Improving Road Transport Operations through Lean Thinking: A Case Study

Abstract

Traditionally, logistics and transportation problems have been addressed through mathematical modelling, operations research, and simulation, but criticism has emerged about their effectiveness to actually address real-life problems. This paper documents a case study whereby the road transport operations of a leading Mexican brewery were improved through lean thinking and waste reduction. Two lean-based principles and tools were combined; the Seven Transportation Extended Wastes and Transportation Value Stream Mapping. Three systematic steps were proposed to facilitate the implementation of improvement. Feasibility studies conducted in this research suggested that lean thinking is an effective alternative for the improvement of road transport operations. The findings of this research could be used as guidance for transport managers to improve road transport operations. This paper also expands the limited evidence of the application of lean thinking in road transport logistics and highlights the research areas where its application has been concentrated in this sector.

Keywords: Lean, road transportation, transportation efficiency, value stream mapping, waste elimination.

1. Introduction

The improvement of transport operations has been traditionally achieved with the use of mathematical modelling, operations research, and simulation methods (Sternberg *et al.*, 2013). Under these, several transportation problems, which include vehicle scheduling problems (e.g. Zhang *et al.*, 2014; Eliiyi *et al.*, 2009), delivery problems (e.g. Urban, 2006; Mitrovic-Minic *et al.*, 2004), transportation problems (e.g. Yu *et al.*, 2015; Faulin, 2003; Zhang and Yun, 2009), vehicle routing problems (e.g. Yu *et al.*, 2013; Lam and Mittenthal, 2013; Kumar *et al.* 2011; Mishra *et al.* 2011; Marinakis and Marinaki, 2008; Zhong *et al.*, 2007) have been addressed, and primarily, based on minimising cost, time or distance, and optimising resource utilisation, routes, and transportation/delivery schedules. Although, these methods and approaches have contributed to tackle the concern that industrialists and researchers have had for the improvement of transport operations since the mid-1990s (Dantzig and Ramser, 1959), criticism has emerged about their effectiveness to actually address real-life transportation problems (Berhan *et al.*, 2014). According to Ak and Erera (2007), one of the most compelling reasons for this is that the large majority of these approaches, and in particular vehicle routing models, are oversimplified by treating parameters such as demand, time, distance, and others, as deterministic, when in real life scenarios they are stochastic in nature. In addition, the improvement of actual road transport

operations and activities to gain efficiency is rarely considered under the mathematical modelling, operations research, and simulation methods (Fugate *et al.*, 2009).

Since significant waste and unnecessary costs are normally present in most transportation networks (McKinnon *et al.*, 2003), the application of lean thinking, alongside its principles and tools, has emerged as an opportunity to complement the traditional improvement methods. This may contribute in overcoming some of their limitations when addressing the improvement of road transportation. In line with the traditional lean's philosophy of waste elimination, the focus of the so called "lean road transportation movement" lies on identifying and eliminating non-value adding activities, specifically relevant to transport operations, in order to improve the overall productivity and efficiency of a company's logistics operations. Generally, the focus of research within the lean field has been on production activities related to quality improvement and the quest for increased efficiency. Although a research stream has also studied the application of lean thinking in supply chains (e.g. Mohammaddust *et al.*, 2015; Qrunfleh and Tarafdar, 2013; Liu *et al.*, 2013), specific research on the utilisation of lean in the road transportation sector is scarce and in early stages (Villarreal *et al.*, 2009). In this context, only a handful of articles have proposed methods or reported a case where transport operations have been improved through both the elimination of non-value added activities and the application of lean concepts and tools (e.g. Villarreal *et al.*, 2013; Villarreal, 2012; Villarreal *et al.*, 2012; Hines and Taylor, 2000). The relatively narrow research on lean road transportation is particularly evident when compared with the vast amount of research on lean application in other industries such as manufacturing (Taj, 2008), processes (Lyons *et al.*, 2013), and services (Sternberg *et al.*, 2013).

To complement and support the limited body of knowledge on lean road transportation, this paper presents a case study where two lean-based principles and tools, i.e. lean-based principles and tools include the Seven Transportation Extended Wastes (STEWs) (Sternberg *et al.*, 2013) and Transportation Value Stream Mapping (TVSM) (Villarreal, 2012), have been combined to improve the road transport operations of a leading Mexican brewing organisation. Besides providing a guiding reference for supply chain and logistics managers when undertaking similar improvement projects as well as expanding the rather limited body of knowledge on lean road transportation, this paper also intends to contribute by inspiring researchers to broaden the study of this under-researched area.

The rest of the paper is organised as follows: Section 2 provides a brief review of the primary research areas that have been derived from the application of lean thinking in road transportation; a description of some of the concepts and the methodology followed in this paper are outlined in Section 3; the case study application of lean thinking in road transport operations is undertaken in Section 4; and Section 5 presents the conclusions.

2. Literature Review on Lean Road Transportation

Within the limited research undertaken in the field of lean road transportation, three research areas (RAs) can be identified. Figure 1 illustrates these RAs and the specific papers that correspond to each of these RAs. These areas are discussed in the following sub-sections.
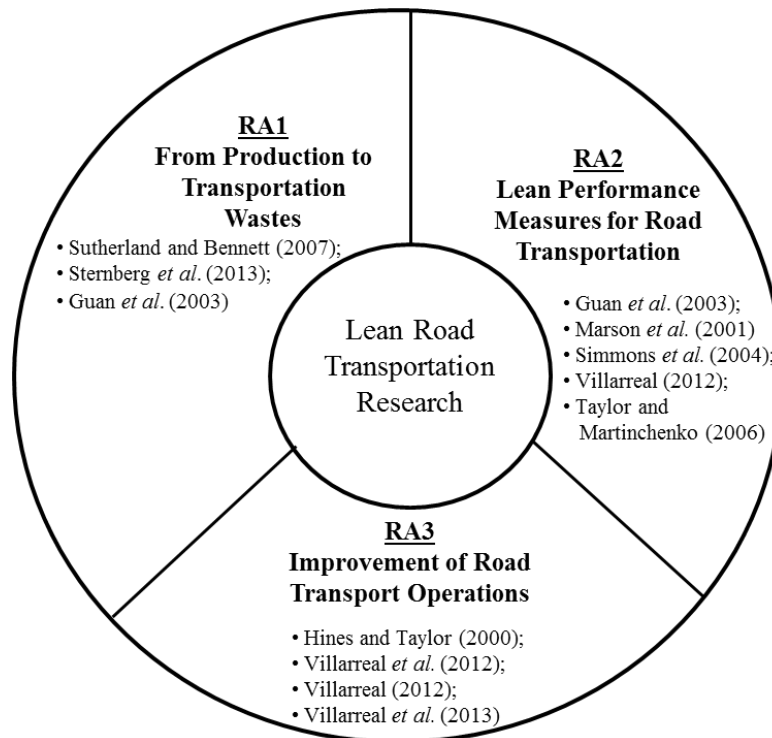
Figure 1. Areas where research on lean transportation has been conducted

2.1 RA 1 - From production to transportation wastes

The origins of lean can be traced back to the 1930s when Henry Ford revolutionised car manufacturing with the introduction of mass production techniques. However, the biggest contribution to the development of lean thinking principles and tools, over the last 50 years, has come from the Japanese automotive manufacturer – Toyota. The central objective of lean philosophy, as introduced by Toyota, is the elimination of non-value added activities (Pettersen, 2009), which consequently contributes to the reduction of costs (e.g. Monden, 1998) and increased value for customers (e.g. Dennis, 2002; Bicheno, 2004). Toyota identified seven major types of non-value adding wastes in production or business processes (Liker, 2004), namely: production of goods not yet ordered, waiting, rectification of mistakes, excess processing, excess movement, excess transport, and excess stock (Ohno, 1988). In this context, Sternberg *et al.* (2013), Sutherland and Bennett (2007), and Guan *et al.* (2003) realised the potential of studying the Toyota's seven wastes within the context of road transport operations, and adapting them for improvement. In this case, Sternberg *et al.* (2013) concluded that only five of the Toyota's wastes applied to motor carrier operations, excluding waste due to excess conveyance and excess inventory. Sternberg *et al.* (2013) included resource utilisation and uncovered assignments as part of the transportation wastes derived from Toyota's original production and business wastes. They called them the "Seven Transportation Extended Wastes" (STEWs).

Similarly, Sutherland and Bennett (2007) defined overproduction, delay/wait, excess transport/conveyance, motion, inventory, space, and errors as the "Seven Deadly Wastes of Logistics". According to Sutherland and Bennett (2007), these wastes keep the management of supply chains away from achieving their full business potential. Finally, Guan *et al.* (2003) identified five transport wastes, these being: driver breaks, excess load time, fill losses, speed losses, and quality delays. Sternberg's *et al.* (2013) STEWs were developed and validated through multiple case studies and they conducted in-depth interviews with carrier

operators, carrier technology providers and carrier service buyers. Hence, these wastes identified by Sternberg *et al.* (2013) were used as the basis to improve the road transport operations of the Mexican organisation studied. Figure 2 presents a description of the STEWs.
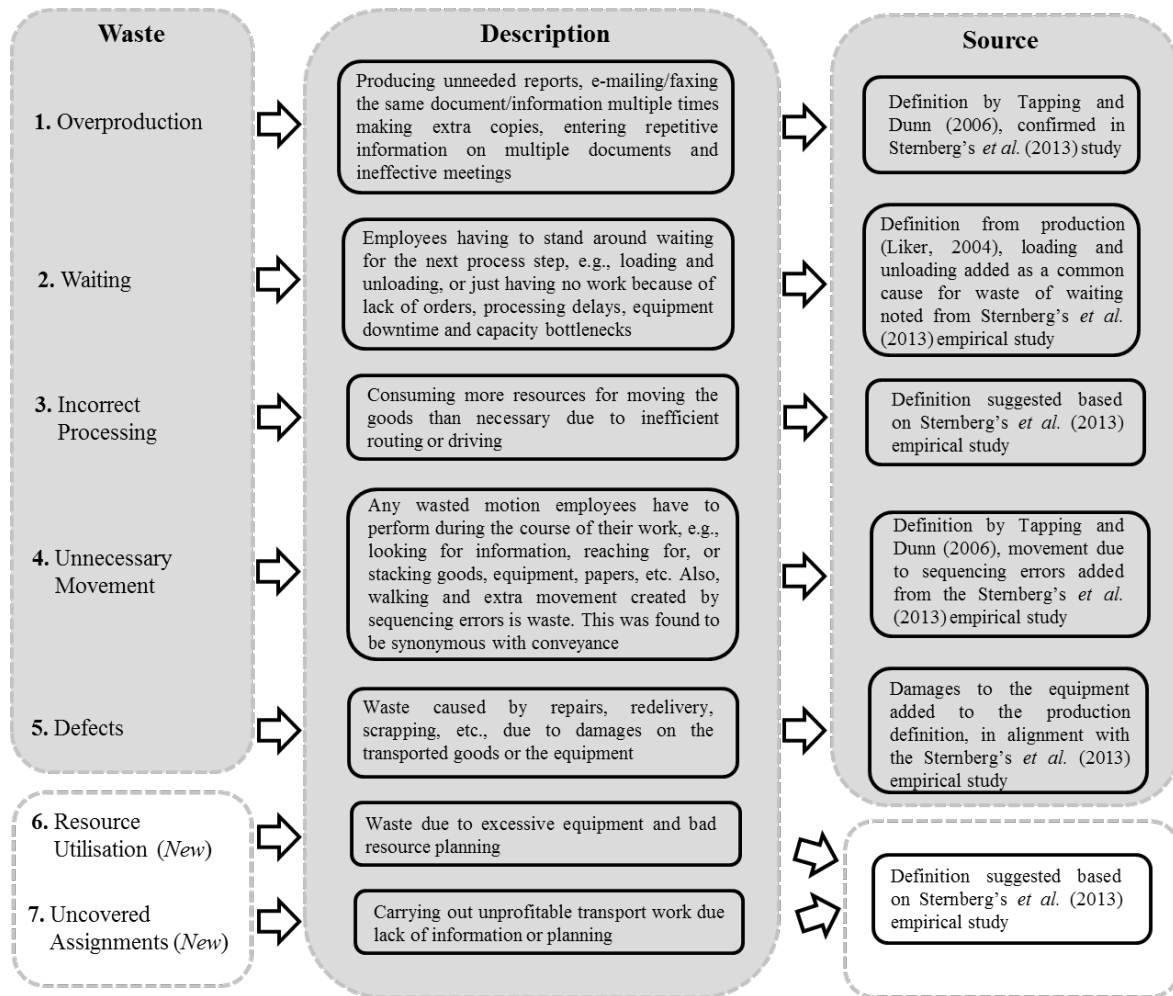
Waste	Description	Source
1. Overproduction	Producing unneeded reports, e-mailing/faxing the same document/information multiple times making extra copies, entering repetitive information on multiple documents and ineffective meetings	Definition by Tapping and Dunn (2006), confirmed in Sternberg's *et al.* (2013) study
2. Waiting	Employees having to stand around waiting for the next process step, e.g., loading and unloading, or just having no work because of lack of orders, processing delays, equipment downtime and capacity bottlenecks	Definition from production (Liker, 2004), loading and unloading added as a common cause for waste of waiting noted from Sternberg's *et al.* (2013) empirical study
3. Incorrect Processing	Consuming more resources for moving the goods than necessary due to inefficient routing or driving	Definition suggested based on Sternberg's *et al.* (2013) empirical study
4. Unnecessary Movement	Any wasted motion employees have to perform during the course of their work, e.g., looking for information, reaching for, or stacking goods, equipment, papers, etc. Also, walking and extra movement created by sequencing errors is waste. This was found to be synonymous with conveyance	Definition by Tapping and Dunn (2006), movement due to sequencing errors added from the Sternberg's *et al.* (2013) empirical study
5. Defects	Waste caused by repairs, redelivery, scrapping, etc., due to damages on the transported goods or the equipment	Damages to the equipment added to the production definition, in alignment with the Sternberg's *et al.* (2013) empirical study
6. Resource Utilisation (*New*)	Waste due to excessive equipment and bad resource planning	Definition suggested based on Sternberg's *et al.* (2013) empirical study
7. Uncovered Assignments (*New*)	Carrying out unprofitable transport work due lack of information or planning	

Figure 2. Description of the Toyota's seven wastes adapted to transport operations (adapted from Sternberg *et al.*, 2013)

2.2 RA 2 - Lean performance measures for road transportation

Measurement on a continuous basis is crucial to improve operations and supply chains (Dey and Cheffi, 2013; Cabral *et al.*, 2012). Thus, the application of lean practices in transportation needs to be supported by adequate metrics to measure the system performance as a basis for continuous improvement. In this line, Taylor and Martinchenko (2006) proposed four lean transportation laws (i.e. transportation waste, daily event management, transportation strategy, and transportation performance), which explain how and where transportation processes may be sub-optimal, and how the application of lean can positively impact these processes and overall organisational performance. Similarly, Mason *et al.* (2001) and Simons *et al.* (2004) adapted and extended the Overall Equipment Effectiveness (OEE) (Nakajima, 1988) metric, used by the lean's Total Productive Maintenance (TPM) (Nakajima, 1988) approach to measure equipment effectiveness, and developed a new metric called Overall Vehicle Effectiveness (OVE). This metric was used by Simons *et al.* (2004) for measuring and improving the performance of truck transportation.

Following on, to reflect the efficiency of a route, Guan *et al.* (2003) modified OVE by dividing the performance factor into two components: route and time efficiencies. Finally, Villarreal (2012) proposed a modified version of the OVE measure called Transportation Overall Vehicle Effectiveness (TOVE). Unlike OVE, TOVE considers total calendar time instead of loading time. This is due to the fact that waste identification and elimination is related to the transportation vehicles utilised to move products. Since vehicles represent a high investment, it is important to keep them in operation at all times. A comparative illustration of the structures of the OVE and TOVE measures is presented in Figure 3. In summary, although both measures broadly classify transportation wastes into three mutually exclusive elements (i.e. availability, performance and quality losses), TOVE adds the administrative availability element. Hence, it divides the availability component into administrative and operating availability. The concept of vehicle administrative availability is important as it has a significant impact on the overall vehicle utilisation and efficiency. It is mainly the result of administrative policies and strategies related to capacity or maintenance decisions. TOVE is obtained from the product of administrative availability, operating availability, performance and quality; whereas OVE is obtained by multiplying the availability, performance and quality components, see Figure 3.
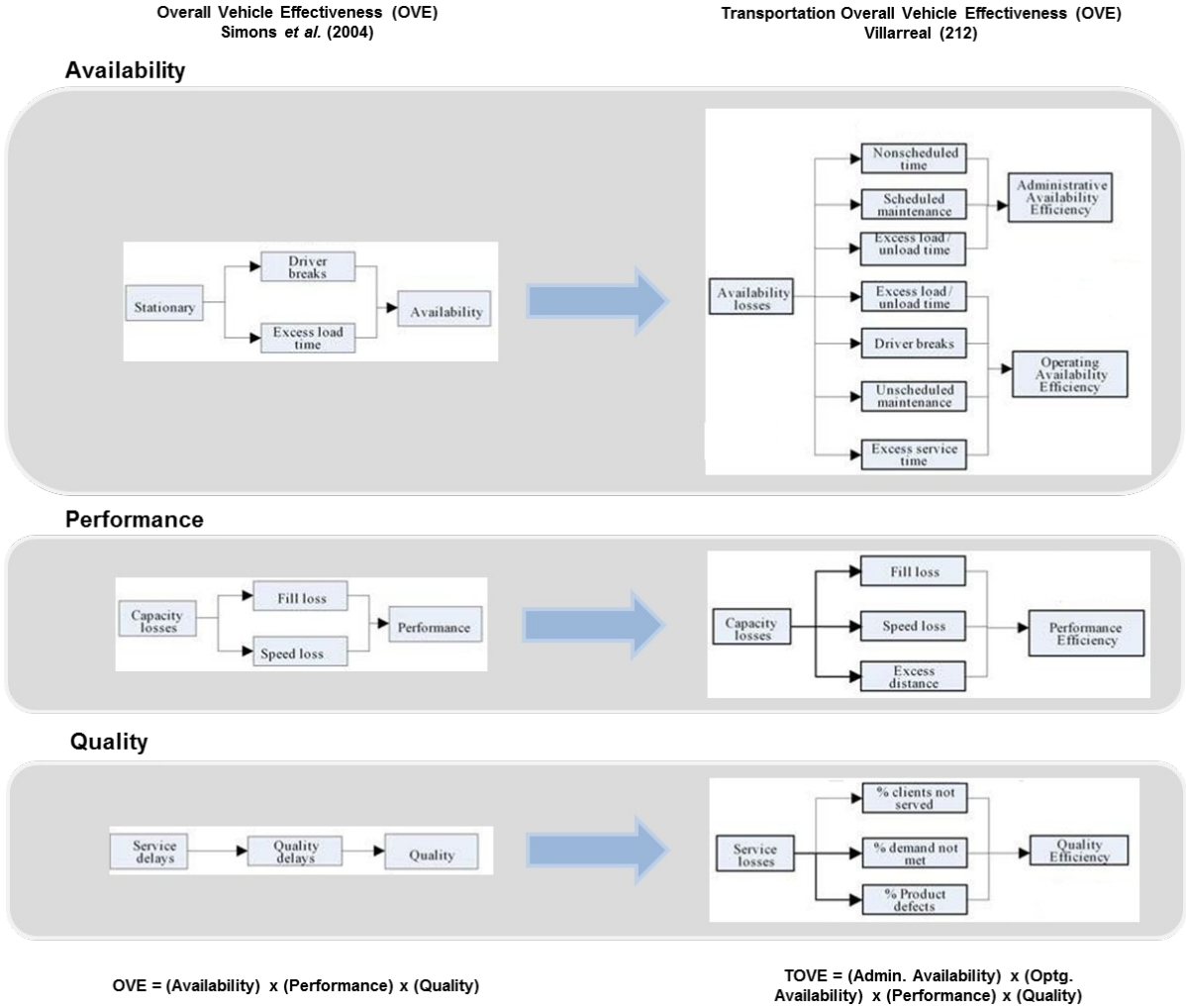

Figure 3. Comparison of the OVE and TOVE structures and components (Adapted from Simons *et al.*, 2004 and Villarreal, 2012)

2.3 RA 3 – Improvement of road transport operations

It is well known that transportation is an activity classified by the lean movement as waste that should be, if possible, eliminated (Womack and Jones, 2003; Ohno, 1988). However, in the current globalised market, transportation is a necessary activity to deliver goods to customers. In fact, although transportation is also recognised as a tertiary economic activity (Chase and Apte, 2007), Villarreal *et al.* (2009) suggest that efficient transport operations can nowadays be considered a differentiating factor that adds service value to customers. Thus, when mapping a supply chain, unnecessary transportation becomes an important waste to identify, measure, and eliminate. According to Fugate *et al.* (2009) and McKinnon *et al.* (1999), unnecessary transportation problems and waste can be addressed by increasing the efficiency of transport operations. In this context, Hines and Taylor (2000) proposed a methodology, consisting of four stages, to increase efficiency and eliminate waste in transport operations. Villarreal *et al.* (2009) reported the application of this methodology in the logistics operations of a Mexican firm, leader in the production and distribution of frozen and refrigerated products. As a result, the organisation saved over $700,000 U.S. Dollars of capital investment and $1.4 million U.S. Dollars per year of operations cost by improving the capacity utilisation and availability of its distribution vehicles (Villarreal *et al.*, 2009).

Villarreal *et al.* (2012) also developed a methodology to reduce transport waste by integrating the Just-in-Time approach of milk runs with the traditional operations research approach of developing algorithms to optimise vehicle routing. Additionally, Villarreal (2012) adapted the lean's Value Stream Mapping (VSM) (Rother and Shook, 2003) tool to support efficiency improvement programmes in transport operations. He called this adapted tool Transportation Value Stream Mapping (TVSM). Finally, Villarreal *et al.* (2013) developed a scheme for increasing transportation efficiency. The scheme was proposed around a modified version of the OEE index used in TPM. This index was adapted as the primary performance measure for transport operations and integrated with the VSM tool to identify and eliminate availability, performance and quality related transportation wastes.

2.4 Other approaches for waste reduction and efficiency increase in road transport operations

Lean relies on practices such as Just-in-Time (JIT), Total Quality Management (TQM), Total Productive Maintenance (TPM), pull, flow, and others, to reduce waste and increase efficiency (Yang *et al.*, 2011). Forrester *et al.* (2010) considers lean as the most influential new paradigm in manufacturing, however, the reduction of waste and improvement of efficiency in the road transport sector has been addressed through different perspectives and using other approaches which are not necessarily based on lean practices or the use of lean tools. For example, Sanchez Rodrigues *et al.* (2014) suggest that avoiding extra travel in road freight operations is vital as these operations are characterised by low-profit margins. For this reason, they proposed a measure, called "Extra Distance", which intends to reduce the additional operational costs associated with transport disruptions. Similarly, Sanchez Rodrigues *et al.* (2008) proposed a model to improve the efficiency of freight transport through a better management of supply chains' uncertainty. Furthermore, Bottani *et al.* (2015) proposed an integrated approach to increase sustainability and efficiency of logistics activities. Similar additional works have been conducted, for example, by Cruijssen *et al.* (2010), McKinnon and Ge (2004), Abbas and Aly (2004) and Davies *et al.* (2007).

In general, other non-lean based approaches reported in the academic literature devised to reduce waste/cost and improve efficiency of road transport operations include the outsourcing of logistics operations (Atkas et al. 2011) and integration of supply, production and distribution/transport activities (Van der Vorst *et al.*, 2009; Mason and Lalwani, 2006).

Other approaches, as previously discussed, have included the development of advanced tools or models based on mathematical modelling, operations research or simulation methods to improve efficiency through the optimisation of cost, time, distance, resource utilisation, routes, or transportation/delivery schedules. Examples of recent works in these areas include Yu *et al.* (2015), Zhang *et al.* (2014), Jemai *et al.* (2013), and Eliiyi *et al.* (2009).

We consider it important to highlight the abovementioned studies and research streams, as future research may more closely look at the synergies of the approaches proposed in these studies and lean thinking. This may provide an opportunity to formulate more inclusive and enhanced methods and strategies for the improvement of road transport operations.

3. Concepts and Methodology

The improvement of the road transport operations of the Mexican organisation studied was addressed by following a sequential three stages approach that consisted of the following steps: (1) Analysing the value stream of the road transport operations, (2) Identifying the STEWs inherent in the road transport operations, and (3) Defining and implementing a strategy for the elimination of the STEWs.

To analyse the value stream of the road transport operations of the Mexican organisation studied, a TVSM (Villarreal, 2012) study was carried out. The use of VSM to document, visualise, quantify and comprehend the material and information flows of value streams in manufacturing operations (e.g. Singh and Sharma, 2009; Seth and Gupta, 2005), healthcare operations (e.g. Lumus *et al.*, 2006; Teichgräber and de Bucourt, 2012), environmental-based operations (Kurdve *et al.*, 2011), and service operations (e.g. Barber and Tietje, 2008) has been widely documented in the academic literature. However, only a small number of researchers have considered the use of VSM to support the analysis and improvement of the value stream of logistics and transport operations (Villarreal *et al.*, 2013; Villarreal, 2012; Villarreal *et al.*, 2012; Hines *et al.*, 1999; Jones *et al.*, 1997). For this reason, besides documenting the application of lean thinking in road transport operations to expand the limited body of knowledge in this area, this paper also contributes by presenting a further case study of the application of VSM in the road transport industry. In this case, the TVSM concentrated on uncovering waste related to transport efficiency (Villarreal *et al.*, 2012) through the entire distribution cycle, from loading product orders to the transportation vehicles to unloading product returns from the market and closing administratively the route or shipment.

The TVSM analysis consists of two main facets; one that included activities pre and post transport and serving clients, known as "Not-In-Transit (NIT)" activities, and the other that contemplated activities related to the actual physical distribution of the product, known as "In-Transit (IT)" activities. Villarreal (2012) suggested that vehicle drivers should focus on performing IT activities only, whereas the execution of NIT activities should be carried out by warehouse operators. This advice was taken into consideration when proposing the improvement initiatives derived from the value stream and STEWs analyses of the transport operations studied. The data collected for NIT activities to conduct the TVSM study included some of the basic metrics of performance reflected in the traditional VSM established by Rother and Shook (2003). These were cycle time, value added time, uptime and setup time. Additionally, NIT activities were aligned to the takt time required to load customer orders to trucks and deliver them on time. On the other hand, data related to average time between clients, truck capacity utilisation level, average distance travelled per client, distance travelled in excess per route, and the percentage of waiting time in transit was collected for IT activities and the TVSM study. Finally, for serving clients; the average number of clients

per route, cycle time, value added time, the percentage of product returns, and the percentage of clients not served was the key data gathered for the TVSM analysis.

The TVSM analysis contributed to the identification and quantification of the STEWs (Sternberg *et al.*, 2013) inherited in the value stream of the transport operations studied. Once the STEWs were identified and quantified, improvement initiatives based on the semi-dynamic design of routes, automation of product loading and inspection, redesign of customer serving procedures, among others, were formulated and implemented (see Section 4), so as to reduce the STEWs and hence improve the road transport operations of the organisation studied.

4. Case Study

This section presents a case study to complement and support the limited body of knowledge on lean road transportation. Voss *et al.* (2002) emphasises the importance of conducting and publishing case study-based research as they suggest that it is particularly suitable for the testing and development of new theory, especially in the field of operations management (McCutcheon and Meredith, 1993). This is evident from the high volume of recent research works published in this field using a single case study research method approach (e.g. Bouzon, 2015; Bevilacqua *et al.*, 2015; Tuli and Shankar, 2015; Diehl and Spinler, 2013; Taylor, 2009). Serrano Lasa *et al.* (2008) commented that many of the breakthrough concepts and theories in operations management, from manufacturing strategy to lean production, have been developed through field case research. Similarly, Zander *et al.* (2015), Cameron and Price (2009) and Eisenhardt (1989) consider a single detailed case study a valid research methodology to study and understand specific phenomenon within specific contexts, such as in this case the application of lean thinking in road transportation. In this study, and as suggested by Voss *et al.* (2002), the case study research approach proved to be a valuable source to document and report the experiences of the authors while conducting the improvement of road transport operations using lean thinking-based principles and tools. Thus, the case study was an ideal research strategy that contributed in enriching the limited body of knowledge on the application of lean thinking in the road transport industry.

The Mexican organisation studied in this research processes and distributes bottled beverage. This organisation is a large, leading national company with major operations in the north of Mexico. This study focused on the distribution of products from regional distribution centres (RDCs) to retailing points that included convenience store chains, independent retailers, and supermarket chains. The company has a number of RDCs across Mexico, but considering the complexity and difficulties of conducting a large scale improvement initiative and the constraints in terms of budget, time, and personnel that organisations normally face when carrying out improvement projects (Marriot *et al.*, 2013), this study focused only on the RDC located in the city of Monterrey, Mexico. Concentrating efforts in only one RDC helped, as suggested by Antony and Banuelas (2002) and Pyzdek (2003), in validating the application and results of lean thinking as an effective and suitable approach to drive the improvement of road transport operations, before proceeding into a future full scale deployment in the rest of the company's RDCs.

In particular, the RDC studied counts with a fleet of about 90 distribution trucks (see Figure 4 for an illustration) to serve about 6,000 customers that include selling points (e.g. convenience stores) and consumption points such as pubs, restaurants, etc.

Figure 4. Illustration of truck utilised in routing operations

Most selling points associated to established chains state morning time windows of three hours. However, some important chains were open 24/7. This offered the opportunity to supply them through evening and night shifts. The rest could be serviced any time of the day except from 2 to 4 P.M. Consumption points, such as restaurants, were supplied during the morning, and pubs and entertaining businesses during late afternoon. The distribution of beverage was made daily through 76 fixed day routes. Labour cost per night or day shift was the same. However, night shifts presented contradictory situations; in one hand, driving conditions made night shifts more attractive due to significantly lower traffic congestion; but on the other hand, operating risk was higher due to the current climate of insecurity. It was common operational practice to have a two-person driving crew per route.

The foremost strategic concern of the company referred to cost reduction. In order to address this situation, the firm established a company-wide strategy for reducing cost. Since routing cost had become an important component of the total cost structure in recent years, it was necessary to consider it for improvement. Labour cost represented an important cost concept. The routing operations of interest presented a consistent level of overtime cost. Labour overtime was paid double for every hour after a day shift of eight hours until a maximum of nine hours per week per worker. Routing cost per hectolitre was about $5.3 US Dollars. This cost included labour (25%), gas (45%), truck maintenance, and other supplies and expenses (30%). Two aspects increased the share of this last concept: first, average truck age in Mexico is estimated to be around 15 years (Subsecretaría de Transporte, 2013). Even though the company's private fleet was not relatively old, it did have an average life of around 10 years. This factor increased maintenance cost. On the other hand, other expense concepts such as licences, permits, insurances, tires and depreciation were also considered part of this cost.

4.1 Analysis of the value stream

As indicated previously, the first step in addressing the improvement of the road transport operations of the organisation studied was to analyse the value stream of such operations. This was done by developing the TVSM for the current routing operations as shown in Figure 5. The data used to construct the TVSM was collected from both company records and field data. This means that data was gathered from an administrative database directly fed by the vehicle drivers' handhelds and the trucks' GPS devices, and a team of researchers collected detailed data by accompanying the truck driving crews. This was done by sampling 30% of the routes. The transport operations mapped consisted of the following activities:

- *Preparation of orders*. This was considered a NIT activity that was comprised of "sub" or "micro" activities such as inspecting the orders' load, the truck, and reviewing the route;
- *Distribution of products* (i.e. transporting products, serving customers and collecting spoiled product). This was considered an IT activity;
- *Returning back to the RDC* was also considered as an IT activity;
- *Closing routes*. This NIT activity included "sub" or "micro" activities such as settling payments from customers with the cashiers and unloading/returning spoiled product and the truck.

In general terms, the TVSM study indicated that the overall average daily journey time for the distribution of goods from the Monterrey RDC to its corresponding retailing stores was 11.5 hrs, see Figure 5. Since an 8 hrs shift was the working standard for the studied organisation, the 3.5 hrs excess contributed to significantly increasing the operational cost, which was associated to overtime. All the activities included in the distribution operations, from preparing the routes, serving the stores until closing every route were executed as part of the journey. Internal NIT activities took 2.5 hrs on average (i.e. 22% of the journey's time), whereas IT activities took an average of 9 hrs (i.e. 78% of the journey's time), see Figure 5. The average number of stores served by a route was 15.

From Figure 5 it is clear that the TVSM shows the various important detail activities of the Monterrey RDC. According to Seth and Gupta (2005), a holistic visualisation of this type offers an actual trigger and a challenge for improvement. Therefore, the next steps in the improvement project consisted of identifying the STEWs (Section 4.2) and defining and implementing a strategy for their elimination (Section 4.3).

4.2 Identification of the STEWs inherent in the road transport operations

The second step in the road transportation improvement project involved the identification of the relevant STEWs. Table 1 presents a summary of the most relevant STEWs identified through the TVSM, the operation activities where they were located, and their effect on the transport operations.

Table 1. Summary of relevant STEWs

Wastes	Operation Activity	Description	Impact on
Incorrect processing and resource utilisation	• Transporting product to customers	• Route sequencing defined by drivers. This resulted in sub-optimal sequencing of the customers visits • Routes not designed according to daily demand (i.e. it does not consider demand variability)	• Truck capacity under-utilisation of 35% • Distance in excess per route of 19% • Long journey time of 11.5 hrs
Unnecessary movements and waiting	• Preparing orders/routes • Serving clients • Returning empty bottles • Closing routes	• Procedures for serving customers, preparing and closing routes have non-value added activities	• Serving time in excess of 65% • Waiting time to close routes

Figure 5. TVSM of the organisation studied

Incorrect processing and resource utilisation

As illustrated in Table 1 and by the Kaizen burst No. 1 in Figure 5, incorrect processing and resource utilisation wastes were found in the transportation of products to customers. These occurred because of the inefficiency in the design of routes (i.e. customer assignment to trucks and visit sequencing). Route design was a shared responsibility between the route dispatcher and the truck drivers. All the routes were defined with disregard of customer demand trends and behaviour. Company's records showed that daily demand from Monday to Wednesday was lower than the level shown during the period from Thursday to Sunday. Additionally, the routes were not designed according to daily demand and route sequences were determined by the driver every day. As a consequence, 35% of transport capacity was under-utilised and there was a 19% of distance per route travelled in excess.

Unnecessary movements and waiting

Unnecessary movements and waiting time were found in the IT operation activities of serving clients as well as the NIT activities of preparing and closing orders. This is shown in Table 1 and by the Kaizen burst No. 2 in Figure 5. These wastes occurred due to the inefficient procedures that contained non-value added activities. According to Villarreal (2012), NIT activities must be carried out by warehousing operators, and hence, vehicle drivers should start working with the truck already loaded and properly inspected. However, in the organisation studied, this was not the case. The crew was required to be present to ensure that order product volume and mix was correct. In addition, there was an important proportion of waiting time because all the routes were inspected during the same period of time. The previous requirement originated that 70% of the total preparation activity was non-value added. In addition, closing routes included the activity of returning empty bottles. Since the majority of the trucks returned almost simultaneously, a high level of waiting time occurred. Therefore, it was found that 40% of the total time of closing routes was classified as waste due to it problem.

Waiting to serve customers was produced by restricted customer time windows that created an accumulation of suppliers arriving simultaneously to do so. Customer service time included the time taken to perform activities that did not add value or were not simplified, for example, inspecting products, verifying with the store leader whether the order was complete, and getting and loading empty bottle returns. The vehicle drivers devoted an important amount of time picking and classifying returned bottles on the street or the customer premises. Serving clients was an activity with 65% of its time categorised as waste. There was also the need to consider the time taken to obtain the payment of the order from the customer.

4.3 Definition of a strategy for the elimination of the STEWs

Different strategies have been proposed by, for example, Villarreal *et al.* (2009), La Londe and Masters (1994), Burns *et al.* (1985), Cooper (1983), among others, to improve transport operations. In this case, however, a group of experts, which include the logistics managers of the organisation studied, vehicle drivers and researchers, were gathered to devise appropriate initiatives to reduce/eliminate the main wastes identified in the previous step. This approach of formulating improvement strategies encouraged the intuitive association within this group of experts to associate each other's ideas, and then to develop the proposed initiatives shown in Table 2. In addition, since most successful improvement initiatives depend heavily on changing employees' activities and attitudes (Karia and Asaari, 2006), involving the company's employees (i.e. logistics managers and vehicle drivers) was considered an strategy to facilitate the easy acceptance and implementation of the proposed initiatives.

Table 2. Improvement strategies proposed to reduce STEWs

Wastes	Waste Description	Initiatives Considered
Incorrect processing and resource utilisation	• Route sequencing defined by drivers. This resulted in the sub-optimal sequencing of customers visits • Routes not designed according to daily demand (i.e. it does not consider demand variability)	• Semi-dynamic route design
Unnecessary movements and waiting	• Procedures for serving customers, preparing and closing routes have non-value activities.	• Automating product loading and inspection • Assigning inspection, loading and unloading product to warehousing operators • Redesigning procedures to serve customers with the use of technology • Negotiating full time window flexibility with store leaders

Evidence suggests that, in general, automation has positive effects on the productivity and ergonomics of logistics, warehousing and manufacturing operations (Echelmeyer *et al.*, 2008; Baker and Halim, 2007; Newman *et al.*, 2002). Based on this, the partial or full automation of repetitive operation activities, such as loading and inspection, was proposed by the team of experts as a possible solution to decrease waiting time, inspection, loading times in excess, and unnecessary movement. They also suggested that reassigning these operation activities to warehousing operators, alongside automation, would also contribute to improve these parameters. For the automation of the loading and inspection operation activities, the organisation considered, after consultation with automation engineers, the design and installation of arm robots that will unload products according to customer orders from moving conveyors. The robots will be equipped with devices that will ensure that the correct quantity and product type is picked. The organisation is currently evaluating the realisation of this proposal as the capital investment required for its implementation is high. However, the feasibility study conducted by the automation engineers concluded that the inspection stages currently executed by the truck crews and warehousing personnel would be reduced by 70 minutes on average.

The initiatives of redesigning procedures with technology to serve customers and negotiating full time window flexibility have the objective of eliminating waiting time to serve and serve time in excess. This includes the proposal and implementation of three initiatives. The first project considered the application of technology to receive and verify daily orders at the store, in particular, for those under franchise. The second initiative consists of ensuring that customers returned bottles in their corresponding boxes. Finally, a team responsible for negotiating time windows considering night hours had approached store leaders. The feasibility studies conducted by the organisation to validate these proposed

initiatives indicated that they had the potential of increasing the number of customers to be served per route, and decreasing the number of routes required to satisfy all stores.

Finally, the project of implementing dynamic daily route design is planned to reduce fill loss and travelled distance in excess, by decreasing incorrect processing and therefore increasing truck capacity utilisation. The initial step in this improvement initiative proposed consists of the implementation of specialised software programmes, e.g. Roadnet Transportation Suite Routing and Scheduling Systems (UPS Logistics Group, 2004) and Map-Info (MapInfo Corporation, 2015). In particular, MapInfo software would help the organisation studied to perform a map and geocode analysis while Roadnet Transportation Suite would enable it to create optimised routes and load plans (Alagöz and Kocasoy, 2008). This is planned to reduce the number of daily routes according to the trend and behaviour of daily demand, assigning customers based on their location and demand. This will improve truck performance efficiency by increasing the utilisation of truck capacity and reducing travelled distance excess per route. The company's management was also recommended to consider the utilisation of trucks for two daily routes, impacting favourably on the administrative availability efficiency. Finally, the company was also suggested to carry out a periodic update of routes to consider new store introduction. This initiative of route design is planned to significantly reduce resource utilisation and incorrect processing wastes. With these improvement initiatives, the organisation estimated that the average number of stores per route would increase from 15 to 25.

Overall, the organisation estimated that the outcome of this project would reduce the transportation cost of its operations by about 40%, once that all the improvement initiatives proposed are approved and implemented by the company. In addition, it is also estimated that there will be a significant decrease in truck investment requirements since it is considered that the average number of trucks necessary to satisfy daily demand will be reduced by also 40%.

4.4 Implementation status of the strategy for the elimination of the STEWs
Table 3 presents a summary of the initiatives suggested and their impact on the STEWs identified and the important performance indicators. Given the recommendations provided, the management of the company decided to deploy an implementation plan consisting of three fronts.

The first two fronts were concentrated on decreasing excess customer serving time and improving warehousing activities. For the first front, the first effort was the implementation of three initiatives. The first initiative considered the application of technology to receive and verify daily orders at the store. The second initiative ensured that customers returned bottles in their corresponding beer cases. Finally, a team responsible for negotiating time windows considering night hours had approached the store leaders. As of today, the first two initiatives have been implemented in the RDC located in the city of Monterrey, Mexico. The last initiative has been put on hold until a better assessment of the security level of the city is obtained. The direct impact observed by the company was a reduction on the average serving time from 40.6 mins to 18.7 minutes.

Table 3. Summary of initiatives suggested and their impact on routing performance indicators

Waste	Description	Initiatives Considered	Impact on
Incorrect processing and resource utilisation	• Route sequencing defined by drivers • Routes not designed according to daily demand	• Semi-dynamic route design	• Truck capacity under-utilisation of 35% • Distance in excess per route of 19% • Long journey time of 11.5 hrs
Unnecessary movements and waiting	• Procedures for serving customers, preparing and closing routes have non-value added activities	• Automating product loading and inspection • Assigning inspection, loading and unloading product to warehousing operators • Redesigning procedures to serve customers with the use of technology • Negotiating full time window flexibility with store leaders	• Serving time in excess of 65% • Waiting time to prepare and close routes

The second front consisted in conducting a project to automate product loading and inspection before routing. After considering the capital investment required estimated in 100 thousand US dollars and the elimination of 25 operators, the management decided to postpone its implementation. Instead, an alternative working scheme was implemented. This new scheme consisted of three changes; (1) loading the product was a responsibility of warehousing operators; (2) the utilisation of representatives of the drivers and warehouse operators that will check and certify that the product is loaded and inspected, are in accordance with customer orders and; (3) the re-assignment of the unloading activity to warehousing operators. This activity has already been simplified by having the right bottles in the right cases done by the customers. The company reported a significant reduction of the average route preparation time from 90 to 23 mins and of the average route closing time from 60 mins to 16 mins.

The last front was in relation to route design. The initial step in this front was the implementation of the UPS Roadnet system. This will reduce the number of daily routes according to the behaviour of daily demand and assign customers based on their location and demand. This will greatly improve routing efficiency by increasing the utilisation of truck capacity and reducing excess distance travelled per route. The last step will also consider the utilisation of trucks for two routes per day. As of today, this initiative presents an important advancement in its implementation in the RDC located in the city of Monterrey, Mexico. Only the last step is still on hold until the security situation in city improves. The firm reports that the result of this application is encouraging; fill loss decreased to 71% from 54.9%, distance travelled in excess was eliminated and, the number of clients (given that serving time per customer was simultaneously reduced) served increased from 15 to 25.

The partially implemented strategy has already provided positive results. The average journey time per route has been reduced to about eight hours, practically eliminating the need for labour overtime. There is still the potential for utilising trucks twice per day and the investment of automating warehousing activities. The first initiative is on hold until a better

social climate is present. The second initiative depends on two conditions; the availability of funds and more important; since the reduction of routes implied a relocation of operating personnel, the management decided to wait for the layoff or relocation of more operating personnel.

Overall, the organisation estimated that the outcome of this project would reduce the loading and transportation cost of its operations by about 40%, once that all the improvement initiatives proposed are approved and implemented by the company. However, since the strategy has been partially implemented, current cost levels have experienced a reduction of 14% mainly due to the reduction in cost of labour overtime and consumption of diesel. In addition, the management also estimated that there will be a significant decrease in truck investment requirements in the medium term since the average number of routes necessary to satisfy daily demand will be reduced by 40%.

5. Conclusions

Since the 1950s, mathematical modelling, operations research, and simulation methods have traditionally been the key techniques used by researchers to improve transport operations (Sternberg *et al.*, 2013). With the support of these techniques, researchers have intended to address various logistics and transportation problems while minimising cost, time or distance, and optimising resource utilisation, routes, and transportation/delivery schedules. This paper documents a case study where a method of improvement based on lean thinking, specifically in the forms of concepts derived from the Toyota's seven production and business wastes and tools such as VSM, has been applied to the road transport operations of a leading Mexican brewing organisation. The paper thus offers a valuable insight to logistics and transport organisations on how lean thinking can significantly improve their operations. Its empirical application, as presented in this paper, comprises some basic and generic steps and adapted concepts and tools that can be easily replicated to a good effect in other organisations and settings beyond the context of the case company. Hence, the paper presents important practical implications for logistics and transport managers as they can refer to this paper as a guide to improve the operations of their organisations. Organisations involved in the management and improvement of distribution and logistics operations will find this study particularly beneficial. This is considered the main practical contribution of this paper.

Besides discussing the application of lean thinking in the road transport industry, the paper also contributes to the lean and logistics literature by highlighting the main research areas where the application of lean has been concentrated in this sector. The limited research undertaken in this area, as has been highlighted through this paper, is expected to inspire scholars to further study lean thinking in road transport operations and explore its compatibility with other traditional methods such as mathematical modelling, operations research, and simulation. Through this, a better understanding of this area will also be achieved, from which more effective strategies for the improvement of transport operations can be formulated. In this line, this paper has demonstrated, through the application of specialised software programmes (i.e. Roadnet Transportation Suite Routing and Scheduling Systems and Map-Info), that lean concepts and tools can complement, or be complemented, by other approaches and tools used to improve road transportation. In this study, these software, which are equipped with inbuilt powerful and advanced operation research techniques, acted as a support mechanism to realise some of the improvement strategies devised for the reduction of waste identified through the TVSM study. Finally, the limited use of lean thinking to improve lean road transport operation suggests that there is no clear understanding on the benefits of lean, and how to use its principles and tools to improve this type of operations. This study has attempted to provide some evidence of the application of

lean thinking to road transport operations, and can serve as a motivation to undertake further research in this area.

The partial application of the proposed scheme has already shown an important improvement of the routing operations of the Mexican company studied. The reduction of serving time per client and of the activities of preparing and closing routes, together with an increase in truck capacity utilisation and the reduction of distance in excess, increased the number of stops per route and eliminated the need for labour overtime. These results suggest lean thinking as an effective and suitable method to target the improvement of road transport operations. However, the use of a single case study research approach suggests that further research is required in different industrial settings and organisations to more widely test the effect of lean thinking in the transportation industry. Therefore, the collection of further evidence through a multiple case study approach is part of the future research agenda of the authors. In addition, to advance this area further, research is required to explore and understand the challenges and define the critical success factors (CSFs) for the deployment of lean thinking initiatives in the transport and logistics sector. Similarly, research is necessary to evaluate whether other lean principles and tools (e.g. OVE or TOVE), besides the ones employed in this paper, can contribute to enhance the positive improvements.

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