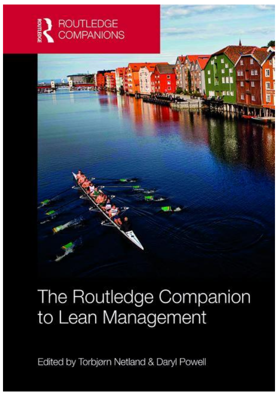

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Lean Distribution

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LEAN DISTRIBUTION[1]

Matthias Holweg and Andreas Reichhart

Introduction

Despite the fact that the benefits of lean production have been documented across many industry settings, firms find it difficult to extend lean principles downstream into their distribution systems. The application of lean to downstream or distribution operations has been scarce. This has been recognized by manufacturers, including Toyota itself. At the Detroit Motor Show in 2000, Toyota's president Fujio Cho—who incidentally co-authored the first article written in English on the Toyota Production System (TPS) (see Sugimori et al., 1977)—announced that it was now "time to apply Toyota's mastery in Just-in-Time production to its distribution and marketing operations" (Andrews, 2000).

Lean distribution is essentially the extension of the demand-driven "pull" signal downstream from the factory to the final customer, in order to build products only when the customer demands them. However, extending lean beyond the factory and component supply system into distribution operations results in a potential conflict: lean production is based on the principle of level scheduling, which by reducing schedule variability enables the tightly synchronized *kanban* links between processes, and even companies. The resulting need for long-term stable production schedules conflicts with the often volatile demand in the marketplace, which a *lean distribution system* cannot buffer against. In the light of this conflict between *lean production* and *lean distribution*, vehicle manufacturers have traditionally decided in favor of the former by producing large proportions of vehicles to forecast, ensuring a high capacity utilization (Holweg and Pil, 2004). Interestingly, Toyota conducted several experiments with more responsive ordering systems in the 1970s to significantly increase the proportion of cars built to customer order, yet later abandoned the system in favor of a less responsive order amendment system (Shioji, 2000).

Lean thinking has been applied across manufacturing and component supply echelons in a wide range of industry sectors, leading to unequivocal performance improvements. However, these accounts stand in stark contrast to the few studies and cases that have been reported on the adoption of lean strategies in distribution. It would appear that adopting a lean distribution strategy presents an equal leap of faith to the one that lean production posed when it was introduced to the Western world three decades ago. To quote a senior executive from an OEM we have worked with: "If we had had to quantify the net benefits from lean distribution before going down that path, we would not have done it, yet we are glad we did."

What is Lean Distribution?

The concept of lean distribution can be defined as a logical extension of the lean production approach. Lean distribution, similar to the concept of *lean supply* (Lamming, 1993; Hines, 1994; MacDuffie and Helper, 1997), should in our view be regarded not as a novel concept in its own right, but as a logical and consequent extension of lean principles into the distribution system downstream from the final manufacturing facility. As such, the distribution echelon in the supply chain only started to receive attention quite late in the lean debate. While the principles of lean production began to evolve in the 1950s and were extended to supplier operations from the 1970s onwards, the distribution function only started to attract mainstream academic attention from the late 1980s (see Figure 20.1) (Davis, 1993; Fisher et al., 1994; Lowson et al., 1999). However, in many supply chains the main focus still rests on the manufacturing operation (Kiff, 1997; Holweg and Pil, 2004).

In this respect, discussing lean distribution—as distinct from lean production—is fraught with difficulty in defining the boundaries of the (sub)system in question. The philosophy of contemporary *lean thinking* can be summarized as maximizing the relative value delivered (considering varying consumer preferences) by reducing waste and thus operational costs. Accordingly, we define lean distribution as *minimizing waste in the downstream supply chain, while making the right product available to the end customer at the right time and location*.

In line with the principles of TPS and lean thinking, this can best be achieved by the end customer "pulling" products from the factory instead of the factory "pushing" products into the market. This is a simple extension of the JIT concept by executing production only once products are pulled by the subsequent process, i.e. the customer. That way, "our worst enemy" (Ohno, 1988)—overproduction—is averted, and the company essentially produces or replenishes its goods against customer orders. Such a definition of lean distribution applies to all types of supply chains, although its implementation will depend on various product- and market-related factors.

The Importance of the P:D Ratio for Lean Distribution

While for some products, such as cars and personal computers, build-to-order supply chains have been suggested (Hertz et al., 2001; Holweg and Pil, 2001; Kapuscinski et al., 2004), other products, such as fashion or sports apparel and groceries, may require inventory-based, yet responsive supply chains and manufacturing techniques (Fisher et al., 1994; Lowson et al., 1999; Christopher, 2000). This has a direct impact on the strategies that can be pursued to minimize distribution costs by eliminating waste.

The main product characteristics that determine the applicability of any order fulfillment strategy are product variety and related differences in demand uncertainty (Fisher, 1997)

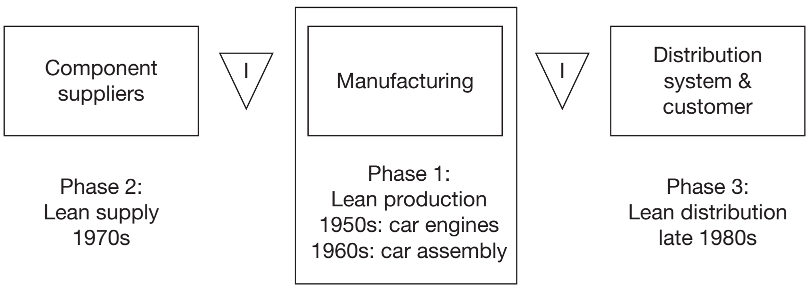

Figure 20.1 Expansion of lean concepts in the value chain

Table 20.1 Distribution scenarios

Scenario	D=0	D>0 *and* P>D	D>0 *and* P≦D
Explanation	Customers require instant gratification at the location of their choice (commonly retail outlets). In this case *P* is almost irrelevant, because inventory will always be required.	Customers are willing to wait but the combined production and distribution time is longer than they are willing to wait.	Customers are willing to wait and the combined production and distribution time is less than they are willing to wait.
Characteristics of necessary inventory	Decentralized inventory is required; the decoupling point must be in retail outlets.	Inventory is required in the distribution system. However, the location of the decoupling point depends on various factors.	No inventory is required in the distribution system.
Industry examples	Fast-moving consumer goods, groceries	Furniture, printers, most automotive spare parts	Traditional project work

combined with the *P*:*D* ratio. In the *P*:*D* model, *P* stands for a product's production lead time and *D* for the delivery lead time a customer is willing to wait for a product after placing an order (Mather, 1988; Shingo, 1989). While the *P*:*D* ratio determines whether distribution systems are generally capable of delivering products without the need for inventory, one of the most significant wastes (Womack and Jones, 1996; Jones et al., 1997; Lowson et al., 1999), the amount of inventory required to satisfy customer needs in inventory-based systems depends primarily on the product variety offered and partially related demand characteristics. Table 20.1 summarizes the characteristics of the three generic distribution strategies depending on a product's *P*:*D* ratio.

Although the first aim should be to reduce the production lead time *P* to avoid stock altogether (Shingo, 1989; Monden, 1998), the important point to make here is that lean distribution cannot simply be defined as stockless distribution or build-to-order (BTO). This is because there will always be products for which customers are not willing to wait as long as it takes to produce them. A wide range of contributions exist about supply chains requiring instant gratification (i.e. where *D=0*), such as food and groceries (Womack and Jones, 1996; Lowson et al., 1999), and textiles (Fisher et al., 1994; Christopher, 1998; Lowson et al., 1999) as well as supply chains with a *P*:*D* ratio of much greater than one, such as furniture (Lowson et al., 1999), automotive spare parts (Womack and Jones, 1996), and printers (Davis, 1993). Lean distribution in these supply chains has often been covered under the "quick response" initiative that started in the textile industry in the mid-1980s (Lowson et al., 1999), or as part of the "agile" supply chain literature (Christopher, 2000).

Womack et al. (1990) and Kiff (2000) have previously examined characteristics of lean distribution in the automotive supply chain. They illustrate how under lean distribution a change in the relationship between customer and vehicle manufacturer would allow the manufacturer to increase its profits over the life cycle of a car and secure customer loyalty, to leverage its knowledge of customer preferences in the product development process, and to improve its production forecast based on improved market understanding. While a number of the techniques mentioned, such as the segmentation of dealerships by car size/type, arguably serve marketing and sales purposes, a close relationship with the end customer can reduce flexibility requirements on manufacturing operations. Not only will sales forecasts improve with an improved understanding of customer needs, but customer expectations can also be managed better to smooth the order flow and reduce variability in demand before it occurs (Womack et al., 1990). However, a detailed account of the operational and organizational difficulties of extending pull beyond the factory is still lacking. This is a particular shortcoming, as even the "lean" Japanese vehicle manufacturers have not achieved the lean transformation of their distribution systems (Andrews, 2000; Shioji, 2000). In this respect, reportedly high percentages of BTO production for the Japanese market (Womack et al., 1990; Shioji, 2000) may have to be re-evaluated, given large vehicle exports into less demanding overseas markets that act as buffers (Holweg and Pil, 2004), and a lower product variety in combination with a less responsive order amendment system (Shioji, 2000; Pil and Holweg, 2004).

Finally, supply chains with a *P*:*D* ratio of smaller or exactly equal to one, such as traditional one-off engineering projects (like large construction projects), are arguably less interesting from a distribution point of view. However, products with a *P*:*D* ratio of close to one featuring potentially strong variations between different customer segments pose a significant problem for distribution systems. This has yet to be covered sufficiently in the literature. Such supply chains may have to rely on some form of inventory in the distribution system for some but not all customers. The car industry provides a good example for such distribution systems (Fisher, 1997; Holweg and Pil, 2004).

Challenges with Lean Distribution

Various authors have investigated the general conflicts between a firm's manufacturing and sales, distribution and/or marketing functions (Shapiro, 1977; Karmarkar, 1996; Malhotra and Sharma, 2002). While few contributions discuss the specific conflicts between *lean manufacturing* and *lean distribution*, some similar conflict areas, such as the cost of manufacturing flexibility (manufacturing) versus the need to respond to changing customer requirements (sales and marketing), have been highlighted (Shapiro, 1977; Karmarkar, 1996; Mukhopadhyay and Gupta, 1998). One of the main causes for the conflicts between manufacturing and marketing is that each function has a different focus. Cost is the focus in the manufacturing department while revenue is the focus in the sales department, while both departments fail to see the overall goal of maximizing profitability (Shapiro, 1977; Mukhopadhyay and Gupta, 1998).

A specific feature of the Toyota Production System, and in particular the kanban production control system, is that it requires a level, or smoothed, production schedule (also referred to as "*heijunka*") (Sugimori et al., 1977; Shingo, 1989; Monden, 1998). Smoothed production schedules minimize the variations between two consecutive periods (day-to-day changes as well as week-to-week changes) to minimize costs through otherwise required capacity or inventory buffers (Shingo, 1989). Market demand, however, is seldom smooth and even aggregated demand over multiple products can vary significantly on a day-by-day basis, let alone the demand for individual products.

The resulting rigidity or inflexibility of lean production schedules has been a major point of criticism (Naylor et al., 1999; Christopher, 2000; Mason-Jones et al., 2000). Hines et al. (2004) argue that a lot of this criticism is based on an overly narrow understanding of the wider lean approach. On the contrary, Towill and Christopher (2002) suggest that the lean (i.e. inventory-based distribution) and agile (i.e. responsive distribution) concepts can be integrated into a combined supply chain strategy, as long as they remain separated by space and/or time. Separation by space is given, for example, when one product is manufactured in a lean plant, while a different product is produced in an agile plant. Separation by time means that the same supply chain can be lean or responsive at different times (e.g. agile during summer and lean during winter). However, problems remain when lean production and lean distribution are to be truly combined for the same product and at the same time. The earlier quoted statement by Fujio Cho provides further support for such a conflict between lean production and lean distribution. Fujimoto (2006) recently revealed that Toyota was still looking for ways to implement a "stress-free" BTO system, i.e. without any adversarial impacts on their lean production processes.

So far, the main coping mechanisms are inventory buffers in the distribution system, which vehicle manufacturers implicitly favor over capacity buffers in their final assembly plants, because of the large investments in plant and machinery required in vehicle assembly. Commonly, this has resulted in a decoupling of production from the distribution function through considerable buffers of unsold vehicles in the market (averages of two months' worth of on-hand inventory have been reported (see Kiff, 1997; Holweg and Pil, 2004)). We see this decoupling as the most visible indication of the conflict between lean production and lean distribution. In many ways holding inventory at this point in the system is the worst possible scenario, as not only is the value of the product the highest (and it is thus the most costly point at which to hold stock), but also the product is fully configured here. This leads to high levels of alternative specification discounts (Williams, 2005).

In general, such localized approaches to managing the supply chain will invariably lead to "islands of excellence" within otherwise inefficient value chains (Womack and Jones, 1996; Holweg and Pil, 2004). Equally, the implementation of lean distribution without the consideration of the wider system will not facilitate an overall lean supply chain, as the savings made in distribution must be weighed against potential adversarial impacts in other parts of the value chain, such as manufacturing. Thus, the implementation of lean distribution must entail the understanding and management of the trade-offs between the sometimes conflicting manufacturing and distribution requirements. The latter argument is well illustrated with the following quote from an automobile company which implemented lean distribution:

> Ten years ago, we thought 100 percent build-to-order was the right approach. Now we have achieved this capability but see that the market and especially our growth strategy require a balanced mix between build-to-order and make-to-forecast production.

The Future of Lean Distribution

The challenge for the future will be to keep the operational capabilities to produce customer specific orders with short lead times and high precision (for those customers who value individuality), while at the same time leveraging the stability that a managed make-to-forecast (MTF) production (for those customers who want instant gratification and a cheap deal) can add in order to reduce operational costs. Such an approach is likely to include at least some of the following characteristics and processes:

- *An increased build-to-order content facilitates lean distribution.* Our findings from research in the automobile industry show that an increase in BTO production by 1 percent can reduce finished goods inventories by an average of 0.67 days of demand.
- *Extending frozen horizons facilitates lean distribution.* The main reason for short frozen horizons is the fear of unused capacities in times of low customer demand. In a setting with managed supply, the frozen horizon can be extended, because a certain percentage of cars are supposed to be produced to stock. This will save costs in the upstream supply chain by providing more reliable planning information to suppliers.
- *Conducting Pareto analysis of customer demand facilitates lean distribution.* Considering large product variety, cars produced to stock are unlikely to meet a specific end customer's wishes.

Therefore, a Pareto analysis of customer demand must be carried out to only produce cars to stock that have a high chance of finding a customer afterwards. Even if a number of vehicle manufacturers claim that they never build the same car twice, given millions of possible option combinations the chances of finding at least a close match can be increased by Pareto techniques.

- *Centralizing inventory facilitates lean distribution.* A number of vehicle manufacturers have already established central holding compounds for cars in order to increase the availability of cars produced to stock without incurring costly dealer transfers. While central holding compounds can reduce the costs of distributing MTF cars, it needs to be investigated whether such a strategy has any advantages over BTO production when it comes to the customer's desire for instant gratification.
- *Producing customer orders before stock orders facilitates lean distribution.* In order to ensure short lead times for customer orders, they must be given priority over stock orders. Otherwise, customers will be discouraged from ordering BTO cars.

Conclusions

In this chapter we have argued that the slow adoption of lean thinking in distribution is due to an inherent conflict between lean manufacturing techniques (related to production smoothing and kanban systems that cannot cope with high levels of variability) and the need to link the production pull signal to variable demand in the marketplace. We concede that quantifying the trade-off between the cost of coping with flexibility in manufacturing and the cost-saving potential due to reduced finished goods inventory and incentives is complex. In the light of Simon's work on bounded rationality (Simon, 1982), it should therefore be hardly surprising that many manufacturers have opted to optimize their manufacturing operations. This requires considerable capital investment and incurs large operating expenses. Thus, the distribution system has been considered only as a secondary concern.

Considering the efforts that firms need to invest in order to achieve comparative reductions in component stock in their manufacturing plants, it is surprising to see so few firms adopt lean distribution strategies. However, the organizational dynamics and barriers that need to be overcome in order to manage the cross-functional trade-offs in the organization can pose considerable obstacles. This is further amplified by misaligned performance metrics, short-termism induced by artificial reporting periods, and the difficulty in quantifying the operational cost savings a priori. Considering this, we believe there is a great unrealized potential in applying lean distribution.

Case Study: Implementing *Douki-Seisan* at Nissan

Nissan Motor Company was established in 1933, and rapidly grew in the post-war years under the guidance of the Japanese Ministry for Trade and Industry (MITI) to become one of the world's top car manufacturers. In the 1990s, however, the company entered a period of poor profitability, and the often-lauded strong interlinkage with its *kereitsu* (conglomerate) partners became a financial liability rather than a source of strength (see Figure 20.2).

Many root causes for the crisis were at play, but one of the obvious failures was a drastic overstocking situation of finished vehicles in the marketplace (see Figure 20.3). Producing ahead of demand and selling cars from inventory clearly was no longer a viable strategy. It locked up large

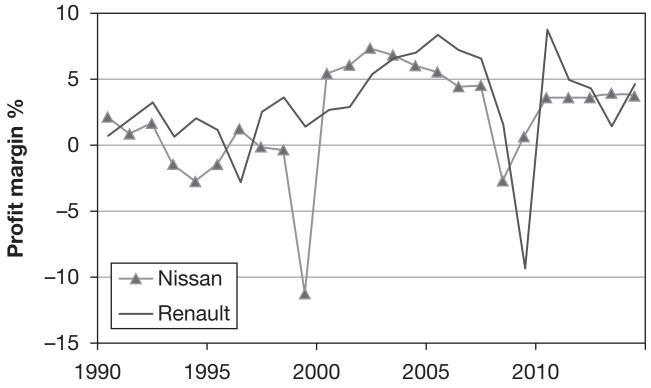

Figure 20.2 Pre-tax profit margins at Nissan and Renault, 1990–2014

Source: Holweg and Oliver (2016).

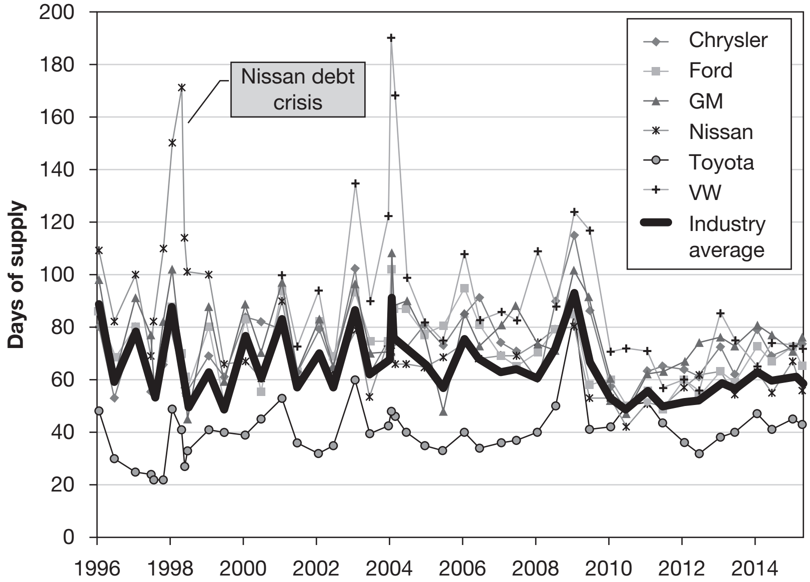

Figure 20.3 Finished vehicle inventory levels in the US market, 1996–2015

Source: Holweg and Oliver (2016).

sums of capital, led to considerable financial losses due to rebates and discounts needed to shift the metal, and often left the customer with a vehicle that did not meet his or her needs (Holweg and Pil, 2004).

In the wake of the merger with Renault, Nissan decided to meet this challenge by implementing "*douki-seisan*" (which literally translates as "the customer leads the way"), a strategic initiative that would extend the lean manufacturing logic to the distribution arm. Key objectives were to raise the build-to-order content, thereby reducing inventory levels as well as sales incentives needed to shift aging stock or to persuade customers to take vehicles that did not meet the required specification.

Operationally, two main changes were implemented. First, a "D-6" (day minus 6) approach was implemented, which saw orders only being "frozen" six days before production. Up to this point unsold vehicles could be amended to meet a customer's needs. Second, unsold stock was merged into national distribution centers (operated by Nissan itself), which allowed all dealers to access these vehicles freely (thereby avoiding costly dealer transfers of individual cars).

The outcomes were impressive, especially in Europe where the shift from MTF to BTO was the most pronounced. Average savings for vehicles built to order, as compared with those made to forecast and sold from stock, ranged in the order of several hundred euros. Nissan observed a significant drop in both inventory and rebates needed to sell its vehicles across all major markets.

More recently, Nissan is further improving its BTO initiative by developing an open order pipeline, which seamlessly integrates all available options for order fulfillment into one system available to the dealer. The boundaries between true build-to-order, order amendment, and fulfillment from central or dealer stock thus blur into one coherent approach to fulfilling customer needs in the shortest possible time, while minimizing inventories and incentives needed in distribution.

Acknowledgments

We would like to thank Philip Wade and Jonathan Brown for their kind support.

Note

1 This chapter is a shortened and updated version of the paper "Lean distribution: Concepts, contributions, conflicts," published in the *International Journal of Production Research*, 2004, *45*(16), 3699–3722.

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