitwattanakosol and Sopadang (2010)	Lean in the high-variety low-volume (HVLV) environment. The objective of this paper is to develop a suitable lean manufacturing system for SMEs

Researcher	Theme and Description
General and Refrigerated Warehouse	
Duiven and Binard (2002)	Cold stores or refrigerated warehouses that are facilities where perishable foodstuffs are handled and stored under controlled temperatures with the aim of maintaining quality
Nitin Magoo (2003)	Refrigerated warehouses play an important link in the storage of food products and serve as an indispensable link in maintaining the availability of otherwise seasonal food products all year round
Gottlieb (2006)	Refrigerated warehouse facilities that operate in different fashions, depending upon whether they offer public or private refrigerated space
CEC (2007)	Refrigerated warehouses with energy efficiency programs run
Pacific Gas and Electric	Secondary research on
Company (2007)	refrigerated warehouse energy efficiency, conducted interviews with contractors and designers, and conducted detailed energy modeling and economic analysis on a series of potential measures that could be addressed within Title 24
Bledso (2009)	Warehousing and cold storage are the central elements in the food harvest, preservation and distribution system and should not be considered in isolation, but rather as a part of a primary sector commonly referred to as the "Cold Chain"
Agricultural Statistics Board (2010)	General refrigerated storage capacity in the United States totaled
California Utilities Statewide Codes and Standards Team (2011)	The proposed changes to the Mandatory Requirements for Refrigerated Warehouses
Cole (2011)	Two process freezing techniques - contactfreezing and air blast freezing

Researcher	Theme and Description
Dharmapriya and Kulatunga (2011)	Investigating new strategy for warehouse optimization by the use of lean warehousing. They studied the efficiency of warehouse operations that depends on the layout arrangement, material handling techniques and media of transportation
Jim Thompson (2011)	Energy use in a cold storage facility is affected by the amount of heat the refrigeration equipment
McMullan (2011)	The procedures of non- destructive infrared evaluation on two commercial refrigeration facilities and report the findings of these inspections with the use of non-destructive testing methods and non- destructive infrared imaging of the refrigerated box
Reindl and Mitchell	Investigating the
(2011)	possibility to utilize product stored in a refrigerated warehouse as a thermal energy storage media to minimize energy costs under real-time pricing rate structures
Lean Warehouse	
Womack and Jones (2003)	Lean thinking in the warehouse and existing manufacturing processes. In a lean operation, it is expected to help in achieving continuous improvement
Garcia (2004)	Showing how a warehouse operation can be improved using lean concepts and techniques. Warehouse improvement requires optimizing material flow, order picking, replenishment, and dock operations. Although many traditional lean techniques maybe difficult to apply, the concepts of improving material flow and eliminating waste can be used to make significant improvement in warehouse lead time.

Researcher	**Theme and Description**
Garcia (2007)	Lean concepts in normal warehouse operation. The operation using a value stream mapping (VSM) and product families and warehouse data, and identified lean improvements and continuous improvements
Calderone (2008)	Involving a large HME supplier that revealed the overall order processing cycle time was grossly inefficient and wasteful activities of handling materials equipment
Sobanski (2009)	Developing a comprehensive lean implementation assessment tool for warehousing operations implementing lean manufacturing principles and techniques
Martichenko and Luery (2011)	Visibility of material flow, inbound logistics, internal warehouse flow, and outbound logistics are critical to the lean warehouse
Venkateswaran et al (2011)	Implementing, documenting, and evaluating the impact of implementing a hybrid 5S strategy versus two traditional 5S on hospital warehouses' operations by using Hybrid 5S that is an integration of inventory management techniques and process improvement tools
Dehdari, P. (2013).	Lean warehousing is an upcoming research fields which often lack clear definitions, measurements and concepts. Adoption of a lean culture in a warehouse environment enables the supply chain to deliver extra added value.

CONCLUSION

The literature review presented here identifies detailed information of lean manufacturing, general warehouse and refrigerated warehouse, and applying lean concepts in warehouses that can be used for developing a proposed model of lean in warehouses operation. Nonetheless, this study also proposes lean tool development and regression model formulation in the warehouses operation in a later stage. It is hypothesized that creating a lean warehouse operation may understand cycle time and identify non-value added activities that are important requirements in order to identify lean improvement opportunities. Implementing lean tools and concepts into warehouse operations has produced impressive results in many different industries. Logistics service providers can have benefits by gradually transforming existing operations through the application of lean tools and concepts. Formulating the multiple regression model of the lean warehouses operation may identify what type of parameters can have a direct impact of the non-value added and necessary non-value added activities.

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