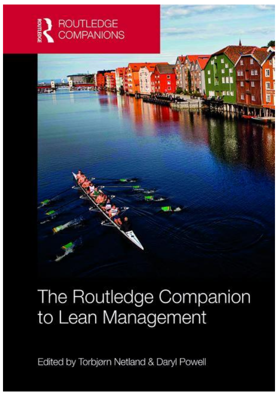

The Routledge Companion to Lean Management

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Lean Supply Chains

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LEAN SUPPLY CHAINS

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Introduction

The idea that supply chains compete against each other, rather than individual firms or brands, has been written about extensively (Christopher, 2005). Similarly, lean thinkers have for some time encouraged us to think beyond the "door to door" of our factory to the extended value stream (Jones and Womack, 2002). Lean principles and practices when adopted and spread among supply chain members effectively will derive potential benefits for all concerned (Hines et al., 2004; Shah and Ward, 2007). Very often the main focus of *lean supply chain initiatives* is the reduction of waste, the elimination of non-value-adding activities, the reduction of costs, and increasing flexibility from order placement to order delivery processes to the end customer (Womack and Jones, 1996; Mollenkopf, et al., 2010; So and Sun, 2010; Martinez-Jurado and Moyano-Fuentes, 2014). The overall aim is to optimize activities along the supply chain from the final customer's point of view (Martínez-Jurado and Moyano-Fuentes, 2014).

Japanese approaches have had a large impact on how many firms consider the role of suppliers in optimizing supply chain performance. This includes the rationalization of the supply base, and a focus on active development of suppliers (Aoki and Kumar, 2014; Gosling et al. 2015). In order to describe characteristics of *lean supply chains*, this chapter explores the experiences of three different companies in three very different sectors—a tale of three lean supply chains. We show how market sector and the underlying structure of the supply chain created different conditions for the implementation of lean concepts. For each case, we give some general background to the context and nature of products, as well as describing sourcing approaches and strategy. We then give an overview of the lean supply chain initiatives implemented, giving some insight into the impact, then we explain the challenges and the lessons learned. The chapter then reflects on a number of questions: How are the case studies different? What are lean supply chains? How are the case studies similar? What are the "levers" of change? We then close by considering the future of lean supply chains.

The concept of the decoupling point is useful as an underlying structure for comparing lean supply chains. The decoupling point describes the way in which orders penetrate the "basic structure" of a supply chain (Hoekstra and Romme, 1992), and provides a buffer between fluctuating customer orders and smooth production output (Naylor et al., 1999). Upstream of the decoupling point, activities are typically speculative, aggregated, and standardized. Downstream of the decoupling point, activities are typically non-speculative and attached to known orders.

Figure 19.1 illustrates how these points relate to different parts of the supply chain. Using the decoupling point concept, a range of structures can be defined to give a simplified classification of supply chain types, including engineer-to-order (ETO), make-to-order (MTO), assemble-to-order (ATO), and make-to-stock (MTS).

This underlying structure defines the basic conditions for how the customer engages and interacts with a supply chain and, in turn, affects the types of practices that are appropriate (Naylor et al., 1999). Throughout this chapter, we use this as a basis for comparing and discussing lean supply chain initiatives. We explore an ETO supply chain from the construction industry, an ATO supply chain from the electronics sector, and a hybrid MTO and MTS supply chain in the automotive industry.

Lean Supply Chain Case 1: Construction

Case Study Background, Context, and Products

Our first case study documents the lean improvement initiatives in a global construction and consultancy organization. The MACE Group has approximately 4,700 employees (3,300 in the UK) at the time of writing, with a turnover of £1.5bn. It operates in a range of sectors, such as infrastructure, education, retail, leisure, and residential building sectors. In this case study we will focus on the unique challenges of delivering one-off iconic commercial and residential buildings in the UK. These are primarily based in London, and include projects such as the Shard, the London Eye, and a range of company headquarters buildings, such as that of Merrill Lynch. Projects might range from one year to, in some cases, up to five years in length. The sector is challenging, since designs tend to be unique architectural showpieces. Hence it is difficult to engage the same supply chain from one project to the next, and those suppliers that are selected often have to work around new design specifications. Applying lean concepts in such a setting is far from easy.

Sourcing and Strategy

The supply base of the company has been rationalized over the past two decades or so. Operating on the Pareto principle, the company has made efforts to focus on less than 20 percent of suppliers

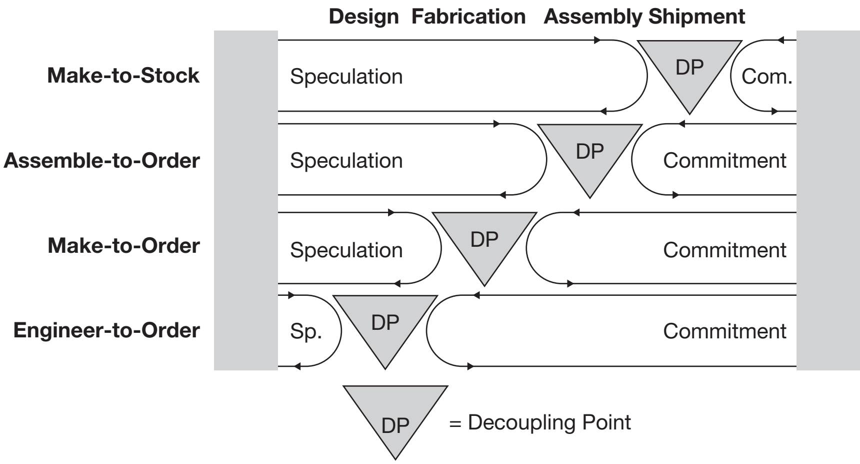

Figure 19.1 Family of supply chain structures

Source: Adapted from Wikner and Rudberg (2005).

that deliver up to 80 percent of the work, and to increasingly reward those companies. This has resulted in a structured supply base consisting of approved suppliers, preferred suppliers, and strategic partners for each business sector. While the company has many suppliers in its complete supply chain, within the specific subsector of interest there are currently 98 suppliers, of which 13 are long-term strategic partners, 33 are preferred suppliers, and 52 are approved suppliers. As will be described later, development initiatives are tailored to the different categories. In terms of the decoupling point, the company operates in an ETO environment, where clients and designers co-create the products. The company holds no material stocks, and sources materials and services on a project-by-project basis.

Lean Supply Chain Initiatives Implemented

The company began a significant supply chain improvement program in the early 2000s, incorporating lean concepts. Importantly, a physical base was established to collate best practice. By 2006, the Mace Business School was established, a first of its kind in the industry. This was a response to the increasing complexity of projects and the interfaces between different parts of the supply chain, and recognition of the importance of the role of active supply chain management. The decision was therefore made to share expertise through learning and knowledge sharing with its supply chain.

This internal "business school" aims to develop and implement training schemes, and gather and undertake supply chain data and intelligence, as well as implement best practice across the organization and supply chain. Training is delivered to the supply chain by senior managers and directors with the relevant expertise. This represented a significant step forward, and a pioneering approach within the industry. Among other things the business school has been responsible for the following:

- executive briefing workshops for suppliers to give information about upcoming projects and work that may be available in the coming months, allowing the supply chain to forecast and gain a better understanding of market outlook;
- "head start" and cluster management workshops to help groups of suppliers work together more effectively, and consider likely interfacing issues at an earlier point;
- leadership coaching and passport training programs to upskill and educate suppliers;
- establishing collaboration with research institutions, such as Cardiff and Reading universities, to foster new thinking and innovative ideas;
- implementing performance management and accreditation systems for suppliers;
- streamlining of the sourcing process, including standard bid templates to reduce workload and lead times;
- incentivizing good performance through awards and accreditations.

The business school has also played a proactive role in developing IT systems to support supply chain management. Industry lead times are monitored through a "foresite" system, a custom web-based system designed to monitor lead times, and project management systems have been implemented allowing suppliers to see up-to-date project plans and drawings. A system has also been developed to provide real-time information to manage risk around performance, financial status and compliance, and to assist in capacity forecasting. The company is committed to developing *building information modeling* (BIM) capabilities, systems that help to visualize and manage design information, both internally and throughout the supply chain. In addition, an internal logistics consultancy was set up. This internal department, as well as taking on external engagement, advises site teams, designers, and clients on logistics and material management issues in advance of the site phase of a project. This includes the encouragement of JIT systems with suppliers to synchronize deliveries with site progress, as well as lean flows of materials as a site develops.

The company has been at the forefront of promoting and adopting modular design principles, such as offsite pre-assembly to reduce process times. All projects are now required to complete a prefabrication and offsite assembly strategy review as early as possible in order to evaluate potential options, and an innovations director has been appointed to promote this strategy. Current examples of this include prefabricated plant rooms and bathroom pods as well as roof structure and membrane. Co-location, where supplier and contractors work together in a central site location, is also regularly used to facilitate information exchange and collaborative working. The latest development at the company is that a *lean construction* expert has been employed to work across a number of projects, and the company has formal ties with the Lean Construction Institute. These efforts have led to multiple awards for its supply chain practices, including *Building* magazine's "Supply Chain Management of the Year Award."

Challenges and Lessons Learned

It is interesting to consider this case in the context of the ETO environment in which it operates. Implementing lean in a production environment that lacks regularity is difficult, and many standard lean concepts may need to be adapted. Capturing project-specific learning is a challenge, since it is not clear if and how lessons will carry over to future projects. At the firm level, the establishment of a department within the organization, including a physical base to support it, has been key to ensuring that knowledge is shared from one project to the next. In addition, the training programs have played a significant role in upskilling and communicating effectively with suppliers.

Lean Supply Chain Case 2: Personal Computers

Case Study Background, Context, and Products

The second case study is of a global personal computer (PC) supply chain, originally owned by IBM but transferred to Lenovo in 2004. The case describes an evolution of a supply chain, from a mass production system through to a lean and agile mass customization-oriented approach (Berry and Naim, 1996, Naylor et al., 1999). That latter state is synonymous with the Dell business model.

At the time of the study IBM had a high degree of vertical ownership of the supply chain involved in marketing and manufacturing as well as research and development of PCs. The supply chain was in fact a large complex network. As well as the company's own sales and marketing outlets and manufacturing plants spread throughout the world it also had a global vendor base.

Production was defined at three main levels—basic components (e.g. microchips, boards, hard disks), sub-assemblies (e.g. keyboards, screens, "boxes"), and finished goods (the PC itself). Intermediate products are sold to sister plants, finished products are sold to sales and marketing, with the latter selling to end customers such as organizations or, via retailers, to consumers.

Sourcing and Strategy

Originally the in-house supply chain was established to be totally self-reliant with sufficient capacity to meet most demand. The company had four different final assembly plants, three sub-assembly plants and four components plants. There were 10 distribution centers and tens of thousands of retail outlets that the company owned. To account for peaks in demand, an external vendor base, at the component and sub-assembly levels, was sourced primarily based on price with multiple vendors procured on a "just in case" basis. While there were "primary" vendors—five printed circuit board suppliers and a hard disk provider at the sub-assembly level, and hundreds of component suppliers—at any time the company could source from thousands of different vendors.

Typically, the cumulative physical lead time from component level through to end customers was 32 weeks. Hence, for consumers who wanted an "off-the-shelf" PC, this meant a speculative MTS strategy was adopted. Despite the vertical ownership business model each unit in the company was a self-contained cost center with its own planning and forecasting systems. Adversarial relationships had developed within the company and also with the external vendor base. The supply chain suffered from classic symptoms found in mass production systems—high levels of waste in the form of scrap rates; product returns; non-value-added lead times; duplicated, excessive, and redundant stock; and poor customer service levels and lack of information transparency.

Lean Supply Chain Initiatives Implemented

With the aim of reducing in-plant lead times and enhancing quality, via the elimination of waste in all its forms, what we now might term lean manufacturing tools and techniques were implemented in the company's own plants in the early 1980s. A major education program was developed for the manufacturing workforce with respect to developing a total quality management culture combined with total productive maintenance and JIT techniques and disciplines, including:

- batch size reduction,
- set-up reduction,
- group technology layout,
- workstation ownership,
- individual quality responsibility, and
- multiskilling.

By 1990 this initiative saw in-house manufacturing lead times and inventory reduced by 50 percent.

Despite the considerable advance in time compression of manufacturing lead times, they were still greater than the time the end customer would be prepared to wait if products were to be fully customized to their requirements. In preparation for developing a totally new approach to satisfying customers, which ultimately led to an ATO-based approach to mass customization, the second phase of the program led to substantive initiatives.

In the early 1980s materials planning was undertaken at individual plant levels. This meant that there were sequential plans from the material requirements planning (MRP) system that led to what we now term the "bullwhip effect." In coping with "bullwhip," plants built up inventory, and duplicated inventory, at the interfaces. To mitigate the "bullwhip effect" the company developed an integrated approach to information flow and materials control. Taking a global approach, the company considered the manufacturing plants across the three levels as a single pipeline entity. Hence a collaborative planning forecast and replenishment (CPFR) system was established that included:

- the creation of a global MRP, that applied MRP logic for subassembly and component requirements;
- shared and agreed forecasts of end demand;

- visibility of stocks and work in process (WIP) throughout the "manufacturing pipeline"; and
- the use of electronic data interchange (EDI) for simultaneous transmission of demand at all manufacturing levels.

While planning was undertaken globally the manufacturing plants still had local autonomy for the execution of the plans. This global planning initiative saw information delays reduced by 70 percent.

In parallel with the development of CPFR there was a reassessment of the global vendor base strategy. The company moved away from an adversarial approach to sourcing and toward a more "partnering" approach that procured suppliers' services as well as goods. This reorientation selected suppliers not just on price but also on capabilities, which included their ability to deliver goods according to other criteria such as quality and lead time. Further, it also included their ability to work with the company such as in new product development. This led to fewer but "better" suppliers in the vendor base.

Tied in with the in-house manufacturing changes in phase 1 and with the CPFR implementation, the vendors were linked to the EDI network, got better longer-term visibility of daily requirements, provided information on their stock and WIP levels, and hence they delivered JIT to the company's plants.

With the previously described initiative as a platform, the company was able to radically rethink its approach to delivering better value to the end customer. While the previous initiatives were very much focused on the manufacturing function the final phase of change was concerned with impacting the "front" and "back" ends of the supply chain. At the "front end" there was the move toward greater interaction with the end customer. Retailer outlets were passed by, allowing customers to place orders directly with the company via the internet and the company delivering directly to the customer.

At the same time, at the "back end" concurrent engineering meant that PCs were designed for manufacturability. However, it also allowed for adoption of greater standardization at the component and sub-assembly levels while offering choice of the finished assembled product. This required an ATO strategy so that assembly of PCs was not finalized and shipped until a direct customer order was received. Hence, strategic stocks of standardized sub-assemblies were required. These were made to an aggregate forecast, but the stock was used for final assembly.

This final phase was the fruition of 10 years of change that meant that end customers had a degree of choice and only had to wait a few days for their PC at a price that was competitive.

Challenges and Lessons Learned

Covering a 10-year span of change requires considerable foresight and vision in terms of an end point. Predicting customers' likely wants and needs, and likely future manufacturing capabilities to fulfill them, over such a period of time suggests a high degree of uncertainty. Therefore, there is a need to articulate a clear vision of the long-term corporate strategy and develop manufacturing and marketing strategies that are strongly aligned. At the end of the change program there was an ATO system that could accommodate the trade-off between increased customer choice and a quick response to their orders while maintaining a degree of efficiency that ensured that any premium paid by the customer was minimized.

The supply chain reengineering program also required multiple considerations regarding the levers for change at different stages. Central to the changes is the buy-in of a culture shift that regarded quality as paramount. This could only be achieved via a holistic and long-term view that required cooperation rather than competition internal to the supply chain.

Lean Supply Chain Case 3: Automotive

Case Study Background, Context, and Products

The last comparative case presented in this chapter is a well-known Japanese automotive *original equipment manufacturer* (OEM), similar to Nissan or Toyota, that has a production facility in India. This OEM started its India operation in the 1990s and provided employment to over 6,000 employees in 2015. The decision to have production facilities in India was influenced by several factors such as:

- the liberalization of the Indian automobile industry and concurrent induction of foreign players changed the market dynamics, with the majority of the leading automotive manufacturers in the world establishing their presence in the Indian market;
- improvement in living standards and the increase in purchase capacity of the Indian middle class due to strong economic growth in the past decade, which has attracted the major automobile manufacturers, including the OEM, to the Indian market;
- the availability of trained manpower at competitive cost was another reason for the OEM to enter the Indian market.

The OEM manufactures more than seven car models with many variants or combinations in its Indian plants. It is leading the automotive industry in terms of volume, high-quality reliable cars, and customer satisfaction and service. This enviable reputation has been built in the past 30 years by closely working with the company's supply network including suppliers, distributors, and dealers in every country it operates or has production facilities in. In India, more than 65 percent of the passenger car market share is captured by segment "A" and "B," where the OEM has little presence. The company witnessed growth of more than 15 percent in February 2015 compared with the same month the year before. This could be attributed to the launch of a new model in category "B."

Sourcing and Strategy

The supply chain structure is very stable with more than 90 percent of material sourced from local suppliers that are either within 50–60 km radius, in the same city, or co-located inside the plant. At the time of data collection, the organization had 111 local first-tier suppliers. Most of the important and large locally procured parts, such as radiators, air-conditioners, seats, bumpers, instrument panels, and body shell parts, were supplied from within the same city—most by their *keiretsu* suppliers, i.e. the same Japanese-owned suppliers. These suppliers have supplied the OEM in Japan for more than 30 years and are now co-located near the OEM plant in India. The remaining suppliers were Indian and other foreign-owned companies, such as American and German, with production facilities in India. Following the Japanese philosophy, the OEM involves all 111 suppliers, instead of only a few strategic suppliers, in the supplier development activities with the aim of improving on suppliers' performance on KPIs related to safety, quality, production, delivery, environment, and costs.

The decoupling point in the automotive industry is very different from that in the construction and electronics industries. In complex industries such as automobile manufacturing, it is harder to implement an ATO approach as seen in the electronics industry. As per statistics, as little as 5 percent of cars manufactured in the United States are MTO. For the upstream operations in the OEM supply chain, MTO is the most prominent system, followed by the majority of first-tier suppliers. An example of an MTO system in our case is a seat supplier which supplies seats just in time in the correct sequence to match the OEM's final assembly schedule. This has helped to address efficiency issues at the supplier and OEM end—limited finished goods of seats at the supplier's plant and limited seats in raw material at the OEM's plants. This was managed by having real-time information exchange between the OEM and its suppliers using technologies like EDI to generate work orders. The downstream operation including distribution center and dealers follows a hybrid system of MTO and MTS. In the hybrid approach, the OEM makes stable high-volume product specifications to forecast (MTS) and build specifications to order less frequently (MTO). The final assembled product is stored either at the OEM's distribution center or at the dealer's end to manage the stock level between the two locations.

Lean Supply Chain Initiatives Implemented

The OEM is an established player in the automotive industry and is known for high-quality and reliable cars. The OEM is considered as an exemplar case for promoting lean initiatives across its supply chain and building collaborative supplier relationships including both horizontal and vertical relationships. The three key activities discussed below have helped its suppliers to become more efficient and effective.

The first is the supplier association that is called *Kyoryoku Kai* in Japan. The OEM has established a supplier association through which network norms and knowledge are shared among community members, which contributes to the improvement of quality and safety in suppliers. The second is suppler consulting through which OEM provides suppliers with on-site assistance as well as education and training on lean and other production systems that can help them to operate more efficiently. This type of support aims to develop suppliers' capability to implement lean initiatives in a learning-by-doing manner. The third is mutual learning activities in which the OEM jointly conducts lean projects at suppliers' plants through which best practices are shared not only between the OEM and its first-tier supplier but also among first-tier suppliers. The main purpose of this activity is to share knowledge in both vertical buyer–supplier relationships and horizontal supplier–supplier relationships. This is achieved by forming voluntary study groups, termed *jishuken* in Japan, in which five to eight suppliers jointly try to improve on quality, production, delivery, safety, and cost-related issues using lean or Japanese production systems in one of these suppliers' plants. Almost 100 such projects are running every year, helping suppliers to learn from each other and the OEM in a learning-by-doing manner.

The OEM organized four to five joint kaizen conventions, such as a quality circle convention, in which only 40–50 strategic first-tier suppliers actively participated. However, all of the 111 first-tier suppliers participated in a general supplier meeting conducted annually. There was an award ceremony organized every year for recognizing best performing suppliers in each area of quality, delivery, cost, new project, and safety and environment. Suppliers' performance across different KPIs was also monitored on a monthly basis and the supplier development team worked with the underperforming supplier(s) to address issues critical to OEM performance. The OEM had a supplier support center to enhance suppliers' capabilities in the areas of safety, quality, production, costs, and *gemba kaizen*. One of the two main roles of the center was to train employees from the supplier end for one year; these employees were in charge of kaizen initiatives in the supplier plant. The center had already trained 50–60 suppliers in 2013, and planned to train all the local suppliers by the end of 2015. The other key role of the center was to support suppliers requesting assistance from the OEM by allocating and sending one or more support personnel from a group of 25 to the supplier's plant. In this case the suppliers had to cover the costs of support. This support was provided not only to the production lines of the OEM supply network, but also to other producers. The head of the supplier support center noted that this activity aimed to improve suppliers' capability.

Challenges and Lessons Learned

Unlike the other two cases included in this chapter, this OEM faced a different set of challenges when operating in the developing economy of India. The biggest challenge faced by the Japanese OEM operating in India was managing labor union and strike issues; the company had a lock-down in the past that significantly affected its production. The other challenge of operating in a developing country is infrastructure voids, i.e. the lack of a good road network, rail network, or shipping network, human resource voids, and managing cordial relationships with local and national government. The OEM is still importing some critical parts from Japan at relatively high costs due to currency fluctuations. The vision is to develop a 100 percent supplier base in India to minimize the effect of currency fluctuations. Developing the skills of the employees at its own plant and the suppliers' plants has helped maintain similar quality to that seen in the mother plant in Japan.

Cross Comparison of the Case Studies

How are the Case Studies Different?

The decoupling points across the three sectors are very different; ETO in construction, ATS in electronic, and hybrid MTO and MTS in the case of the automotive sector. Therefore the way in which the companies engage with the customer is different, as is the nature of work activities. In the construction sector case study, the contractor works closely with clients to co-design unique building solutions. Many manufactured products are heavy, bulky, and difficult to transport, so there is a tendency toward national supply arrangements. One-off projects make the standardization agenda promoted in lean very difficult to pursue, so techniques have to be adapted. Due to a more standard product range in the electronics and automotive sectors, it is easier to apply lean principles at the plant level. These sectors tend to operate globally.

What is a Lean Supply Chain? How are the Cases Similar?

To describe common characteristics of lean supply chains, we look at similarities across the three cases, as given in Table 19.1. All three sectors face challenges of complexity at the design, production, and supply chain level, though they all have a different approach in addressing these challenges. In each case there is also recognition that there is a dependence on suppliers' performance to meet the end goal of delivering the quality product on time and in full. Hence, each company has been prepared to lead change and play an active role in the development of individual suppliers, clusters of suppliers, and, in some cases, the whole network of suppliers. This endeavor is often longitudinal in nature with significant attitudinal change required. All three case studies place emphasis on moving toward more collaborative models of working, as well as rationalizing the number of suppliers in order to promote longer-term partnerships. Working closely with strategic suppliers, all three cases have managed to reduce complexity in delivery practices by adopting modular approaches and greater use of sub-assemblies and pre-assembly. On a final note, the three sectors all seem to be facing similar pressure from regulatory and government bodies to design more environmental friendly products to meet the needs of future generations.

It is also worth noting that the journeys described in the case examples take different starting points and trajectories, encountering slightly different issues. The electronics industry gives insight into a long history of industrial engineering improvements in the 1980s and through to

Table 19.1 Comparing lean supply chain initiatives across the case companies

Initiatives	*Case Study 1 Construction*	*Case Study 2 PC*	*Case Study 3 Automotive*
Rationalization of supply base	Pareto and strategic partners	Tiered structure with primary vendors	Keiretsu suppliers
Communication management and leadership	Executive briefings, head-start workshops, cluster meetings, colocation. Lean champion, affiliations with lean bodies	CPFR, shared forecasts, active WIP management	Supplier associations (Kyoryoku Kai), supplier support center, co-location
Performance management	KPIs, accreditations and supplier awards		KPIs and supplier awards
Training	Leadership training schemes, passport program	Large education program	Joint lean projects (jishuken), in-house, and gemba-based training for supplier
Knowledge exchange, and technical support	Physical base for best practice, logistics consultancy		Consultancy; on-site problem solving; jishuken
Delivery practices	Modular approaches and greater use of pre-assembly	Greater use of sub-assemblies, industrial engineering initiatives	Modular approaches for critical parts such as dashboard; just-in-sequence supply of engine from inside the plant; JIT delivery from local suppliers
Joint time compression	Lead time monitoring and management through "foresite" system	Active lead time reduction	Joint supplier activities promoted to achieve lead time reduction targets
Quality initiatives	Fostering a culture of continuous improvement	TQM, TPM	Japanese Production System; awards for best 5S, kaizen, and quality circle projects for the suppliers
Supplier participation in design and engineering activities	Strategic partners contribute to tenders and bids	Limited involvement of suppliers	Suppliers and customers involved in design and engineering activities

lean supply chain developments. The automotive example explains that even for a pioneer of lean concepts experienced in the application of lean thinking, opening a new plant in the emerging market of India creates significant challenges.

What are the "Levers" of Change?

The substantive levers of change may be categorized as technological, organizational, and attitudinal (Towill, 1997). The first may include specific manufacturing technologies such as machine tools but also information and communication technologies (ICT). Organizational factors may include changes associated with processes and procedures. The last category encompasses human factors and includes the development of relationships intra- and inter-organizationally.

The dominant lever in the three cases studies presented is attitudinal. All three case studies highlight the need for developing new ways of working that require buy-in from individuals within a specific organization but also with suppliers. It should be noted that all three case studies take as their focal point a dominant customer perspective and hence new relationships are instigated upstream in the supply chain from the focal company. Each of the case studies also suggests an internal focus prior to instigating external change. This has a lot in common with seminal work on supply chain management by Stevens (1989) who suggested a model for supply chain change. In that model, companies bring about internal change before widening the scope first to the supply base and only then to the customer end of the business.

A key lesson is the development of closer collaborative arrangements between the focal company and the supply base. This necessitates visibility of supplier operational capabilities, which may be facilitated by ICT. However, this requires willingness by the suppliers to expose them to detailed scrutiny in the form of monitoring of key performance indices. The potential payback for the suppliers is greater transparency of demand, support by the focal company in enhancing capabilities, and the promise of continued business if they do perform to set standards.

The Future of Lean Supply Chains

The case studies above cover a period of time spanning from the 1980s to the present. In each example, we find commonalities and differences with respect to the actual initiatives developed and implemented and the outcomes. This suggests the continuous evolution, and perhaps occasional revolution, of supply chain strategies and/or contextual adaptations.

As Hines et al. (2004) suggest, lean now encompasses all "good" things related to operations management, including agile production, theory of constraints, Six Sigma, and production planning and control systems such as MRP and ERP. Thus we find that there is no single unified lean supply chain management approach, with Vamshi et al. (2015) identifying 30 different existing frameworks.

A plethora of approaches to lean supply chain management potentially could result in confusion as well as the provision of opportunities. The former may result in practitioners seeking distinctiveness that does not exist in lean supply chains, the latter in having a strategic suite of options from which to choose and to evolve in the spirit of continuous improvement.

We suggest that there is a need to return to some basic principles of which the family of supply chain structures provides the foundations. Research has been undertaken in defining the characteristics of the processes downstream and upstream of the decoupling points (see Olhager, 2003; Wikner and Rudberg, 2005; Gosling and Naim, 2009), yielding "leagility," i.e. exploitation of lean and agile facets in a holistic approach to managing supply chains (Naylor et al., 1999) and networks (Purvis et al., 2014).

Another strand in the lean supply chain research could focus on the triadic buyer–supplier–supplier relationship and how such relationships promote knowledge sharing and mutual learning among network members (Dyer and Nobeoka, 2000; Wu and Choi, 2005; Wilhelm, 2011; Aoki and Kumar, 2014). Here focus could be on cooperation and competition among network suppliers and how that affects knowledge acquisition and learning (Wilhelm, 2011; Aoki and Kumar, 2014).

There is considerable discourse on the ongoing viability of lean supply chains in delivering value and ensuring resilience to ongoing and growing challenges such as climate change and humanitarian crises. The former requires more sustainable approaches to supply chain management while the latter may need redundancy in the form of capacity and stock holding, "just in case."

Determining the right mix of efficiency and effectiveness in the supply chain is a future research endeavor. By taking a contingent approach we can ensure that right solutions are selected for each and every problem we face in the supply chain. Further, we can ensure that we capitalize on new and emerging technologies, such as additive layer manufacturing and the internet of things, to facilitate the delivery of value to all stakeholders, such as customers, employees, suppliers, and wider society.

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