2013

Lean Distribution Concept, Constructs and Practices

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Abstract
In today's competitive market, applying lean thinking provides supply chain the ability to produce and deliver products in a timely and cost effective manner. To date, little research addressed lean distribution concept as an effective approach for improving supply chains. This caused a level of ambiguity regarding the concept's dimensional structure and its practices. This paper aims to explore the antecedents of lean distribution concept and identify its constructs and practices using a data driven analytical approach (i.e. exploratory factor analysis). Findings show that enhancing communication with customers, optimising transportation activity, people participating in problem solving procedures and increasing the reliability of distribution operations are critical dimensions of lean distribution paradigm.

Keywords: Supply Chain Management, Lean Distribution Dimensional Structure, Exploratory Factor Analysis

Introduction
Competition between enterprises is growing at an ever-increasing rate. Managers realize that competition is no longer limited to enterprise against enterprise rather than supply chain network versus supply chain network (Li et al., 2005). Distribution centres play a key role in improving supply chain performance, however shortened products life cycle, variations in customer demand, and extending supply chains across the globe drastically increase distribution uncertainty and variability (Frazelle, 2002). Given these pervasive challenges, successful distribution companies have to achieve high customer service level while reducing cost and waste to remain competitive.

Since lean thinking seeks to eliminate the sources of waste or at least mitigate their impact on companies' performance, it is counted as a necessary ingredient for improving the competitiveness of the distribution companies (Reichhart and Holweg, 2007). Despite this, lean as an industry standard is not clearly defined with a specific regard to the distribution process. There is a lack of publications that address the theoretical logic and the underlying factors of lean distribution. This paper aims to fill the research gap through two main steps;

- Identify lean distribution dimensions and their corresponding practices through an extensive literature review on lean logistics and supply chain articles.

- Statistically validate the identified dimensions and practices using exploratory factor analysis approach.

Lean distribution literature review

While lean manufacturing literature began to grow in 1950s and were extended to suppliers operations in 1970s, lean distribution started to attract academic attention in 1980s (Ohno, 1988). The concept has captured the attention of the practitioners who are seeking better ways to do business, and the researchers who see the topic as a research gap (Hines et al., 2004). It presents an extension of the Just in Time (JIT) concept – replenishing items only when they are ordered by the end customer – (Reichart and Holweg, 2007). It is also defined as the ability to reduce both movements and waste in distribution centres while still keeping high customer service level (Jaca et al., 2011). Each distribution function – from receiving customer orders to products delivery – can benefit from the lean principles which lead to high process quality, minimum levels of waste, cost cutbacks, and increasing productivity (Wang, 2008).

Whereas the principles of lean management are relatively constant for all application domains, specific lean dimensions were addressed in the quest of creating value in distribution centres (Kiff, 2000). Managing demand variability, facilitating orders replenishment, optimizing products flow, simplifying distribution networks structure, enhancing workforce leadership, and controlling inventory and operations cost are important lean distribution dimensions that were mentioned by (Jones, 2002; Baker, 2004; Hopp and Spearmman, 2004). In other study, three lean distribution concepts were investigated and considered crucial for reducing material costs as well as facilitating their flow; (1) investigating the root causes of parts damaging in the picking process, (2) managing storage spaces effectively, and (3) establishing robust communication between people (Manrodt et al., 2008). Myerson (2012) noted that in order to make distribution centres waste free warehouse orders should be assembled in the most efficient manner, optimizing storage space and minimizing non-value added activities. The author added that lean manufacturing techniques (e.g. 5S, value stream mapping, team building, *Kaizen*, problem solving and error proofing) can be effective in supporting lean distribution implementation. Establishing effective partnership and collaboration with suppliers was also defined as a necessary requirement for developing capabilities of JIT orders replenishment and delivery (Helper, 1991). Unlike traditional distribution systems, where price is the dominant factor in selecting suppliers, suppliers are selected in lean systems based on a combination of different factors such as quality, reliability, and delivery performance (Ellram, 1995).

Zylstra (2006) provided a comparison of the traditional forecast-based distribution management against lean distribution philosophy, as shown in Table 1. A lean distribution framework was presented by the author containing five main factors that form the solution to a lean transformation including customer service policies, buffer strategy, replenishment cycle, pull approach, and operating and sourcing capabilities. Lean distribution was also described using the SCOR (Supply Chain Operations Reference) by identifying the sources of waste in the Plan, Source, Make, Delivery, and Return functions (Myerson, 2012). Taylor (2006) has introduced lean logistics and distribution through other dimensions including transportation management, inventory control, distribution network structure, and management information system.

In conclusion, lean distribution is viewed as a configuration of interacted practices, tools, and tightly related factors. Applying lean thinking on the distribution elements individually cannot remove the whole system's waste. All distribution activities need to be looked at, from customer orders back to product replenishment from suppliers, and forward through all the successive activities of packaging, shipping and delivery to the customer.

Table 1 Lean distribution versus traditional distribution management

Distribution Elements	Traditional Management Approach	Lean Distribution
Forecasts	Should be strived to be more accurate. It is utilized in both long-term aggregate planning and short-term operational scheduling.	It has limited accuracy and used only for long-term and aggregate planning.
Inventory	Should be close to customer in order to meet orders lead time.	Should be consolidated at the source and redirect flow quickly according to the changing in replenishment needs.
Systems Variations	Not explicitly embedded in the planning process. Variations upset the plans and cause continuous resetting for them.	Taken into consideration as all lean practices work on isolating systems variation
Transportation	Forecast-driven, changes with the changing in orders forecasting.	It is driven based on customer demand and delivery conditions.

Lean distribution theoretical logic

A significant field work has been carried out in order to define how lean distribution is designed and provide a clear illustration on how its multiple facets linked together. A senior member and a shaper of strategies in the Irish distribution industry was interviewed to gather information about distribution companies and the characteristics of its supply chains, as well as an overview of the current awareness of lean distribution concepts and practices. A number of interviews were then held with seven distribution industry professionals from Ireland, UK and Portugal, followed by two observational visits to distribution companies in Dublin and Birmingham, aiming to identify the most relevant factors and constructs of lean distribution paradigm. Seven lean constructs are defined based on the literature review, managers' interviews, and site visits, Figure 1. The seven factors combined to form a cohesive distribution system. To achieve a high distribution leanness level, a collection of lean practices have to be defined and implemented in an integration fashion rather than a series of disjoined cost reduction attempts.

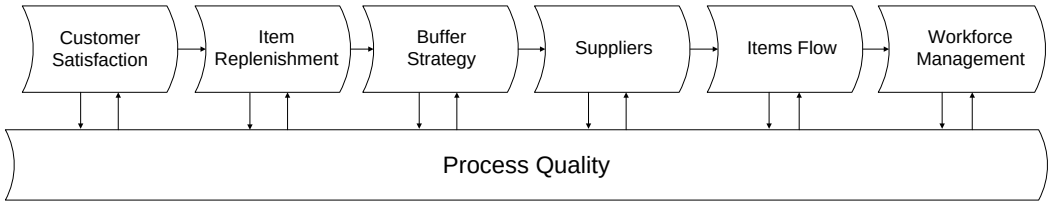

Figure 1 Lean Distribution Constructs

Customer satisfaction:

Understanding and precisely identifying customer needs is important for the lean transformation journey (Womack et al., 1991). The full identification of customer demand allows managers to leverage the knowledge of their customer preferences and hence improves the accuracy of the forecast plans and service quality level (Reichhart and Holweg, 2007). It also allows decision makers and distribution planners to create more efficient replenishment strategies, buffering control, items delivery schedules and distribution network structure (Kiff, 2000). Customer demand management is also a pivotal factor toward increasing customer value and service level (Chua and Katayama, 2009). Demand levelling – by offering discounts to customers according to the time by which they are willing to postpone their orders – is employed to minimize customer demand variability and increase the potential of customer retentions (Jones et al., 1997). Customers segmentation, postponement, cross-docking and mass customization distribution are addressed as common improvement initiatives to increase distribution flexibility and decrease orders cycle time (Baker, 2004).

Items Replenishment:

The faster the products can flow from the source to the destination with less uncertainty, the higher the possibility to satisfy customer orders on time (Jones et al., 1997). Establishing an effective pull approach requires a speed and consistent replenishment process. Pull replenishment is closely relying on three significant factors; customer service policy, replenishment strategy and buffer placement (Enns, 2007). The right combination of these factors results in smooth replenishment process and fast response to the changes in demand.

It is also necessary for the lean replenishment to tighten the linkage between customers demand and items upstream flow by eliminating the waste and non-value added activities (e.g. supplier negotiation, replenishment orders review and approval) (Holweg and Pil, 2004). Several lean practices and strategies were applied to reduce the waste and isolate the variability from the replenishment activities including demand levelling, controlling inventory level and facilitating items flow across the distribution network (Zylstra, 2006).

Buffer Strategies:

Buffers are required to isolate the performance of distribution operations away from the fluctuation of customers demand and suppliers delivery. The buffers may be in the form of inventory, resource capacity or time (Zylstra, 2006). In lean environment, distribution companies should keep zero inventory level and replenish their goods directly against customer orders (i.e. pull systems). Nevertheless, lean distribution cannot simply be defined as stockless distribution or build-to-order, but an efficient inventory control, yet responsive to customers demand (Baker and Halim, 2007). Replacing traditional distribution role – holding inventory and breaking bulk for customer orders – to act as cross-dock or configuration centre (i.e. postponement) eliminates inventory excess and maintains high customer service level (Baker, 2004). Class-Based Storage policy (CBS) (Storing items according to their types into specific storage classes) was presented as critical lean distribution practice (Petersen and Aase, 2004). CBS provides easy tracking for the stored items and increasing the efficiency of the storing and picking operations.

Installing automated warehouse equipments (e.g. automated conveyors and storing systems) is also essential to support lean distribution implementation given their ability in directing finished products rapidly into warehouse areas without the goods ever being stored (Van Hoek et al., 2001). According to Zylstra (2006), inventory should be placed as far back as possible in the supply chain because of the fluctuation of demand for a single item at the customer site is much higher than the fluctuation for a group of customer demands for the same SKU. The closer the buffer to the sources (i.e. suppliers or manufacturers) the better the response to demand swings (Apte and Viswanathan, 2000).

Suppliers:

Suppliers with effective replenishment mechanism and fast response to demand fluctuation can effectively add value to customers. Honda America applied successful project to improve the quality of delivery for its suppliers (MacDuffie and Helper, 2002). Ford Motor Company has also successfully implemented JIT distribution approach by establishing a cost-effective supplier relationship (Christensen, 1996). The author mentioned that accurate data exchanging between distribution companies and their suppliers encourages the mutual planning and problem solving efforts in the supply pipeline. Other practices such as supplier partnership, collaboration and long-term commitment were suggested in different publications to strengthen buyer-supplier relationships (Gentry, 1996; Jayaram et al., 2008).

Items Flow:

Warehouse layout design, storage and picking operations, and transportation efficiency are all

important factors that influence the internal and external items flow within the distribution system (Chua and Katayama, 2009). Creating an efficient layout for the warehouses is a complex process since it aims to satisfy contradicted objectives (e.g. space minimization, easy products picking, efficient items flows, safe working environment, minimum material handling cost and high throughput rate) (Mulcahy, 1994). Generating an optimal utilization for the warehouse space (i.e. receiving, storage and shipping spaces) is a significant factor toward achieving a smooth item flow (Frazella, 2002; Hudock, 1998).

Selecting a proper transportation mode (e.g. rail, truck, air or ship), the types of carriage (i.e. common, contract or private) and shipment capacities (i.e. full truck load, half-truck load or flexible) are also key decisions that influence items flow (Narus and Anderson, 1996). For example, using half-truck load may result in higher transportation costs compared with full-truck load capacity; however it is a better option regarding the product lead time and entire distribution cost.

Workforce Management:

Lean philosophy is not only a collection of tools and practices to improve firms performance, but is also a set of new cultural issues that people need to embrace in order to achieve a sustainable lean performance. It is important to address three fundamental issues before adopting major culture-changing initiative like lean; leadership, workers motivation and problem solving (Wilson, 2010). Many lean implementation attempts have failed because leaders have not the ability to articulate clear plans to their people and do not have the courage and character to make difficult decisions in the right time (Ignizio, 2009). The lack of support and involvement of managers also results unsuccessful lean implementation process. Leaders have to motivate workers in order to reinforce the lean implementation process and accept its associated changes (Achanga et al., 2006). The clear communication between managers, engineers and supervisors with the workforce by periodic meetings, discussions and the exchange of information is important (Armistead, 1999). Supply chain partners, from upstream suppliers to the downstream distributors, also have to collaborate as a team to provide a value to the end-customer (Manrodt et al., 2008). The author stated that the Chief Operating Officer at Turtle Wax has emphasized that companies got it wrong when they put too much attention on the tools, and not on the people. Training, sharing mutual values between group members, improving communication channels and developing human capital ensure the growth and wellness of the employee (Chua and Katayama, 2009).

Process Quality:

The quality function is a continuous process applied on all supply chain activities to ensure efficient operations performance. Acquiring a quality culture in addition to the successful implementation of its practices are essential to achieve reliable and consistent services, short delivery lead time, operating at low cost and flexibility in accommodating system changes. Quality concept in distribution includes aspects like employees training and empowerment, customer focus, top management commitment, continuous improvement, problem solving methodologies, quality verification, operations reliability, inspection procedures and corrective actions process (Bhasin and Burcher 2006; Nabhani and Shokri, 2009). Providing an efficient and error free transaction for information has also significant influence on operations efficiency and system's level of quality (Chen et al., 2005). JIT in distribution is fostered by the technological development, especially by improving information and tracking technologies (e.g. bar-code and sales-based ordering systems) (Christensen, 1996). Information technologies such as Enterprise Resource Planning (ERP), warehouse and transportation management systems play vital role in providing high quality lean implementation in distribution (Frazelle, 2002).

Based on the review of lean distribution dimensions' literature, a preliminary list of lean distribution factors and their correspondent practices was developed in Table 2.

Table 2 Initial set of Lean Distribution constructs and their corresponding practices

Distribution Elements	Practice Code	Practice Description
Customers	Cust_1	Clear customer service agreements are issued containing (e.g. service lead time, replenishment strategy).
	Cust_2	Comprehensive identification of customer needs and expectations is done.
	Cust_3	Change customer service agreement according to customer's condition, value and requirement
	Cust_4	Customer feedbacks are used to enhance operations performance.
	Cust_5	Provides customers the ability to follow-up the replenishment process and get information about replenishment problems.
Items Replenishment	Rep_1	Reduce the number of customer orders that are consolidated into a single replenishment order
	Rep_2	Access to actual customer consumption and uses it as a trigger to the replenishment process
	Rep_3	Company's replenishment strategy is flexible subject to customer requirements, conditions and values
	Rep_4	Take steps to simplify its distribution network in order to decrease shipments lead time and cost
	Rep_5	Line balancing approach is used to reduce bottleneck in product flow
	Rep_6	Place replenishment orders in high frequency with small lot sizes
	Rep_7	Customer demands are levelled to reduce variability and enhance the planning process
Buffer Strategy	Buff_1	Emergency stocks are kept near to the sources (i.e. Manufacturer or main distribution centre) in order to deal with unexpected or rush orders
	Buff_2	Employing automated warehouse tracking technology
	Buff_3	Products flow are managed in consistent small batch sizes throughout the daily work activities
	Buff_4	Products with similar characteristics are stored at same location
	Buff_5	Products buffer between the internal operations (i.e. Work in Process) are minimised
Suppliers	Supp_1	Getting up to date information about suppliers problems
	Supp_2	The company's suppliers are involved in setting the replenishment policies and strategies
	Supp_3	Establishing continuous cooperation with key suppliers to resolve customer issues
Items Flow	Flow_1	The quality of the transportation activity is frequently reviewed, aiming to increase the efficiency
	Flow_2	Select freight companies that offer flexible capacities for the shipment process
	Flow_3	All mechanical handling equipment are maintained regularly
	Flow_4	Employ layout design solutions in order to minimise the internal travel distance and time
People	Staf_1	Sort-out, organises and visually represents the equipment and tools that are needed in the workplace to maximise workers utilisation
	Staf_2	Establish a clear communication channels between people in the distribution facility
	Staf_3	The workplace is kept clean, clear and free of debris
	Staf_4	Employees feedback and concerns are encouraged and included before making changes and taking actions
	Staf_5	Managers, supervisors and employees are involved in determining facility goals and their achievement feasibility
	Staf_6	Daily work activities are organised into teamwork functions in order to enrich work environment and enhance problem solving activities
	Staf_7	Employees participate, initiate and lead problem-solving activities autonomously
Quality	Qu_1	Standard operating procedures are provided to the company's operators, aiming to standardise operations steps
	Qu_2	Identify and regularly discusses the best practices of its operations
	Qu_3	Apply statistical process control procedures (e.g. six sigma) to insure the reliability of the distribution operations
	Qu_4	Advanced technology systems are installed to standardise and simplify the processes, and to reduce the redundancy and transaction errors (e.g. ERP)
	Qu_5	Develop continuous improvement plans to sustain and improve distribution performance
	Qu_6	Utilize structured problem solving methodologies (e.g. 5 whys) in order to apply root cause analysis
	Qu_7	Quality verification and inspection procedures are created for each distribution function
	Qu_8	Develop corrective action procedures in order to rectify quality problems
	Qu_9	Clear goals and key performance indicators (KPIs) are identified

In order to incorporate the identified lean practices to the real life distribution functions, face and content validity processes were taken place through several interviews with distribution managers and supply chain academics along with a number of site visits for a number of distribution centres based in Ireland.

Research methodology

Since lean distribution philosophy is still in its early stage of empirical inquiry, a data driven analytical model (i.e. exploratory factor analysis (EFA)) were developed to identify its dimensional structural and examine its reliability and validity. The model was based on a survey for more than 700 distribution companies in Ireland and UK. A quantitative questionnaire – based on numerical scales – was developed to ascertain the extent to which

the proposed lean practices were implemented in the surveyed companies. It relied on a careful review of literature, deep discussions with distribution academics and practitioners and a clear conceptualization of the formulated research objectives. The responses were measured on a 5-point Likert scale with '1' equated with no implementation of the practice and '5' equated with a full implementation. A packet containing a cover letter, copy of the survey and introduction of lean distribution was sent to the surveyed companies by post and online. After two weeks, follow-up phone calls were conducted for all participating companies followed by three reminders sent by e-mail as suggested by (Dillman, 2000). After the follow-up calls, the companies were decreased from 700 to 600 due to companies shutting down and changing activities. The majority of the 150 respondents (about 85%) were from manufacturing companies and wholesalers. Over 70% of the respondents were technical senior managers (i.e. distribution managers, warehousing managers and purchasing managers) while the rest were top-executives and directing managers.

The exploratory analysis started with conducting a missing item analyses on the survey responses with eliminating the records that have missing data. Following that, corrected item total correlation (CITC) scores were calculated for each item to assess their reliability. CITC refers to the correlation of an item with the composite score of all the items forming the same latent variable. The item is usually a candidate of elimination if its correlation has recorded 0.3 or below indicting that item measures something different from the scale as a whole (Shah and Ward, 2007). Three reliability analysis iterations were conducted and 12 practices with CITC values below 0.30 were removed (cust-3, rep-1, rep-6, buff-1, Buff-2, buff-3, supp-1, supp-2, supp-3, flow-1, flow-2, and staf-4).

Following reliability assessment, EFA was conducted to determine the number of latent variables that cover the complete set of items and provide explanation for the variations among the original variables. Three iterations of EFA were conducted and 7 practices were eliminated as their cross-section loading exceeded |0.4| with more than two factors. Table 3 presents the final list of eigenvalues with 5 factors exceeding 1 and representing 67% of the variance. Before the final decision concerning the number of factors is taken, the retained items loading were checked.

Table 3 Significant factors with eigenvalues > 1.00 for the final EFA iteration

Factors	Initial Eigen value			Extraction Sums of Squared Loadings		
	Variance	% of Variance	Cumulative	Total	% of Variance	Cumulative
1	6.583	31.346	31.364	6.583	31.346	31.364
2	2.553	12.158	43.504	2.553	12.158	43.504
3	2.296	10.934	54.438	2.296	10.934	54.438
4	1.618	7.706	62.144	1.618	7.706	62.144
5	1.439	6.852	68.995	1.439	6.852	68.995
9	.638	3.040	84.015			
10	.588	2.798	86.813			
11	.523	2.492	89.304			
Kaiser-Meyer-Olkin Measure of sampling Adequacy				0.743		
Bartlett's Test of Sphericity		Approx. Chi-Square		696.702		
		Df		210		
		Sig.		0.00		

Extraction Method: Principal Component Analysis

As illustrated in Table 4, all items loadings on the five factors are above 0.4 with only one factor. The five factors were labelled based on the items loading and the understanding of the lean distribution theoretical logic. First factor embraces qu_1, qu_7, qu_8, qu_9, staf_1 and staf_3 which are all related to Quality construct and hence factor 1 is labelled 'Distribution Quality'. Factor 2 is identified as 'Customer' since it embraces three practices focus on reducing the demand variation and increasing the robustness of communication channels with customers; cust_1, cust_2 and cust_4. Factor 3 is labelled 'Item Replenishment' with 4

practices (rep_2, rep_5, rep_7 and buff_5). A combination of practices aim to provide effective improvement and planning tool to increase the reliability of distribution operations as well as managing the distribution labours and employees (qu_3, qu_5, staf_2, staf_5 and staf_7) were involved in factor 4 which labelled 'Workforce and Planning'. Decreasing transportation cost and time along with simplifying distribution network were the targets of (flow1, flow2 and rep4) practices, creating the fifth factor 'Transportation'. Figure 2 illustrates the five main factors of lean distribution and their correspondent practices.

Table 4 Correlation coefficient of the lean distribution variables in final EFA iteration

Independent Variable	Principle Component				
	1	2	3	4	5
Qu_9	.841				
Qu_8	.831				
Staf_1	.667				
Qu_7	.663				
Qu_1	.583				
Staf_3	.545				
Cust_4		.853			
Cust_1		.817			
Cust_2		.659			
Rep_5			.845		
Buff_5			.805		
Rep_2			.752		
Rep_7			.746		
Qu_3			.	.798	
Qu_5				.785	
Staf_7				.737	
Staf_2				.639	
Staf_5				.546	
Flow_1					.869
Flow_2					.853
Rep_4					.554

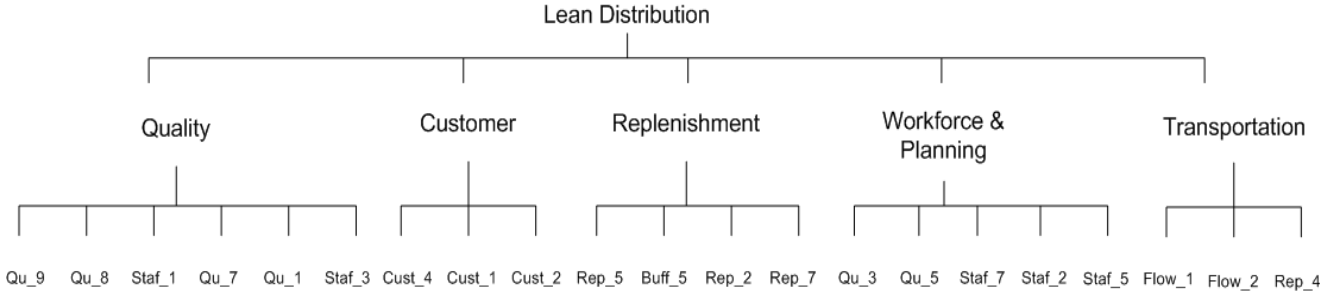

Figure 2 Exploratory structure of lean distribution concept (Source: Author).

Conclusion

This paper aimed to contribute to the lean distribution knowledge area by defining the concept's dimensional structure. Out of 40 lean distribution practices representing the initial strategic and operational space surrounding the lean distribution concept, 21 practices were extracted using exploratory factor analysis. The exploratory technique is considered the

stepping stone for further analysis phases like confirmatory studies. Confirmatory factor analysis (CFA) is recommended to confirm the exploratory lean distribution model by more rigorous statistical techniques.

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