Transformation of the European auto industry: the future of Lean

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Lean legacy

More than two decades have passed since Lean Production set out with the promise 'to build cars at the rate the customers demand' [Monden (1983)]. Monden stressed that the overall objective of the Toyota Production System, the ancestor of the Lean philosophy [(Nishiguchi and Beaudet (1998)], was to only build cars to order and hence avoid the substantive waste inherent in overproduction. The industry has focused efforts on employing Japanese best practices and closing the productivity gap. However, it still suffers in a climate of overcapacity, spiraling costs, and punctured profits [Howard et al. (2001)], illustrated by the Ford Motor Company, which announced that full-year automotive profitability in North America is not expected until 2009 (Ford (2006)]. While Lean efforts have delivered considerable improvements in manufacturing efficiency, from the customers' perspective they have often failed due to a myopic focus on the factory floor. Indeed, 15 years after the publication of the seminal work "The machine that changed the world" [Womack et al. (1990)], few volume vehicle manufacturers are able to build to customer order and only one builds solely to customer order. This article presents an overview of the current work to move towards the new paradigm: building cars to customer order.

In the U.S., where vehicles traditionally are sold from dealer stock, 74% of consumers would rather order their vehicle and wait instead of buying one from the dealer's lot that is incorrectly equipped. Researchers in the U.K. have quantified the limit of that waiting time, showing that 59% of customers want their vehicle to be delivered within 14 days or less [Elias (2000)]. However, build-to-order (BTO) customers in Europe currently have to wait an average of 48 days for their European cars to be delivered or 63 days for a Japanese model built in Europe [ICDP (2000)]. Customers value BTO vehicles and automotive companies could reduce their stock levels and therefore increase their margins, so it is of little surprise that most major car manufacturers are striving to develop BTO business models. The desire to achieve the true Lean goal is leading vehicle manufacturers toward what many now believe to be the inevitable future for the automotive industry. The question for many automotive executives is not when but how, exactly, will such a radically 'different' business model operate? This question is being tackled on a European scale [(Miemczyk and Holweg (2004)].

Build to order — ILIPT

The European integrated project 'Intelligent Logistics for Innovative Product Technologies' [ILIPT] is an E.U.-funded consortium of thirty leading automotive manufactures with representatives from across Europe and throughout the supply chain. Their aim is simple — to define, validate, and operationalize a process that enables European customers to order and have delivered a new car within 5 days.

The project has three core themes. Theme 1 examines the product configurations necessary to achieve build-to-order, addressing new product technologies, tools, and management methods. Theme 2 explores new concepts in delivering flexible production networks, addressing capacity management, collaboration across value streams, and the interoperability of processes. Theme 3 is developing novel methods and tools to simulate, assess, and validate this radical business model and provide a transition path for the European automotive industry to migrate from its current state into the future vision.

Changing product design

Almost every vehicle manufacturer faces the problem of increasing product complexity and reduced lifecycle time, whilst having to develop and manufacture a larger number of variants within shorter time-to-market cycles. To cope with this there has been a shift in thinking, away from production-push and economy of scale, towards customer-pull and economies of scope. This involves reconsidering vehicles in terms of commonality, a process that starts at the design stage.

Characteristics, such as body construction and vehicle complexity, can affect total lead-time, not just in production but across the supply chain. This reinforces and broadens the significance of vehicle design. Design engineers who think their boundaries begin and end at production must reconsider. Vehicle construction and the links with complexity and process reliability have a wide-reaching impact that stretches throughout the value stream. The scope of vehicle design appears to be increasing, and now includes not only the product characteristics but also the means for its delivery.

The automotive industry is now required to offer ever increasing levels of product variety. We are currently witnessing rapid increases in the number of models and model variants that are available on the global market. It is important to distinguish between vehicle complexity and variety; both of which represent a major inhibitor to rapid BTO.

Complexity is defined as the level of internal component variation handled by manufacturing and logistics operations sufficient to construct the vehicle. Typical automobile complexity today comprises around 4,000 to 5,000 parts [Fine and McDuffie (2000)]. Variety is defined as the level of product choice offered to customers [Batchelor (2000)]. High levels of variety are normally associated with an increase in parts complexity, leading to a trade-off between the variety offered in the marketplace, the volume of production, and the effectiveness of manufacturing operations. Variety can range from 820 different combinations of specification available in a vehicle like the Nissan Primera, to 3 billion in a Mercedes Benz S-class [Holweg and Pil (2001)]. Indeed, the cost of complexity has become an important topic in the literature and one that we shall return to later.

Two approaches have been identified that minimize the impact of component complexity on production: process-based approaches, such as flexible manufacturing equipment, and product-based approaches, which allow for high variety whilst reducing the level of component variation, and include using product platforms, modular design concepts, and component standardization.

A key issue is the reliability of the production and delivery process. An unreliable production and delivery process perpetuates the stock push system as dealers sell from stock rather than place vehicles on order and risk upsetting customers. Each customer order must become a batch-size-of-one, meeting exact customer requirements in terms of specification and delivery date. Therefore, a fundamental change in mindset is required to shift towards BTO, suggesting dramatic rises in flexibility and responsiveness across supply chain partners. In production this is traditionally achieved in two ways: either through increasing labor levels and investing in equipment and facilities, or by developing new design solutions, such as adopting modular assembly.

In Europe, the emergence of innovative metal-forming techniques and materials is a key factor in platform sharing, spreading the cost of investment across many models. Currently the common platform strategy is probably the most widely accepted answer to the challenge of maintaining capacity levels despite growth in niche vehicles. The platform strategy enables car manufacturers to offer a complete range of product families, with different appearance, style, and image, based on common and standardized technology. In this way the development costs can be allocated to a larger number of vehicles and the development time can be reduced by simultaneous engineering. Production cost can be reduced through a higher level of standardization. Moreover, vehicles that belong to the same product family can easily be manufactured on a shared production line, adding more flexibility to react to fluctuations in demand and lowering the unit investment costs.

Modularity can be applied to the management of complex systems by breaking systems into modules with defined parameters and tasks that are interdependent within and independent across vehicle architecture. Three types of modularity are of interest in rapid BTO: modularity in design (MID), modularity in production (MIP), and modularity in use (MIU). Their benefits include, MID: reductions in complexity resulting from reduction in parts, MIP: leaner production through fewer operations performed on the line, and MIU: higher product variety by offering customers a choice of modules. Minimizing internal vehicle complexity through the use of modular build enables BTO by reducing inventories, part count, and assembly lead time. The delivery of modules by first-tier suppliers located in adjacent parks can further reduce complexity and lead-time in production.

Lean and agile approaches will still be required to ensure that these production and delivery processes flow and meet customer demand.

Software solutions to increase capacity flexibility

Production optimizations software provides real-time capacity planning, based on plant-specific constraints. But neither body storage towers, nor optimization software can ultimately be considered a substitute for implementing best practice across the total production process. The emphasis of all future developments within the information communication technology (ICT) systems of the automotive industry will be on collaboration, seamless information-flow, and monitoring. New technologies, such as Radio Frequency Identification (RFID), and extended system processing capacities will allow the processes to become a reality. ILIPT considers ICT as a major enabler of new logistics concepts within a flexible production network. This is allied with new forms of functional cooperation between the companies involved along the value chain. Unfortunately, the current development of ICT infrastructure and systems within the automotive industry do not fulfill the new requirements [Howard et al. (2006)].

In the near future a range of new ERP tools will be available which contrast with those found in today's heterogenic ICT-landscape. A systems architecture is needed that is able to transform all diverse formats into a network of compatible systems. Using this approach, it will be possible to interrogate and manage the supply network from every level of the supply chain. Since all relevant components are to be equipped with communication technology such as RFID, it is possible for suppliers and customers to monitor and view the movement of parts within the supply chain. In today's world, ICT systems are mainly used to document past activities or simulate future planning and execution processes. ICT on the other hand will make it possible to see the process in real-time and allow the variance between planned and real-time execution processes to be tracked. In the near future each part may have its own IP-address, stating its module/part number, planned distribution route, as well as its current physical location and status of production. Furthermore, the parts will be able to communicate directly into the supply chain if interruptions appear. Overall, new ICT will allow the connection to be made between reality and electronic systems for the first time.

It is unlikely that there will ever be a single system for the whole automotive industry. The current lack of system integration means that different tiers within the supply base have to connect to the separate systems of each of their customers. A set of standards to support the necessary information exchange does not currently exist for the newest approaches (i.e., demand capacity management). ILIPT has identified and begun to specify and develop a number of tools and processes which are necessary to fulfill the vision of the project. These include a virtual order bank and new processes and data standards for capacity utilization handling and planning that require the exchange of data.

The flow of material and information, planning and control processes, as well as supporting ICT systems, play a central role on the road to a 5-day-car within the ILIPT project. Today, the flow of information between partners in a supply chain is frequently limited. The flexibility needed in supply networks to fulfill the demand of a 5-day-car can only be attained by realizing a new level of collaboration in the supply network.

Validation and transformation

ILIPT's theme 3 is seeking to model and validate the process changes detailed in the other themes and map a path for the transformation of the industry. This includes the development of cost models, process simulation, and Key Performance Indicators (KPIs). With increased variety comes increased cost. Firms experience lower performance because they experience higher direct manufacturing costs, higher logistical costs, hold higher inventory levels, and have higher overheads. The cost of offering variety has to be balanced against the extra revenue that it can generate. A core part of the ILIPT work is the development of complexity cost models. Initial work has been completed, using a case study approach, drawing data from an automotive production plant. A complexity cost model has been developed based upon an analysis of cost patterns against increasing complexity. Both information and material flows have been included in the model. Typical patterns for complexity cost relationships have been identified, already well known within accounting systems, and they include: fixed, fixed step, linear, digressive, and progressive. Preliminary analysis of the results from the model against actual plant data show high correlation and the case study company is already employing the model as a guide during scenario planning.

Dynamic evaluation methodologies are being developed to enable analyses of structural and process changes performed for BTO scenarios in their dynamic network environment or for the whole supply chain. This methodology will form the basis of a prototype model to validate and demonstrate the validity of the BTO concepts to the automotive industry.

To validate and measure a transition to a BTO system a set of key performance measures are required that can act as progress indicators. To this end a set of KPIs is under development. The KPIs fall naturally into four groups: finance, process, structure, and resource. The measures all integrate within the proposed process and product structures and form part of the process simulation models. In addition, research is seeking to describe the transition path, from current state to the future vision of BTO. This part of the work is just beginning as the concepts from the other themes are beginning to firm up. However, it has already been recognized that no matter how compelling the business case put forward, agents of change who are not afraid of taking an un-trodden path will be required to drive this radical agenda.

Agents of change

The true change agents for BTO in the automotive sector may lie within one of three groups: the investment banks, early adopters of BTO, and the customers.

From our experience in managing and recording the transition to Lean, initially in the wider automotive industry, then the aerospace industry, and more recently in the construction industry, we know that a key success factor is leadership at the highest level. But who is it who appoints the leaders? The automotive industry is beholden to the banking community. Whilst the works of Liker (2004), Monden (1983), Ohno (1978), and Womack et al. (1990) are frequently cited as the manuals to read to understand Lean change, the 2001 report, 'Lean Manufacturing' by Dresdner Kleinwort Wasserstein provided detailed projections of the expected performance improvements of major automotive companies [Merlis et al. (2001)]. In addition, this report makes recommendations to investors based on different automotive companies' implementation of Lean Manufacturing principles. They state that Lean activity "would strongly support our positive investment position towards the group."

Investment banks, brokers, and analysts constantly pore over the industries' machinations and ultimately decide the level of the vehicle manufacturer's available cash flow. The investment banks wield the power and leadership decisions are driven by investors, with leaders often coming from within the banking community itself. As we have found in the case made for Lean implementation, if the financial community decide that a BTO strategy is operationable, then it is they who may be able to drive change. This may be done through either directly demanding that leaders implement BTO or through directing investors towards those companies judged to be best placed to exploit this opportunity.

The requirement for a responsive supply chain is clearly evident. In spite of this, a number of failures in ICT implementation have been reported. These show that the biggest problems for BTO are electronic information system standardization and inter-firm trust. However, the first to market with a fully operational BTO system may find themselves dominating the market in the way that Toyota has done with the Toyota Production System that spawned Lean. Toyota has been very open in letting other car manufacturers come and study its production techniques. In doing so it has ensured that many have spent their time seeking to catch up and following their lead instead of developing their own processes that may threaten Toyota's dominance. However, the first to market may also find themselves incurring the greatest costs in developing their systems and early adopters may find themselves financially better placed if they can copy and utilize BTO processes developed elsewhere. Either way, the companies who can most rapidly achieve BTO will be able to both fulfill customer demand and take advantage of greater cash flow through a massive reduction in stock. This will reverberate throughout the supply chain, and will enable early adopters to reinvest and move forward rapidly.

Customers in all markets are becoming more sophisticated and more demanding. The computer industry has led the way, with the customer holding greater knowledge and defining the internal workings of their machine to give a specification to match their exact needs. Historically, steel and metal components have been the source of value creation within the automotive sector. Increasingly vehicle characteristics can be defined by electronic components and electronic systems are now the high value components within a vehicle. Ownership of this capability is largely held by the suppliers and not the OEMs. This represents a power shift as customers demand to control what is inside their vehicles. In much the same way as a customer orders a computer from Dell with an Intel processor, so in the future the customer may specify Siemens technology inside their vehicle. With three-quarters of U.S. customers prepared to wait for their personally specified vehicle, manufacturers will increasingly find themselves unable to sell from stock at a price point that will allow them to remain in business in the longer term. Customer demand may, therefore, ultimately shape the future of the industry.

Conclusion

Lean has delivered significant value to the automotive industry, but has not as yet delivered on its heralded promise of zero inventory or just-in-time approach to customer order. The decoupling point, where build-to-stock becomes build-to-order, is all too frequently absent at the vehicle purchasing interface where both customer and financial drivers show it is desirable. Neither Japanese, U.S., or European car manufacturers have yet achieved an operational supply chain that is responsive enough to meet customer demand for the BTO vehicle.

The ILIPT consortium is currently engaged in the design and validation of tools, methods, and processes that will facilitate the production of a car built to order within five days. The project, engaging 30 significant automotive companies within Europe, has the goal of developing leading practice within two years for the provision of BTO. Demonstrating processes and ICT infrastructures and a pathway enabling the move to BTO is the major challenge for the ILIPT project. The change agents may come from a number of different areas. The challenge for the industry and its leaders will be to rapidly transition to exploit the ideas, processes, and technologies that are emerging.

Failure to adopt BTO in the automotive industry has not been through lack of effort. Most volume vehicle manufacturers have expended a great deal of time and money attempting to achieve short delivery cycles based on true customer orders. A number of failures have been identified in terms of collaborative ICT implementation. This reflects the system failure to adapt to the new requirements of the wider market. Indeed, the first to market with a genuine, operational, BTO system will have a significant advantage, one that may be difficult to emulate.

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