USING A THEORETICAL ROAD MAP FOR THE MANAGEMENT OF LEAN SUPPLY CHAINS

JD NEL (University of South Africa)
JA BADENHORST-WEISS (University of South Africa)

Abstract: Lean supply chains aim to reduce cost and waste and have to be managed accordingly. The article proposes a theoretical road map for managing lean supply chains. The road map consists of three major elements. The first element establishes whether organisations should implement a lean supply chain strategy or not. This decision is based on the supply chain determinants of market demand predictability, market winners and the position of the supply chain's decoupling point (if necessary). Once a lean supply chain strategy is suggested based on these theoretical principles, the road map advises organisations how their supply chain drivers should be managed to conform to lean supply chain principles. The road map also indicates which key performance indicators are important to measure performance within lean supply chains. The road map was tested empirically within four organisations. The article concludes that the road map can be useful for organisations to manage their lean supply chains.

Key phrases: *lean supply chain, supply chain driver, supply chain performance, supply chain strategy*

1 INTRODUCTION

Competition among organisations is moving more and more towards supply chain versus supply chain (Christopher 2005:18, 28; Gough 2003:78; Handfield, Monczka, Giunipero & Patterson 2011:7; Lambert 2006:1; Lo & Power 2010:139). Organisational success thus depends upon formulating and executing clear supply chain strategies (Taylor 2004:279). Supply chain strategies are strategies required by organisations for managing the integration of all the supply chain activities through improved supply chain relationships to achieve a competitive advantage for the supply chain (Hines 2004:5) and should form part of the organisation's business strategy (Swink, Melnyk, Cooper & Hartley 2011:26). Organisations should have strategies in place if they wish to survive in today's competitive business environment.

Effective supply chain strategies provide organisations with radically new opportunities to create competitive advantage (Ross 1998:334). Organisations want to select supply chain strategies that can achieve high levels of effectiveness by creating customer value or efficiency by minimising cost (Hines 2004:105). To achieve this there are basically three different supply chain strategies. They are lean supply chain strategies, agile supply chain strategies and a combination of lean and agile supply chain strategies (Raturi & Evans 2005:208; Towill & Christopher 2002:300). Agile supply chain strategies aim at creating customer value by being agile and responding quickly

to customers' needs (Jacobs, Chase & Aquilano 2009:364; Lee 2002:114; Yusuf, Gunasekaran, Adeleye & Sivayoganathan 2004:381), while lean supply chain strategies aim to reduce cost and waste (Vitasek, Manrodt & Abbott 2005:40). The focus of the article is on lean supply chains.

Organisations that implement the wrong supply chain strategy often find that their return on investment (ROI) are unsatisfactory and that they are stuck between the strategies, yielding a less than optimal ROI (Hines 2004:57; Porter 1985:16; Prajogo 2007:70). Organisations have to make the trade-off between efficiency and responsiveness in their supply chains. If an organisation needs to reduce costs, the only viable solution will be to build an efficient supply chain. If an organisation, for example, concentrates on the quality of its service as means of gaining competitive advantage, it needs a more responsive supply chain (Taylor 2004:282).

The most critical element of a supply chain strategy is deciding how to make the trade-off between responsiveness and efficiency (Taylor 2004:279). Many organisations are managing their supply chain incorrectly and are trying to pursue both strategies, which results in poor supply chain performance (Fisher 1997:1).

The research problem for the research on which this article reports was therefore based on the following question: How should organisations make sure that a lean supply chain strategy is appropriate for them and when they do, how should they manage their supply chains? The research endeavoured to investigate the research problem with the main objective of suggesting a theoretical road map for managing lean supply chains. The secondary objectives, as articulated in this article, were firstly to conduct a literature review to determine what the important determinants of a lean supply chain strategy are and secondly, to determine how specific supply chain drivers should be managed to reduce cost and waste in lean supply chains. Thirdly, key performance indicators are identified for lean supply chain strategies. The suggested road map to manage lean supply chains was tested in selected organisations.

2 LITERATURE REVIEW

A lean supply chain is a set of organisations directly linked by upstream and downstream flows of information, products and finances that collaboratively work to

reduce cost and waste (Agus & Hajinoor 2012:95; Eriksson 2010:395; Perez, de Castro, Simons & Giminez 2010:56, 57; Vitasek *et al*. 2005:40). Organisations thus aim at achieving this by means of a low-cost or lean supply chain strategy (Christopher 2005:10; Hines 2004:57) that aims at creating the highest cost efficiencies in the supply chain.

For such efficiencies to be achieved, non-value-added activities should be eliminated, scale economies should be pursued and optimisation techniques should be deployed to get the best capacity utilisation in production and distribution (Jacobs *et al*. 2009:364; Lee 2002:113). Waste can occur in the form of time, inventory, process redundancy or even digital waste (Vitasek *et al*. 2005:42). Lean supply chains thus operate at low costs with constant use of capacity and high stock-turning rates (Seuring 2003:183). Matching end-customer demand with reliable supply enables a lean supply chain characterised by high inventory turnovers and excellent use of supply chain resources (Ayers 2004:46). A lean supply chain thus focuses on high productivity in material flow and minimising costs of shipping the product to the end customer (Raturi & Evans 2005:208).

2.1 Important determinants of lean supply chains

Lean supply chains are appropriate for and match products with low demand and supply uncertainties where demand can be predicted and stable processes are operated efficiently to achieve economies of scale (Bruce, Daly & Towers 2004:154; Seuring 2003:184). Efficiency can be stressed when demand information is highly predictable (Ayers 2004:46; Towill & Christopher 2002:301). Organisations can make decisions against forecasts with little risk (Christopher 2003:287) because demand is predictable (with low levels of uncertainty and variety that is low) (Towill & Christopher 2002:301). Materials, components or products can be ordered ahead of demand, and manufacturing and transportation facilities can be optimised in terms of cost and asset utilisation (Christopher 2005:120). Predictable market demand is therefore an important determinant of lean supply chains.

Another important determinant is the market winner. Market winners differentiate an organisation's products and services from those of its competitors (Bozarth &

Handfield 2006:31). Market winners are means to win the orders of customers and once they are identified and understood, appropriate supply chain strategies can be designed and implemented (Quesada, Rachamadugu, Gonzalez & Martinez 2008: 297). The supply chain must excel at market winners (Mason-Jones, Naylor & Towill 2000:4063). The market winner for lean supply chains is low cost, while the market winner for agile supply chains is agility in the form of high service levels (Christopher 2004:32; Mason-Jones *et al.* 2000:4064).

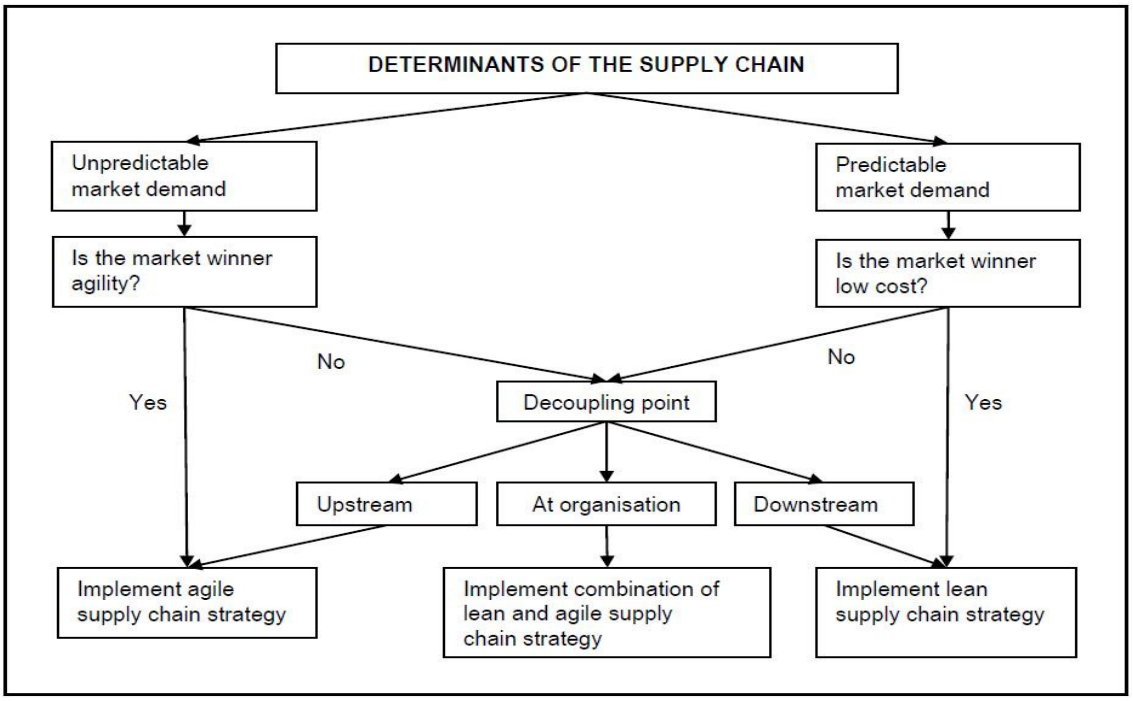
Therefore, if organisations have a predictable market demand and low cost as market winner, a lean supply chain strategy is appropriate. However, if organisations (1) have an unpredictable market demand and low cost as market winner or (2) have a predictable market demand and agility as market winner, the decoupling point should be used to determine a supply chain strategy. The decoupling point may be termed the point at which real demand penetrates upstream in a supply chain (Christopher 2003:288). The decoupling point therefore is the point in the product flow stream to which the customer's order penetrates and where real-time data and forecast-driven activities meet (Mason-Jones *et al.* 2000:4061). The supply chain from the customer to the inventory decoupling point faces a highly volatile demand. The processes are consequently designed to be agile (i.e. responsive) downstream of the decoupling point (Towill & Christopher 2002:300) to make provision for the more unpredictable marketplace (Mason-Jones *et al*. 2000:4065).

Upstream of this decoupling point, the processes are designed to be lean (Towill & Christopher 2002:300). Upstream organisations work to a stable demand with relatively low variety and can therefore focus on lean low-cost manufacture (Lysons & Farrington 2006:146). Risk can thus be reduced by delaying the time at which the decision must be taken to make a specific product available in a specific place for as long as possible (Tellarini, Pellandini, Battezzati, Fascina & Ferrozzi 2007:190). The flow of products upstream from the decoupling point therefore may well be forecast-driven (Christopher 2003:289; Lysons & Farrington 2006:146).

Therefore, if organisations (1) have an unpredictable market demand and low cost as market winner or (2) have a predictable market demand and agility as market winner,

a lean supply chain strategy will be suggested to organisations that are positioned upstream from the decoupling point. Organisations positioned downstream from it will follow an agile supply chain strategy and organisations positioned at the decoupling point will follow a lean supply chain strategy in their supply chain upstream from the decoupling point and an agile supply chain strategy downstream from the decoupling point. To conclude, when the supply chain characteristics of market demand predictability, market winner and decoupling point (if necessary) are used as important determinants, a supply chain strategy can be suggested or implied to organisations. This is illustrated in Figure 1.

FIGURE 1: SELECTION OF SUPPLY CHAIN STRATEGY BASED ON SUPPLY CHAIN DETERMINANTS



Source: Authors

2.2 Managing supply chain drivers in lean supply chains

Supply chains consist of a network of facilities and distribution options that perform the functions of procurement of materials and the transportation and distribution of products to customers (Agus & Hajinoor 2012:94). In any supply chain there are drivers that determine the performance of the supply chain and if these drivers are

managed correctly, organisations can improve their supply chain performance in terms of responsiveness and efficiency. Supply chain drivers (facilities, inventory, sourcing, information, transportation and pricing) interact with each other and should be managed differently for different supply chain strategies (Chopra & Meindl 2010:59).

2.2.1 Facilities

Facilities are the actual physical locations in the supply chain network where the product is manufactured, assembled or stored and might be warehouses or distribution centres or simply the stock rooms of retail stores (Fernie & Sparks 2009:7). Decisions regarding the role, location, capacity and flexibility of facilities have a significant impact on the supply chain's performance (Chopra & Meindl 2010:59; Hugos 2006:10). In lean supply chains, location and capacity factors must be managed correctly to enhance efficiency (Reid & Sanders 2007:316). Economies of scale can be utilised by centralising facilities (Hugos 2006:35).

It is much less costly to operate a few large facilities than to operate many smaller facilities with the same total capacity (Simchi-Levi, Kaminsky & Simchi-Levi, 2008:232). An organisation with fewer facilities will increase efficiency, but reduce responsiveness (Chopra & Meindl 2010:59). Centralised facilities will thus reduce both the cycle inventory and the safety stock levels and should be used in lean supply chains (Raturi & Evans 2005:209, 210; Simchi-Levi *et al*. 2008:51; Wisner, Tan & Leong, 2009:325). When organisations plan inventory levels, they have to consider capacity (Benton 2010:64). The capacity of a facility is the maximum average rate at which entities, such as inventories, can flow through the system (Hopp 2008:13). It is the limit on the amount of output that a process can produce given an amount of inputs and resources made available to the process in terms of, for example, machine hours, labour hours and tools (Swink *et al*. 2011:57). Lean supply chains strive to maintain high utilisation rates (Hugos 2006:37; Stavrulaki & Davis 2010:145).

2.2.2 Inventory

Facilities contain controlled quantities of materials called inventories (Taylor 2004:22). Inventory can be seen as stored capacity (Benton 2010:64). Inventory is thus the stock

of any item or resource used in an organisation (Jacobs *et al*. 2009:547). Organisations in the supply chain invest significant amounts of money in holding inventory (Mangan, Lalwani, Butcher & Javadpour 2012:190). Organisations also need to make decisions about inventory concerning responsiveness and efficiency and have to optimise the trade-off between various inventory management costs. In lean supply chains, organisations should strive to reduce inventory levels as such reduction would make the organisation more efficient (Chopra & Meindl 2010:60; Harrison & Van Hoek 2011:193; Hugos 2006:12, 35).

2.2.3 Sourcing

Sourcing is a supply chain driver that has major implications for an organisation and its supply chain's responsiveness and efficiency. Sourcing decisions, which are often strategic decisions, are important because they determine the capacity and resource requirements of supply chain members (Bozarth & Handfield 2006:297). Sourcing involves the choice of who will perform a particular supply chain activity, such as production, storage, transportation, or the management of information. At the strategic level, these decisions determine what functions an organisation performs and what functions the organisation outsources to other organisations. Sourcing certain processes to other parties may increase a supply chain’s efficiency but reduce its responsiveness because of longer lead times due to, for example, location (Chopra & Meindl 2010:60). Organisations that aim for efficiency should select suppliers on the basis of low prices and economies of scale.

2.2.4 Information

Supply chains are also networks of information flow and managing information (Hopp 2008:201) that require technology systems to initiate activities and track information regarding supply chain processes (Bowersox *et al.* 2010:95). Therefore, timely and accurate demand information is a critical component of an effective supply chain (Wisner *et al.* 2009:140) and information sharing is the key to a seamless supply chain (Jeong & Hong 2007:584; Sridharan, Caines & Patterson 2005:314). All information across the supply chain is not necessarily visible (Langley *et al*. 2009:189). The trade-off between responsiveness and efficiency involves weighing

the benefits of obtaining good information against the cost of acquiring it (Hugos 2006:16). Accurate and relevant customer demand information can also make the supply chain more efficient because the organisation can forecast demand better and produce only the required amount of products. It can also provide organisations with shipping options that allow them to choose the lowest cost possibilities while still meeting the necessary service requirements (Chopra & Meindl 2010:60).

2.2.5 Transportation

Transport is required for the physical movement of materials between points in the supply chain in the journey from production to consumption (Fernie & Sparks 2009:7; Waters 2009:404). It is the physical link connecting an organisation's customers, raw material suppliers and other supply chain members (Langley, Coyle, Gibson, Novack & Bardi 2009:271). Knowledge of the transportation system is fundamental to the efficient and economic operation of an organisation's supply chain. Transportation can take the form of many combinations of modes and routes, each with its own performance characteristics (Bowersox, Closs & Cooper 2010:209; Chopra & Meindl 2010:60; Langley *et al*. 2009:271; Mangan *et al*. 2012:124).

Transportation also has a large impact on a lean supply chain's efficiency (Chopra & Meindl 2010:60). Efficiency can be enhanced by transporting products in larger batches and less often, thus being more cost-effective (Hugos 2006:36). An organisation can also use slower and cheaper means of transport to make the supply chain more efficient, but it may be less responsive (Bozarth & Handfield 2006:342, Chopra & Meindl 2010:60). Efficiency can be improved by reducing waiting times, eliminating the excessive movement of goods and reducing transport distances. An obvious way of reducing distances travelled is to determine and schedule more efficient routes for vehicles (Pienaar 2009:373-376; Waters 2009:429).

2.2.6 Pricing

Pricing determines how much an organisation will charge for products that it makes available in the supply chain (Chopra & Meindl 2010:60) and should be expected to cover cost of production, promotion, as well as distribution plus a reasonable profit

(Benton 2010:281). Organisations with lean supply chain strategies will use lower margins and higher volumes to increase their profits.

In conclusion, the management of supply chain drivers will have a significant effect on the supply chain performance of lean supply chains, and depending on how these supply chain drivers are utilised they will have different effects on the supply chain's efficiency. The effect of the supply chain drivers on efficiency within supply chains is listed in Table 1. Nine components listed below were identified in the six supply chain drivers:

- Capacity utilisation,
- Location of facilities,
- Inventory levels,
- Lead times,
- Transportation cost,
- Transportation frequency,
- Information,
- Supplier selection,
- Pricing and profit margins.

TABLE 1: EFFECT OF SUPPLY CHAIN DRIVERS ON A SUPPLY CHAIN'S EFFICIENCY

Supply chain driver	Managing supply chain driver component for efficiency
Facilities	Capacity utilisation: Little excess capacity (lower costs through maintaining high average utilisation rate) Location: Few central facilities serve wide areas
Inventory	Inventory levels: Low inventory levels; generate high turns and minimise inventory throughout the supply chain to lower cost
Transportation	Transportation frequency: Shipments are few, large Transportation cost: Slow, cheaper modes of transport Lead times: Shorten lead time as long as it does not increase cost
Information	Information: Cost of information drops while other costs rise
Sourcing	Supplier selection criteria: Based on economies of scale; price and quality (in terms of reliability)
Pricing	Pricing and profit margins: Lower margins, higher volume; price is the prime customer driver

Source: Compiled from Bruce *et al.* (2004:155); Chopra & Meindl (2010:48, 59, 60); Christopher (2003:285); Hines (2004:63); Hugos (2006:37) and Webster (2008:352).

2.3 Key performance indicator categories

One of the keys to improving supply chain performance is to have sound performance measures in place for monitoring performance (Taylor 2004:173). Performance measures need to be aligned across all levels of the organisation to ensure that organisational performance and supply chain performance are closely aligned (Kussing 2009:447). Numerous key performance indicators (KPIs) can be used to evaluate supply chain performance and identify improvements to the design and operation of supply chains (Evans & Collier 2007:363). However, unless the right KPIs are established to support the organisation's strategy, the supply chain may be poorly designed and managed (Raturi & Evans 2005:203).

Supply chain performance KPIs can be categorised in five performance categories across the supply chain, with several performance measures within each category. These performance categories have several KPIs that measure them. Table 2 illustrates the KPI categories with some specific KPIs in each category.

TABLE 2: SUPPLY CHAIN PERFORMANCE CATEGORIES AND KPIS

KPI category	Specific KPIs
Supply chain delivery reliability	Delivery performance Fill rates Perfect order fulfilment
Supply chain responsiveness	Order fulfilment lead time
Supply chain flexibility	Supply chain response time Production flexibility
Supply chain cost	Cost measures within the organisation Total supply chain management cost across the supply chain
Supply chain asset management efficiency	Cash-to-cash cycle time Inventory days of supply Asset turns

Source: Adapted from Bolstorff and Rosenbaum (2003:51-53).

Implementing a supply chain strategy requires KPIs that align performance with the objectives of other supply chain members (Lambert & Pohlen 2006:204). The selected KPIs to measure supply chain performance measurement need to be able to measure the goals of the supply chain strategy (Wang, Heng & Chau 2007:333). As already implied, organisations will select a lean strategy when trying to reduce cost and waste in order to gain a cost advantage (Towill & Christopher 2002:300).

KPIs thus have to be selected to measure the extent to which organisations with lean supply chains succeed in meeting this market winner. The important KPI categories for a lean supply chain strategy are illustrated in Table 3, which shows that total supply chain cost and supply chain asset management efficiency KPIs should be used to measure lean supply chains. Supply chain delivery reliability KPIs can also be included because lean supply chains aim to reduce waste (Bolstorff & Rosenbaum 2003:51-53; Taylor 2004:185, 189).

TABLE 3: IMPORTANT KPI CATEGORIES FOR LEAN SUPPLY CHAINS

Market winner	Supply chain KPI category	Specific KPIs
Low cost	Total supply chain management cost	Cost measures within the organisation Total supply chain cost (across the supply chain)
	Supply chain asset management efficiency	Cash-to-cash cycle time Inventory days of supply Asset turns
	Supply chain delivery reliability	Delivery performance Fill rates Perfect order fulfilment

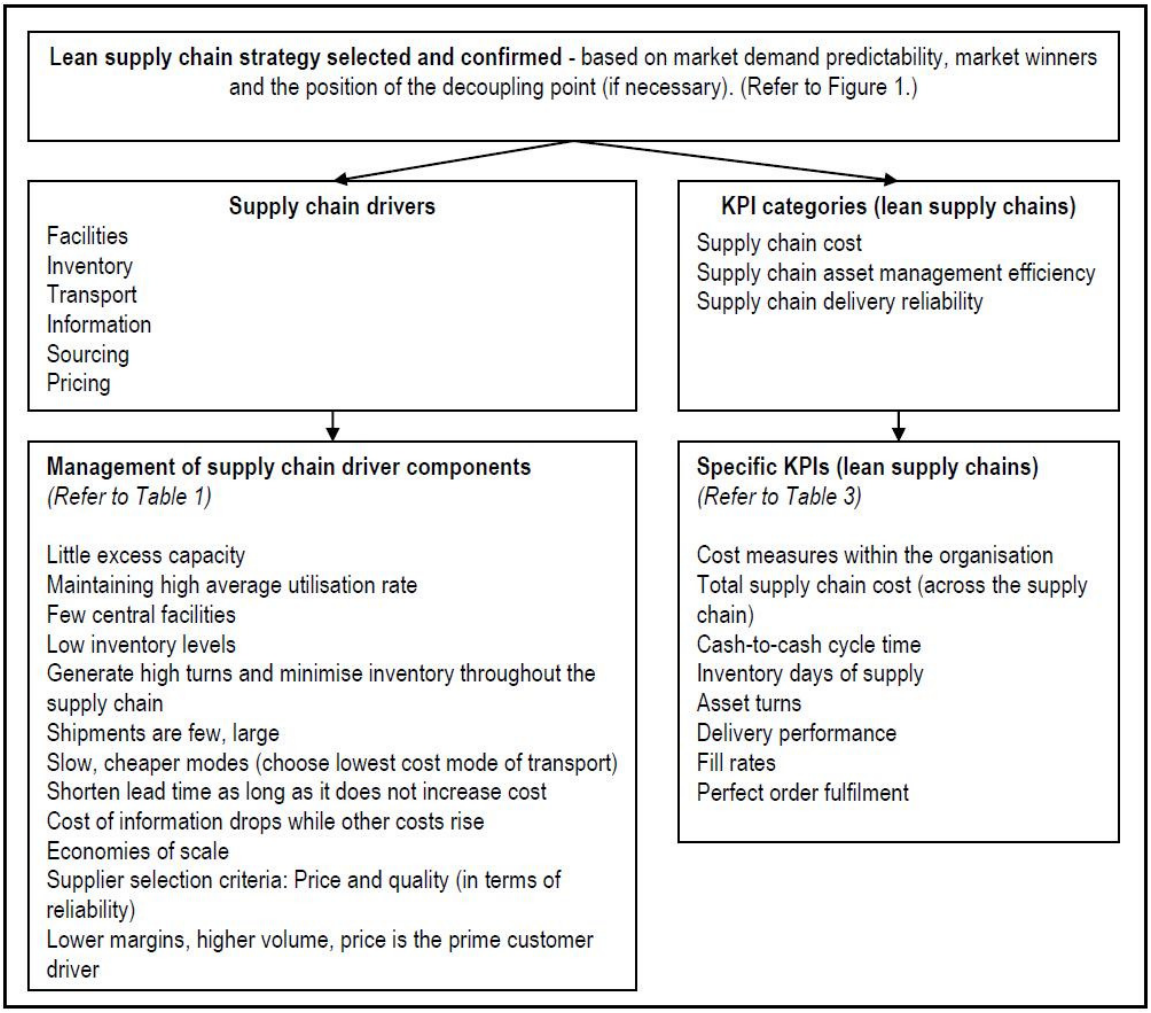
Source: Compiled from Agarwal and Shankar (2002:32); Bolstorff and Rosenbaum (2003:51-53, 68); Christopher and Towill (2001:237); Reiner and Schodl (2003:312) and Taylor (2004:184-189).

To conclude, when organisations select a lean supply chain strategy based on the determinants of market demand predictability, market winners and the position of the decoupling point (if necessary), they have to manage their supply chain drivers in a specific manner. These organisations also have to focus on specific KPI categories. These issues are summarised in Figure 2, which provides a theoretical road map on how to manage lean supply chains.

3 RESEARCH METHODOLOGY

The research methodology for the study on which this article is based comprised two phases. The first phase was a literature review conducted on the topic of lean supply chains. The literature review identified important supply chain determinants for lean supply chains. The literature review also looked at the management of supply chain drivers within lean supply chain strategies as well as the KPI categories on which organisations with lean supply chains should focus. From the literature review a road map was compiled with suggestions on how to manage and measure the performance of lean supply chains.

FIGURE 2: ROAD MAP ON HOW TO MANAGE LEAN SUPPLY CHAINS



Source: Authors

The second phase of the study consisted of empirical research to test the suggested road map in selected organisations. The sample for the research comprised thirteen organisations. These organisations were selected by means of convenience, judgmental and purposive sampling to ensure that organisations that were leaders in their industries were selected in the sample. The organisations were from the manufacturing, wholesale, distribution and retail industries and were either market leaders or in the top three organisations in their respective industries.

It was essential to include some organisations that (1) were implementing lean supply chain strategies or (2) would be advised to implement a lean supply chain

strategy. For confidentiality purposes, these organisations were named Organisation A to Organisation M. A structured questionnaire was developed and used as research instrument and the data were obtained by means of a qualified field worker, who conducted the personal interviews with managers who were involved in the organisation's supply chain.

4 RESEARCH FINDINGS: TESTING THE THEORETICAL ROAD MAP TO MANAGE LEAN SUPPLY CHAINS

Essentially, the theoretical road map consists of three main parts. The first part establishes whether organisations should implement a lean supply chain strategy based on the supply chain determinants of market demand predictability, market winners and the position of the decoupling point (if necessary). The second part suggests how organisations with a lean supply chain strategy should be managing their supply chains and the third part highlights which KPI categories are important for measuring performance in lean supply chains. Three of the thirteen organisations indicated that they were implementing a lean supply chain strategy. These three organisations were thus used to test the theoretical road map.

4.1 Using key supply chain determinants to suggest a lean supply chain strategy

As mentioned earlier, the supply chain determinants that were used to suggest a supply chain strategy are market demand predictability, market winners and the position of the decoupling point in the supply chain (if necessary). If organisations had a predictable market demand and low cost as market winner, a lean supply chain strategy is implied. If, however, organisations (1) have an unpredictable market demand and low cost as market winner or (2) have a predictable market demand and agility as market winner, the decoupling point was used to determine a supply chain strategy. If the decoupling point was positioned downstream from the organisation, a lean supply chain strategy was suggested to that organisation.

All three organisations (A, B and C) had a predictable market demand. However, only Organisation B had low cost as its market winner. A lean supply chain strategy is suggested to Organisation B based on its market demand predictability and market

winner. Organisations A and C had agility as their market winner. A combination of lean and agile supply chain strategies was suggested to Organisations A and C because the position of the supply chain's decoupling point was downstream. Thus, the theoretical road map indicated that Organisations A and C may have been focusing on the wrong supply chain strategy. They were focusing on a lean supply chain strategy while they should have been focusing on an agile supply chain strategy as well. It was suggested that Organisations A and C should explore the possibilities of being lean upstream from the decoupling point and on being agile downstream from the decoupling point.

The theoretical road map also suggested a lean supply chain strategy for Organisation E. Organisation E had a predictable market demand and had low cost as its market winner. However, Organisation E indicated that it was implementing a combination of a lean and an agile supply chain strategy. The research findings of Organisation E are also discussed because the road map suggests a lean supply chain strategy for Organisation E. Therefore, the research findings of four organisations (A, B, C and E) are discussed.

Table 4 shows which of the organisations indicated that they were implementing a lean supply chain strategy. The table also shows which organisations should be implementing a lean supply chain strategy according to the theoretical road map based on the identified determinants.

TABLE 4: ORGANISATIONS' LINKS TO LEAN SUPPLY CHAIN STRATEGIES

Organisation	Organisations that indicated that they were implementing a lean supply chain strategy	Lean supply chain strategy suggested by the theoretical road map based on important supply chain determinants
A	Yes	No
B	Yes	Yes
C	Yes	No
E	No	Yes

Source: Authors

Only organisation B indicated that it was implementing a supply chain strategy that was being suggested to it by the supply chain determinants of market demand predictability, market winners and the position of the decoupling point (if necessary).

This is highlighted by the shaded area. Organisations A, C and E were implementing a different supply chain strategy to the one being suggested to them by the theoretical road map.

4.2 Management of supply chain drivers

Table 5 shows how these four organisations (A, B, C and E) were managing their supply chain drivers and whether they were following theoretical principles provided in the literature. A four-point Likert scale was used (where 1 = a very strong focus on lean supply chain principles to 4 = a very strong focus on agile supply chain principles) to determine the extent to which these organisations were managing their supply chain drivers according to lean supply chain principles. A response of 1 or 2 was deemed satisfactory to indicate that the supply chain drivers' components were being managed according to lean supply chain principles. As already mentioned, the theoretical road map suggests a lean supply chain strategy for Organisations B and E. The supply chain driver components of these two organisations that were managed according to lean supply chain principles are shaded.

TABLE 5: MANAGEMENT OF SUPPLY CHAIN DRIVERS ACCORDING TO LEAN SUPPLY CHAIN PRINCIPLES

Components of supply chain drivers	Organisation's management according to lean supply chain principles			
	A	B	C	E
Capacity utilisation	Yes	Yes	Yes	Yes
Location of facilities	No	No	No	Yes
Inventory levels	Yes	Yes	Yes	Yes
Lead times	Yes	Yes	No	No
Transportation cost	Yes	Yes	Yes	Yes
Transportation frequency	No	Yes	No	Yes
Information	No	Yes	No	No
Supplier selection	No	Yes	No	No
Pricing and profit margins	Yes	Yes	No response	Yes

Source: Authors

Organisation B was managing eight of the nine supply chain driver components according to lean supply chain principles. The only aspect that was not managed according to lean supply chain principles was the location of their facilities. Organisation B was using decentralised facilities, which in theory increases costs and is not in line with the objective of minimising costs. Organisation B can therefore

analyse whether they should centralise their facilities or not. Therefore, the theoretical road map was useful in showing Organisation B that it was managing most of its supply chain drivers according to lean supply chain principles.

Organisation E was managing six of the nine supply chain driver components according to lean supply chain principles. The three components that were being managed according to agile supply chain principles were lead times; investments in information systems and supplier selection. Organisation E could consider analysing these supply chain driver components to determine whether there were cost saving opportunities which they may have been neglecting because of their focus on agility. For example, it was suggested that Organisation E ask themselves why they were selecting their suppliers based on agility if their market demand was predictable and if low cost was their market winner. It was also recommended that they should determine whether they were not in fact investing too much in their information systems. The theoretical road map thus also successfully highlighted areas where Organisation E could alter the way in which they were managing some of their supply chain drivers.

According to their responses, Organisations A and C were implementing a lean supply chain strategy. However, based on the characteristics of their market demand predictability, market winners and the decoupling point of the organisations' supply chains, a combination of lean and agile supply chain strategies was suggested to Organisations A and C according to theoretical principles. Organisation A was managing five of the nine supply chain driver components according to lean supply chain principles while Organisation C was doing so with three of the nine supply chain driver components. Organisation C did not respond to one of the components. This is significant because Organisations A and C may have been focusing on cutting costs in areas where it may not have been necessary and where customers may have required more agility. This becomes evident when analysing the manner in which Organisations A and C were managing their supply chain drivers.

Several of Organisations A and C's supply chain drivers were being managed according to agile supply chain principles. The components that both organisations

were managing according to agile supply chain principles were the location of their facilities, transportation frequency, information systems and supplier selection. Organisation C was also emphasising shorter (but potentially more expensive) lead times that were characteristic to agile supply chains. Organisations A and C needed to analyse these supply chain driver components to see whether in fact it was necessary to reduce costs in these areas. Organisations A and C may have realised that agility was required in some components of their supply chain drivers. For example, it makes sense that Organisations A and C were using decentralised facilities and that their transportation frequencies were high. This conformed to their need for agility.

Once again, the road map clearly indicates that these organisations should not focus only on a lean supply chain strategy (and that they may have been focusing on the wrong supply chain strategy). This could help Organisations A and C to determine which supply chain drivers need to be managed to reduce cost and which need to be managed for agility.

4.3 The focus of KPI categories

Organisations with lean supply chain strategies should focus primarily on the following KPI categories: total supply chain cost, supply chain asset management efficiency and supply chain delivery reliability. Total supply chain costs were divided into two sections namely, supply chain costs within the organisation and total supply chain costs across the supply chain. Table 6 illustrates how these four organisations (A, B, C and E) rated the importance of these KPI categories in their organisations. The shaded areas highlight which KPI categories should be used to measure the performance of Organisations B and E who, according to the theoretical road map, should have been implementing a lean supply chain strategy.

TABLE 6: THE IMPORTANCE RATING OF KPI CATEGORIES IN SELECTED ORGANISATIONS

KPI category	Organisation's importance rating of KPI category			
	A	B	C	E
Supply chain delivery reliability	1st	2nd	3rd	1st
Supply chain responsiveness	2nd	Not rated	4th	1st
Supply chain flexibility	Not rated	Not rated	5th	Not rated

KPI category	Organisation's importance rating of KPI category			
	A	B	C	E
Supply chain cost within the organisation	3rd	1st	1st	1st
Total supply chain cost across the supply chain	Not rated	Not rated	2nd	1st
Supply chain asset management efficiency	Not rated	Not rated	1st	6th

Source: Authors

Organisation B rated supply chain costs in their organisation as the most important KPI category, but did not rate total supply chain costs across the entire supply chain as well as supply chain asset management efficiency KPIs as being important. Organisation B rated supply chain delivery reliability as second most important KPI category. Delivery reliability is an important KPI category because reliability reduces, for example, waiting times which in turn reduces costs. It could be recommended that Organisation B focus more on total supply chain costs across the supply chain to reduce cost, because their market demand was predictable and their market winner was low cost. It could be suggested to Organisation B that they should try to develop their supply chain relationships more and should strive towards higher degrees of supply chain integration.

Organisation E rated total supply chain costs (in the organisation and across the supply chain) as well as supply chain delivery reliability and supply chain responsiveness as the most important KPI categories. The organisation rated the supply chain asset management efficiency KPI category very low. It could be recommended to them that they determine whether it is important or not to measure this KPI category. Once again, the theoretical road map successfully highlighted the important KPI categories that Organisations B and E may have been neglecting in the measurement of their performance.

Organisation A rated the supply chain costs in its organisation as the third most important KPI category. Total supply chain costs and supply chain asset management efficiency KPIs were not rated as being important. Organisation A also rated supply chain delivery reliability as the most important KPI category and rated supply chain responsiveness as the second most important KPI category. Organisation C rated supply chain costs in their organisation and supply chain asset management efficiency KPIs as the most important KPI categories and they also

emphasised the importance of total supply chain costs across the entire supply chain. It was further suggested that Organisations A and C may have to determine whether the other KPI categories may be important for them to measure. They may have to focus more on KPI costs that measure supply chain agility.

5 CONCLUSIONS AND RECOMMENDATIONS

Based on the research reported in this article, it appears as if organisations may be managing their supply chains incorrectly and that they may be pursuing strategies that are not applicable to their organisation. This article suggests a theoretical road map based on theoretical principles to organisations to manage lean supply chains. Organisations with a predictable market demand and with low cost as market winner should implement a lean supply chain strategy. If organisations (1) have an unpredictable market demand and low cost as market winner or (2) have a predictable market demand and agility as market winner, a lean supply chain strategy will be suggested to organisations that are positioned upstream from the decoupling point.

In lean supply chains, the supply chain drivers will be managed to achieve efficiency. There are six supply chain drivers. They are facilities, inventory, transportation, information, sourcing and pricing margins. The article highlighted how these supply chain drivers ought to be managed to achieve efficiency according to theoretical principles. The article also emphasised important KPI categories to measure performance within lean supply chains. These KPI categories are total supply chain costs, supply chain asset management efficiency and supply chain delivery reliability.

Four organisations were included in the discussion of the empirical research that is reported in this article. A lean supply chain strategy was suggested to two organisations (B and E) based on theoretical principles of market demand predictability, market winners and the position of the decoupling point for lean supply chains. The theoretical road map successfully indicated which organisations should be implementing a lean supply chain strategy and which organisations should not be doing so. The road map also highlighted where organisations B and E should

consider managing some of their supply chain drivers differently to try and reduce costs. Lastly, the road map also indicated some KPI categories that Organisations B and E may have been neglecting in the measurement of their performance.

In conclusion: the theoretical road map to manage lean supply chains is a usable instrument. It clearly indicates when organisations should be implementing a lean supply chain strategy based on the theoretical principles of specific supply chain determinants. It then clearly indicates how organisations with lean supply chain strategies should be managing their supply chain drivers. Lastly, the theoretical road map also highlights which KPI categories are important to measure performance.

REFERENCES

AGARWAL A & SHANKAR R. 2002. Analysing alternatives for improvement in supply chain performance. *Work study*, 51(1):32–37.

AGUS A & HAJINOOR MS. 2012. Lean production supply chain management as driver towards enhancing product quality and business performance: case study of manufacturing companies in Malaysia. *International Journal of Quality & Reliability Management,* 29(1):92-121.

AYERS JB. 2004. Supply chain project management: A structured collaborative and measurable approach. Boca Raton, Fl: St. Lucie Press.

BENTON WC. 2010. Purchasing and supply chain management. Boston, MA: McGraw Hill.

BOLSTORFF P & ROSENBAUM R. 2003. Supply chain excellence: A handbook for dramatic improvement using the SCOR model. New York, NY: Amacom.

BOWERSOX DJ, CLOSS DJ & COOPER MB. 2010. Supply chain logistics management. Boston, MA: McGraw Hill.

BOZARTH CC & HANDFIELD RB. 2006. Introduction to operations and supply chain management. Upper Saddle River, NJ: Pearson Prentice Hall.

BRUCE M, DALY L & TOWERS N. 2004. Lean or agile: A solution for supply chain management in the textiles and clothing industry? *International Journal of Operations and Production Management*, 24(2):151–170.

CHOPRA S & MEINDL P. 2010. Supply chain management: Strategy, planning and operation. Boston, MA: Pearson.

CHRISTOPHER M. 2003. Creating agile supply chains, IN GATTORNA JL (ed). Gower handbook of supply chain management. Burlington, VT: Gower. pp. 283–295.

CHRISTOPHER M. 2004. Supply chains: A marketing perspective, IN NEW S & WESTBROOK R (eds). Understanding supply chains: Concepts, critiques and futures. New York, NY: Oxford University Press. pp.23–42.

CHRISTOPHER M. 2005. Logistics and supply chain management: Creating value-adding networks. Harlow, England: Prentice Hall.

CHRISTOPHER M & TOWILL D. 2001. An integrated model for the design of agile supply chains. *International Journal of Physical Distribution and Logistics Management*, 31(4): 235–246.

ERIKSSON PE. 2010. Improving construction supply chain collaboration and performance: a lean construction pilot project. *Supply Chain Management: an International Journal*, 15(5):394-403.

EVANS JR & COLLIER DA. 2007. Operations management: An integrated goods and services approach. Mason, OH: Thomson South Western.

FERNIE J & SPARKS L. 2009. Retail logistics: changes and challenges, IN FERNIE J & SPARKS L (eds). Logistics & Retail management: emerging issues and new challenges in the retail supply chain. London, England: Kogan Page. pp. 3-37.

FISHER ML. 1997. What is the right supply chain for your product? *Harvard Business Review*: March-April:1–12.

GOUGH K. 2003. Performance measurement in the supply chain. *Logistics and Transport Focus* 5(5). p. 78.

HARRISON A & VAN HOEK R. Logistics management and strategy: competing through the supply chain. Harlow, England: Financial Times Prentice Hall.

HANDFIELD RB, MONCZKA RM, GIUNIPERO LC & PATTERSON JL. 2011. Sourcing and supply chain management. Not known: South-Western.

HINES T. 2004. Supply chain strategies: Customer-driven and customer-focused. Boston, MA: Elsevier.

HOPP WJ. 2008. Supply chain science. Boston, MA: McGraw-Hill Irwin.

HUGOS M. 2006. Essentials of supply chain management. Hoboken, NJ: Wiley.

JACOBS FR, CHASE RB & AQUILANO NJ. 2009. Operations and supply management. New York, NY: McGraw-Hill Irwin.

JEONG JS & HONG P. 2007. Customer orientation and performance outcomes in supply chain management. *Journal of Enterprise Information Management*, 20(5):578–594).

KUSSING U. 2009. Controlling logistics performance, IN PIENAAR WJ & VOGT JJ (eds). Business logistics management: a supply chain perspective. Cape Town: Oxford University Press. pp. 438–459.

LAMBERT DM. 2006. Supply chain management, IN LAMBERT DM (ed). Supply chain management: processes, partnerships, performance. Florida: Supply Chain Management Institute. pp. 1–24.

LAMBERT DM & POHLEN TL. 2006. Supply chain management performance measurement, IN LAMBERT DM (ed). Supply chain management: Processes, partnerships, performance. Sarasota, FL: Supply Chain Management Institute. pp. 197–216.

LANGLEY CJ (Jr), COYLE JJ, GIBSON BJ, NOVACK RA & BARDI EJ. 2009. Managing supply chains: A logistics approach. Not known: South-Western Cengage Learning.

LEE HL. 2002. Aligning supply chain strategies with product uncertainties. *California Management Review*, 44(3):105–119.

LO SM & POWER D. 2010. An empirical investigation of the relationship between product nature and supply chain strategy. *Supply Chain Management: an International Journal*, 15(2):139-153.

LYSONS K & FARRINGTON B. 2006. Purchasing and supply chain management. Harlow, England: Prentice Hall-Financial Times.

MANGAN J, LALWANI C, BUTCHER T & JAVADPOUR R. 2012. Global logistics and supply chain management. Chichester, West Sussex: Wiley.

MASON-JONES R, NAYLOR B & TOWILL DR. 2000. Lean, agile or leagile? Matching your supply chain to the marketplace. *International Journal of Production Research*, 38(17):4061–4070.

PEREZ C, DE CASTRO R, SIMONS D & GIMINEZ G. 2010. Development of lean supply chains: a case study of the Catalan pork sector. *Supply Chain Management: an International Journal*, 15(1):55-68.

PIENAAR WJ. 2009. Transport management, IN PIENAAR WJ & VOGT JJ (eds). Business logistics management: a supply chain perspective. Cape Town: Oxford University Press. pp. 362–382.

PORTER ME. 1985. Competitive advantage: Creating and sustaining superior performance. New York, NY: Free Press.

PRAJOGO DI. 2007. The relationship between competitive strategies and product quality. Industrial Management and Data Systems, 107(1):69–83.

QUESADA G, RACHAMADUGU R, GONZALEZ M & MARTINEZ JL. 2008. Linking order winning and external supply chain integration strategies. *Supply Chain Management: An International Journal*, 13(4):296–303.

RATURI AS & EVANS JR. 2005. Principles of operations management. Mason, OH: South-Western.

REID RD & SANDERS NR. 2007. Operations management: An integrated approach. Hoboken, NJ: Wiley.

REINER G & SCHODL R. 2003. A model for the support and evaluation of strategic supply chain design, IN SEURING S, MÜLLER M, GOLDBACH M & SCHNEIDEWIND U (eds). Strategy and organisation in supply chains. Heidelberg, Germany: Physica-Verlag. pp. 305–320.

ROSS DF. 1998. Competing through supply chain management: Creating market-winning strategies through supply chain partnerships. New York, NY: Chapman & Hall.

SEURING S. 2003. Strategic supply chain management – from focused factories to focused supply chains, IN SEURING S, MÜLLER M, GOLDBACH M & SCHNEIDEWIND U (eds). Strategy and organisation in supply chains. Heidelberg, Germany: Physica-Verlag. 181–196.

SIMCHI-LEVI D, KAMINSKY P & SIMCHI-LEVI E. 2008. Designing and managing the supply chain: Concepts, strategies, and case studies. Boston, MA: McGraw-Hill.

SRIDHARAN UV, CAINES WR & PATTERSON CC. 2005. Implementation of supply chain management and its impact on the value of firms. *Supply Chain Management: An International Journal*, 10(4):313–318.

STAVRULAKI E & DAVIS M. 2010. Aligning products with supply chain processes and strategy. *The International Journal of Logistics Management*, 21(1):127-151.

SWINK M, MELNYK SA, COOPER MB & HARTLEY JL. 2011. Managing operations across the supply chain. New York, NY: McGraw-Hill Irwin.

TAYLOR DA. 2004. Supply chains: A manager's guide. Boston, MA: Addison-Wesley.

TELLARINI F, PELLANDINI S, BATTEZZATI L, FASCINA G & FERROZZI C. 2007. Designing the supply chain, IN PERRET F-L, JAFFEUX C, FENDER M & WIESER P (eds). Essentials of logistics and management. Lausanne: EPFL Press. pp. 173–205.

TOWILL DR & CHRISTOPHER M. 2002. The supply chain strategy conundrum: To be lean or agile or to be lean and agile? *International Journal of Logistics: Research and Applications*, 5(3):299–309.

VITASEK K, MANRODT KB & ABBOTT J. 2005. What makes a lean supply chain? *Supply Chain Management Review*, 9(7):39–45.

WANG WYC, HENG MSH & CHAU PYK. 2007. Supply chain management: issues in the new era of collaboration and competition. London, England: Idea group.

WATERS D. 2009. Supply chain management: An introduction to logistics. London: Palgrave Macmillan.

WEBSTER S. 2008. Principles and tools for supply chain management. Boston, MA: McGraw Hill.

WISNER JD, TAN K-C & LEONG GK. 2009. Principles of supply chain management: A balanced approach. Mason, OH: South-Western Cengage Learning.

YUSUF YY, GUNASEKARAN A, ADELEYE EO & SIVAYOGANATHAN K. 2004. Agile supply chain capabilities: Determinants of competitive objectives. *European Journal of Operational Research*, 159(2):379–392.