Toyota Production System in House Building

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Introduction

The advantage gained by Japanese car manufacturers over their western competitors has been well documented (Womack, Jones & Roos, 1990, Nishiguchi, 1994, Hines, 1994, Womack & Jones, 1996). These advantages have been felt both at the vehicle assembler level and at the component manufacturer level. At the assembler level, Womack, Roos and Jones (1990) report quality gaps of 2 to 1, productivity gaps of 1.82 to 1 and inventory levels ten times higher outside Japan. At the direct or first tier component supplier level, similar or larger gaps have been demonstrated by Hines (1998). In addition the Andersen Consulting sponsored research team (Andersen Consulting, 1992) found 100 to 1 quality gaps, 2 to 1 productivity gaps and 7 to 1 inventory gaps when comparing the abilities of UK and Japanese component makers within four product category areas.

However, of even more interest is the significant gap between Japanese “best practice” and the approaches demonstrated by Toyota and their supply base (Hines, 1998). Within this latter work the following gaps were found between the Toyota supply chain in Japan and a comparable one based in the UK:

- A 5 day “pull” based lead time between the final product assembler and their 2nd tier suppliers in Japan and a 40 day “push” based lead time in the UK

- For the same portion of the supply chain, inventory levels in Japan totalled 21 days compared to 127 in the UK

- Variability in demand (actual orders vs one month out forecast) varied by 4% in Japan and 12% in the UK

- Quality levels for product bought from suppliers was 5.1 parts per million in Japan compare with over 1500 ppm in the UK

- Productivity gaps were measured at 2.8 to 1 in the first supplier tier and 4.35 in lower supply tiers

The Toyota Production System is, simply put, a method of shortening the time it takes to convert customer orders into vehicle deliveries. In order to achieve this the entire sequence from order to delivery is arranged in a single, continuous flow with ongoing efforts made in terms of shortening the sequence and making it flow more smoothly. The result of this is a far higher level of productivity, better quality and a major reduction in wasted time, money and effort, or, in short, better products made more cost effectively (Toyota Motor Corporation, 1992). In this present case we will explore how this general approach and the lean principles behind it have been translated by Toyota to the production of modular housing in Japan.

Toyota Production System: Key Principles

The purpose of the Toyota Production System is to eliminate various kinds of waste through improvement activity and hence producing significant profits. The primary goal of the system is therefore cost reduction or productivity improvement.

In order to meet their cost reduction targets Toyota have three subgoals:

- Quantity control, which enables the system to adapt to daily and monthly fluctuations in demand for quantity and variety

- Quality assurance, which assures that each process will supply only good units to subsequent processes

- Respect for humanity, which must be cultivated while the system utilises human resources to attain cost objectives

The interaction of these subgoals is illustrated in Figure 1.

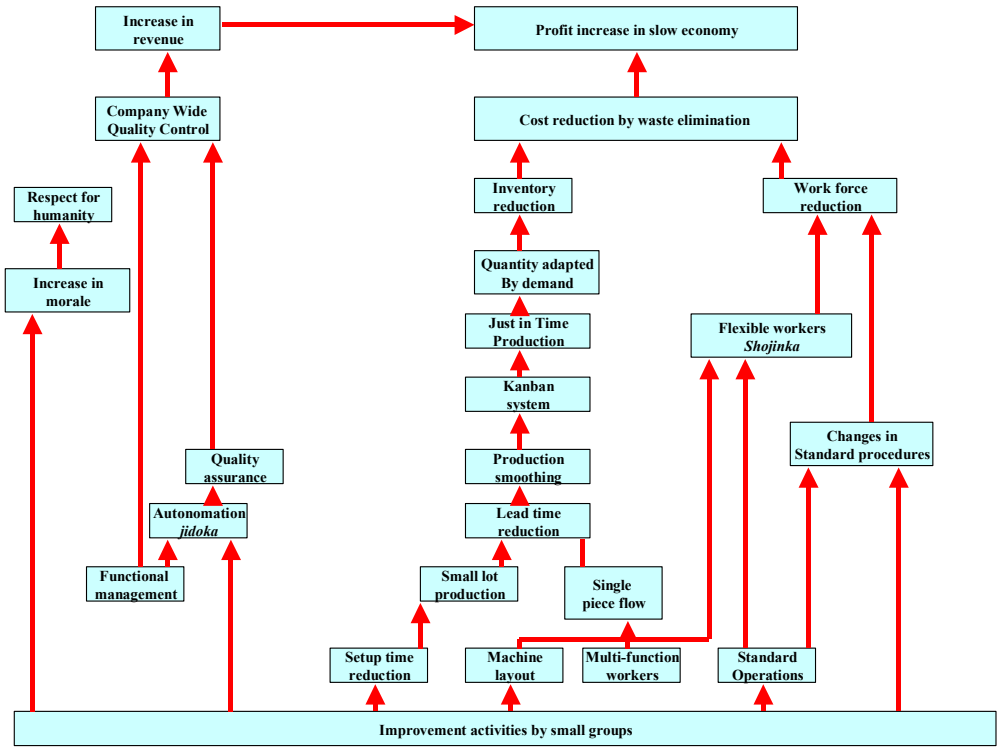

Figure 1: How Cost, Quantity, Quality & Humanity is Improved by the Toyota Production System, Modified from Monden, 1997

At the heart of the Toyota Production System is the concept of a continuous flow of production. This is achieved through Just-In-Time (JIT) and Autonomation. JIT involves the production of the necessary units in the necessary quantities at the necessary time. Autonomation (*Ninbenno-aru Jidoka* often abbreviated to *Jidoka*) is an autonomous approach to defect control where intelligent machines stop producing if defects are being made. Autonomation supports JIT by never allowing defects from a preceding process to flow into and disrupt a subsequent process. At Toyota, the *Kanban* system is used as a way of dispatching production during a month and managing in a JIT way.

Lean Principles

The characteristics of the lean organisation and the lean supply chain are described clearly in the book Lean Thinking (Womack & Jones, 1996). This book provides a vision of a world transformed from mass production to a lean enterprise. The authors highlight the huge amounts of waste that occur in most organisations and show that a systematic attack on waste, both within companies and along the supply chains, can have tremendous benefits to the short run profitability and long term prospects of companies and organisations.

As described above, Lean production methods were pioneered by Toyota in Japan. Lean Thinking distils the essence of the lean approach into five key principles and shows how the concepts can be extended beyond automotive production to any company or organisation, in any sector, in any country. In this case we will explore how Toyota translated it from a high volume car production environment to the production of modular homes.

The five lean principles

1 Specify what does and does not create **value** from the customer's perspective and not from the perspective of individual firms, functions and departments

2 Identify all the steps necessary to design, order and produce the product across the whole **value stream** to highlight non value adding waste

3 Make those actions that create value **flow** without interruption, detours, backflows, waiting or scrap

4 Only make what is **pull**ed by the customer.

5 Strive for **perfection** by continually removing successive layers of waste as they are uncovered.

These principles are fundamental to the elimination of waste. They are easy to remember (although not always easy to achieve) and should be the guide for everyone in the organisation who becomes involved in the lean transformation.

In order to go lean, you need to understand customers and what they value. To get a company focused on these needs you must define the value streams inside your company (all the activities which are needed to provide a particular product or service) and, later, the value streams in your wider supply chain as well. To satisfy customers you will need to eliminate or at least reduce the wasteful activities in your value streams that your customers would not wish to pay for.

Next you have to find a way of setting the direction, fixing targets and seeing whether or not change is actually occurring. You need a framework to deliver value for your customers as well as a toolkit to make the change.

If you can do this effectively you won't need to benchmark competitors to set some arbitrary and often incomparable target; perfection or the complete elimination of waste should be your goal.

Understanding Value & Waste

The rationale behind going lean centres on creating value and removing waste both inside and between companies. This is fundamental to a lean value stream. Improved customer focus and productivity gains lead to leaner operations, which in turn help to expose further waste and quality problems in the system. The systematic attack on waste is also a systematic assault on the factors underlying poor quality and fundamental management problems.

What is Value?

Value is what the customer wants. It consists of their articulated and latent needs and may be expressed as a perception rather than in concise facts and figures. In general there will be a number of key dimensions of customer value, we call these Value Attributes. Examples of Value Attributes include tangible elements such as product features, quality and delivery times as well as more intangible elements such as service and relationship. Each customer will have their own set of Value Attributes for different products and services, although groups of customers may be clustered into distinct market segments.

It is important to start by gaining an external view of value as company's view of what is valuable to their customers is very often wrong or distorted. The description of the customers' value profile becomes strategic as it the basis of understanding how to create a competitive advantage. It involves the direct participation of the management but, most of all, of the customers, moving from an internal focus towards an external one.

It is our contention that an integrated or holistic process-based approach is the most effective way to drive companies towards a value-based competitive advantage. Remember, customers receive the output of complete processes not just individual departments.

What is Waste?

Waste is anything that does not add value to the customer. As a guide, seven wastes have been identified within the Toyota Production System (Monden, 1997). The Japanese call this muda.

Figure 2: The Seven Wastes

Getting the Balance Right

Clearly it is necessary to balance customer value with the cost of generating it in order to provide a competitive offering. This is true whether your organisation seeks to offer a premium, standard or budget product/service. In the following figure we can plot the degree of customer perceived value for a product or brand against the relative cost of providing it. This latter cost would include the waste involved in providing the product or service. Offerings that are in the premium market would be in the top right part of the figures, those in the budget end of the market, in the bottom left. However, any offering above the diagonal equilibrium line will add value to the customer. Firms in this position are likely to win market share and grow. Those below the line are much less likely to have a comfortable future. A common feature of lean businesses is their movement to an above-the-line position.

To illustrate this, let us use the example of two mid sector car brands, Rover and Audi in the late 1990s. Due to a number of factors, Rover found themselves in a mid market position but with a poor market perception for value. As a result they had a choice as to how to improve their position. They chose to institute a programme of drastic cost cutting (a leftward shift in their position) by measures such as staff redundancies. However, as Rover were very frequently in the news with such "bad news" stories, their perceived customer value fell further, resulting in them being further away from the line than before. The result – further reduction in market share.

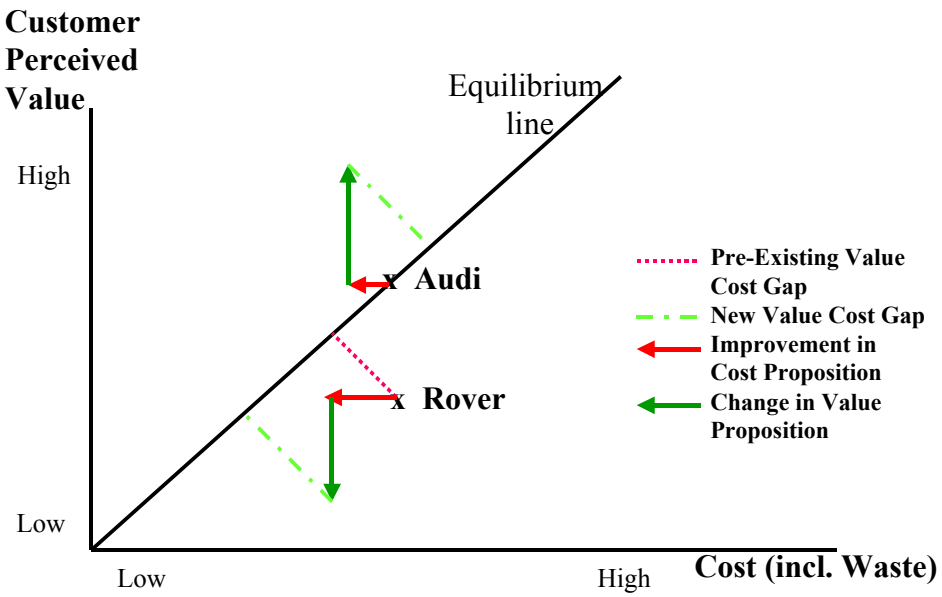

Figure 3: Customer Perceived Value & Cost Example

In contrast Audi were undertaking less radical cost improvements but working on improving their customer value proposition by launching models such as the Audi TT. As a result a small leftward shift was accompanied by a large vertical increase, meaning that they had repositioned themselves as a firm that in the eyes of the customer were adding a lot of value. Their market share consequently increased markedly.

The moral of the story, and one that Rover have now learnt, is therefore to address both customer perceived value and the degree of waste in an organisation simultaneously. Indeed finding the right balance between the two in future improvement efforts will be a central task for any management team.

Application to House Building

Toyota has been reducing costs and focusing on customer value for over half a century. However, the recessionary situation in Japan since the start of the 1990s has created the appropriate “crisis” for them to accelerate this approach. This is evidenced, for instance, by the title of the 1994 Annual Report “How We Saved $1.5 Billion” (Toyota Motor Corporation, 1994). Their efforts to do this have been focused on:

- Developing parts that are as good as their predecessors but less expensive
- Modifying production processes to make them more cost-effective
- Using fewer standard parts
- Streamlining logistics systems

- Encouraging lean production practices in their suppliers and their suppliers

- Raising white collar productivity

In 1975 Toyota decided to enter the prefabricated housing market and now have three factories in Japan including one at Kasugai near Nagoya in Japan. In doing this they sought to leverage the competitive advantage that they had developed in the car industry by applying it to factory made “unit structure” homes. In general the time from customer order to the end of final production is less than one month with 80% of the construction activity being carried out within the factory.

Their product is steel-framed and utilises a new concept in home-building: S&I (Super-skeleton and Intelligent in-fill). This type of construction combines a highly rigid and durable structure with leading-edge construction techniques that draw on the technological prowess of the Toyota Group. In June 2000, they began sales of Vie-(alpha) steel houses in partnership with Nippon Steel Corporation. The move was aimed at increasing products for lower-price categories of homes and homes for colder regions. They have also branched out into the condominium business to respond more widely to customer needs. Present production volumes of their full range of houses were 3,666 units in 2001.

Figure 4: Examples of Toyota Homes

The product is made using two feeder lines and a final assembly line before being shipped to the final erection location. The process flow for this is illustrated in Figure 5. The total time from taking an order to the final completion of the construction site is typically around 20-25 days making for a very fast total process using a minimum of on-site time and labour.

The production of the outer metal frame has three major factory operations:

(i) Arc-welding of metal frame using robots

(ii) Cation-type electro-deposition line applying nine coats of paint

(iii) Frame assembly

The production of the walls has two major factory operations:

(i) Creation of the wooden walls, floor and ceiling

(ii) Installation of exterior walls into guide frames

These outer metal frames and walls are then fitted out and other components are fitted inside the “unit assembly”. These units at this point resemble Portakabin. They may be outfitted to a very degree with, for instance, a full bathroom suite and floor covering. The final unit is then inspected and shipped to its final construction site. The final construction of the house on the site takes around 12 hours after the foundations are laid. This contrasts with the more typical 10-15 weeks for a traditional timber or blocked house in the UK.

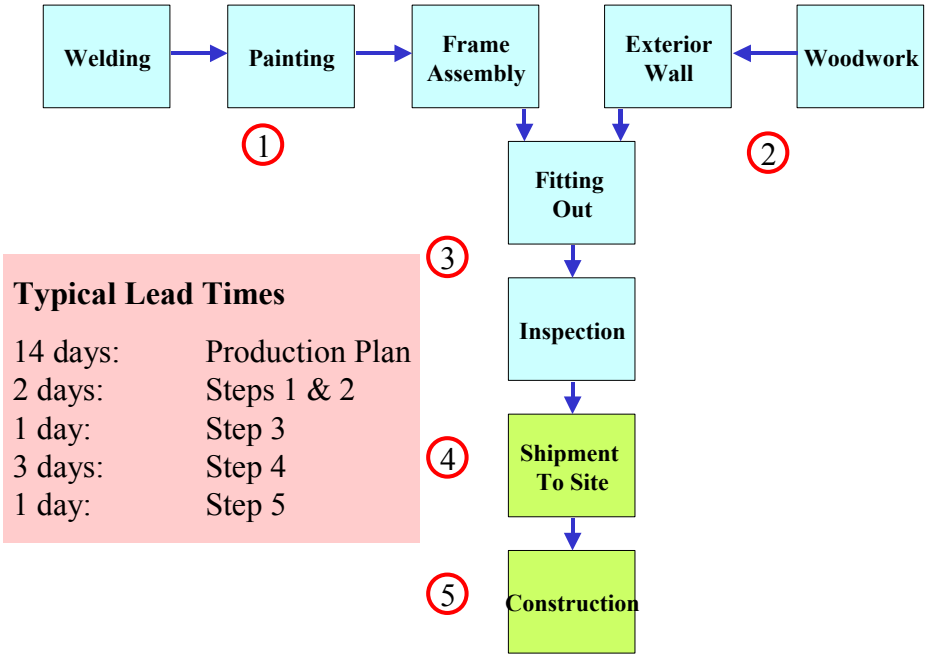

Figure 5: Process Flow Activity at Toyota Homes

Link to Lean Thinking

There are a number of important lessons from this approach to house building, many relying on the re-application of Toyota Production System to this (significantly) lower production volume. These include:

1. Application of a Type of Single Minutes Exchange of Die Principle

One of the key approaches within TPS is quick set up using a tool called Single Minutes Exchange of Dies or SMED (Monden, 1997). In a traditional high volume lean factory this involves the following four concepts:

- **Separation of internal setup from the external setup.** Internal setup refers to those actions that inevitably require that the machine be stopped whereas external setup refers to actions that can be taken while the machine is operating.

- **Convert as much as possible of the internal setup to the external setup.**

- **Eliminate the adjustment process in the internal setup.**

- **Abolishing the setup step itself.**

If this SMED process is likened to the prefabricated house process the external setup may be seen to be the factory build that has been separated from the internal setup (or those activities that occur at the site). Toyota has converted 80% of the internal setup (or site work) to external setup (or work at the factory) where it can be achieved far more quickly and cost effectively. This requires a high degree of precision in the manufacturing process together with a significant degree of modularity or product component standardisation. Thus little adjustment is required at site. However, even Toyota Homes are yet to complete eliminate activity at the construction site!

2. Application of JIT manufacturing including a Kanban Pull System

Inside the house factory the range of tools and approaches employed is very similar to what one would expect in a much higher volume manufacturing facility with evidence of the following approaches:

- *Kanban* pull systems internally and with suppliers
- Standardised work
- *Takt* time levelled production scheduling
- *Kaizen* improvement activity
- *Andon* visual management approach
- Fast stock turns: between 1 & 6 days stock of different parts

3. Use of Active Supply Chain Development

The last notable feature of the case is the way that the firm actively involves their suppliers in what could be called a “high pressure improvement based collaboration”. To facilitate strategic alignment, education and improvement activities Toyota Homes organises a Supplier Association or *Kyoryoku Kai* (Hines, 1994). This group consists of 40 key suppliers whose focus on improvement is largely within the areas of cost, quality and delivery performance (lead time and punctuality).

Within this group senior staff meet about every 6 weeks for strategy alignment and to receive outside input from academics and other experts. At a less senior operating level meetings are arranged monthly in order to identify and implement improvement activities within the areas of materials, manufacturing techniques, logistics and construction activity. These activities are designed to meet the exacting standards set by Toyota for initial target costs as well as targets for improvement set for each supplier.

Conclusion

This case has sought to show how Lean Thinking and in particular the Toyota Production System can be applied to a significantly lower production environment. Case evidence from Toyota Homes has been presented that demonstrates a system with radically reduced timescales and cost structure that has resulted in the firm achieving a year-on-year compound increase in sales of over 10% within the largely stagnant Japanese market whilst at the same time producing a high level of profitability.

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