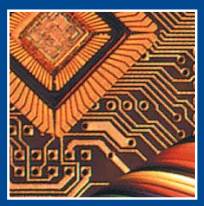

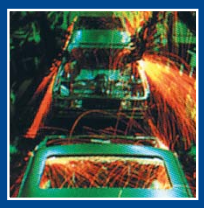

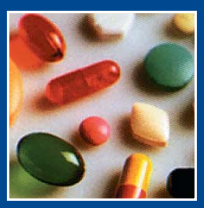

An Executive Guide to Lean Thinking

Deloitte & Touche

An Executive Guide to Lean Thinking
Deloitte & Touche Senior Executive Series of Briefing Papers

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INTRODUCTION

Lean has resulted in companies reporting:

- Throughput times and defects reduced by 90%
- Inventories reduced by three quarters
- Unit costs slashed in half

All this has been done at very little capital cost to the companies involved.

With performance improvements of this magnitude it has been possible for companies to double output and profit with the same headcount.

Throughout the 1990s, UK manufacturing organisation have become subject to the growing pressure, especially in mature industries, to become leaner and more competitive. For some, these pressures were accompanied by a desire to quantify and understand the extent of the competitive 'gap' between themselves and the 'rest of the world'. The most prolific attempts occurred in the automotive assembly and component-manufacturing sector and took the form of a series of benchmarking activities.

The findings of these studies shocked the 'world' and the results provided not just a 'wake up call' to the automotive industry but they identified a new powerful approach to manufacturing – 'lean'. Research into the 'lean organisation' continued to attract attention and the lean approach began to be adapted and adopted by businesses in other industrial sectors, with equally successful results.

'Lean thinking' is a powerful model of the competitive organisation that is based on a 'common sense' approach to management, combining processes of continuous improvement and the integration of entire supply chains.

UK Manufacturing: The Modern Pressures For Change

In broad terms, UK industry is under severe pressure to change and to compete in an ever-smaller yet global market. These pressures and the severity of the competitive challenge will vary by sector but general patterns can be found and in unfortunate combinations that threaten the survival of the sector over the long term. Most of these pressures set or change the 'rules' of competition for manufacturing businesses. They also increase the managerial workload as the uncertainty and turbulence in product

markets intensifies and new entrants, often in low labour cost economies such as the former Soviet Union, seek to exploit their raw material and technology bases.

General Competitive Pressures

- **Industrial Over-Capacity** and the price competition amongst manufacturers 'desperately seeking' customers or the industry enters contraction and sites are closed and their associated supply chains decline.
- **Liberalisation of trade barriers** and the ability to access markets with less bureaucratic controls exposes domestic manufacturing to imports.
- **Foreign Direct Investments** in the UK have risen in terms of new 'green field' and the purchase of existing 'brown field' operations. For many of the 'green field' sites these organisation have brought with them trusted 'first tier' suppliers as new investors in the UK.
- **Government Intervention** has increased in terms of regulatory issues concerning monopolies and mergers, competitive regulations, and social welfare compliance.
- **Increasingly sophisticated customers** with a new ability to select between manufacturers and buy through a variety of channels including the internet. Industrial customers too have increased in their demands and the deliberate selection of suppliers with whom to form alliances over the longer term. These selection criteria go far beyond the simplistic notion of price and includes the 'competence' of the supplier firm.
- **Accreditation Standards** have created a common level of performance for manufacturing organisations and set 'hurdles' for effective entry to certain markets.
- **Demanding Stakeholders** and shareholders, armed with greater information about the firm and its markets, places an additional pressure on management to meet continuously performance expectations by these pressure groups.
- **Technological Penalties** have also risen as the costs and advances in the performance of new technology
- **Environmentalism and Corporate Citizenship** has increased the duty of the firm to comply with regulations, promote these activities and to invest monies, resources and time.

The response to these pressures has been varied and has involved what can only be described as a series of 'cure-all' techniques that have offered manufacturers the potential for radical 'turnarounds'. However, most of these techniques have failed to deliver their promises and created additional problems – not least in lowering the credibility of management themselves. These 'fashions' and trends have focused improvements in the performance of individual business departments, but failed to deliver the system-wide improvements that can be exploited commercially. Unfortunately, many of these 'worthy causes' have been implemented poorly or in haste almost as 'sticking plasters'. Th real result has been a lack of sustainable improvements in performance in the key financial indicators of the firm (as measured by metrics such as stock turns or return on net assets).

The reason why so many of these previous initiatives have not resulted in sustainable improvements are numerous but in essence the real cause is that a 'systems' approach has not been adopted whereby the organisation and its relationships (within and beyond the firm) are optimised and provide true customer value. For even the

manufacturer of 'simple products' to optimise the system is difficult and requires a 'buy in' from the entire workforce from top to bottom and also with the strategically important firms that make up the supply chain. To achieve this goal, of optimisation, and to align all initiatives within the firm to make best use of the scarce human resources available, many high profile manufacturing organisations have found the 'lean thinking' approach to the hold the key to sustainable improvements throughout the organisation. These 'leaning' organisations also rely and dependent upon their unique supply chain and in turn are beginning to ask for suppliers to adopt the approach to extend the benefits of the new system of material flow and competitive advantage.

Lean Thinking

Following the global success of "The Machine That Changed The World", two of the co-authors, Jim Womack (USA) and Professor Daniel Jones (UK) began to explore the emulation and implementation of the 'lean approach' by Western businesses in different sectors. In 1996, Womack and Jones released their findings, drawing from over 52 organisations, in the publication "Lean Thinking". These organisations included manufacturers of machinery, aerospace parts, luxury vehicles and entire supply chains. The book contained the impressive performance improvements achieved by organisations emulating the 'lean approach' in the West.

The authors concluded that there are five key principles driving lean thinking:

1. The definition of **Value**.
2. The identification and integrated management of the entire **Value Stream**.
3. The design of production systems that ensure materials **Flow**.
4. The introduction of **Pull** Production systems to support customer service.
5. The continuous improvement of all business activities to achieve **Perfection.**

First Principle: Defining Value

The lean approach begins with the definition of the 'value' from the perspective of the end customer. The lean organisation defines value by investing time and resources in understanding the final application of the product supplied in order to unearth the value derived from it by the consumer in terms of product and service.

The value, defined from a customer's perspective, is then aligned within the organisation and value-adding activities can be recognised as any activity that the customer is happy and prepared to pay for. Cost is, therefore, those activities which add no customer value and for which they are forced to pay. A general estimate for a typical manufacturing firm is that value-adding accounts for less than 5% of the total time a material is at the factory. It is horrifying to think that remaining 95% of the time is spent adding costs (storage, delaying at queues within the factory, transportation between processes, inspection etc.).

More frightening still is the knowledge that such wastes are present at every supplier, customer and distribution point as the product moves towards the actual consumer and that many of these ‘wastes’ have actually been ‘designed into’ the entire internal and external material flow processes.

Second Principle: Identifying the Value Stream
A value stream has two forms, the first an internal sequence of activities that must be combined to create a product or service (the internal value stream) and the second is concerns the business, its customers and its suppliers (supply chain value stream).

The internal value stream therefore contains all the assets, people and processes to manufacture products. The supply chain value stream includes every organisation that must combine to produce the final product offered to the customer and these value streams need to be structured and controlled in order to optimise the material flow throughout the entire chain. The second principle highlights the importance of taking a holistic approach to the firm and its value chain or chains in which it operates. Effectively these elements are different features of one process and one system and that regarding the entire material flow in this way opens up many opportunities.

As the benchmarking studies confirm, lean organisations take a holistic approach to value creation and the integration of their respective the value streams and in so doing benefits financially. The core belief of the lean system is a mutual ‘win: win’ and collaboration between business departments, managers and workers, and with suppliers and customers in order to survive and profit from manufacturing. For the lean producer, conflict lowers the performance of the value stream.

The Third Principle: Make Material Flow

Lean organisations are primarily concerned with making materials flow in the system with high levels of stock turn without allowing the material to idle in queues or stagnate at large stock points. Taiichi Ohno, the designer of the Toyota Production System was besotted with making materials flow and to assist in this process he developed seven classifications of waste in manufacturing facilities. The ability to ensure materials flow within the factory, and derive value rather than cost, involves the elimination of ‘waste’.

Ohno's Seven Wastes

1. **Overproduction**. The manufacture of products that are in quantities that are well in excess of actual customer demand for the product. The waste of overproduction, often associated with large batch sizing policies, has a negative impact on the costs of the firm.
2. **Unnecessary stocks**. Closely associated with batch manufacturing is holding high levels of stock
3. **Producing quality defects**. An obvious 'waste' that reduces profit margins results from 'poor quality' and any firm that seeks to increase productivity and material flow will concentrate on raising the level of quality performance achieved throughout the factory.
4. **Delays (waiting)**. For materials to flow all internal value stream delays must be kept to a minimum. Large batches not only hide quality defects but also create delays as they queue throughout the factory during the conversion process.
5. **Unnecessary transport**. Another 'waste', for which the customer gains no value but for which the manufacturer incurs costs, is the actual amount of travel that a manufactured material endures as it passes through the conversion processes within the factory.
6. **Inappropriate processing**. From an engineering perspective, there is a 'waste' associated with technology that results from using very high specification assets to produce goods that would better be converted using simpler machinery. Thus using complicated assets to conduct simple tasks is a 'waste' associated with investments and poor product routing which increases the number of bottlenecks and queues in the factory.
7. **Unnecessary motion.** The final form of 'waste' concerns the ergonomics of the factory and manufacturing task itself. Recently this lesson has come to haunt many UK manufacturers that have neglected to design work routines and is reflected in the amount of industrial compensation and repetitive strain injury (RSI) claims. It is no surprise that throughout he 1990s, Toyota has invested heavily, in finances and engineering resources, to make the workplace even easier for the employee.

The flow logic developed by Ohno and used by all lean producers is quite easy to follow – materials must be kept moving without interruption. This process is naturally connected directly with the 'payment cycle' for materials and the quicker material moves then the quicker payment is received. To flow materials properly, at low cost, requires the quality of the material to be completely assured or you simply move defects around the factory quicker and end up with more chaos. Conversely, speeding up machines may not provide the greatest return for manufacturers if the output of these machines languishes in huge stockpiles.

Eliminating 'waste' and improving material flow, therefore improves the responsiveness of the factory to the market allowing the firm to work to actual demand rather than forecasts. The approach also reduces the costs of manufacturing and the 'safety stocks' returning capital back to the lean business.

Principle Four: Implementing Pull Production

Pull production is a principle that has evolved from Toyota's innovation, the kanban. The kanban approach is best illustrated by the burger racks at MacDonald's where products are taken by counter staff to satisfy customers and the movement of these

materials from the rack triggers the replenishment of an identical burger. The same principle applies for the lean approach where 'flow' cannot be used to move materials between departments/processes. At these points it is important to have materials available when required and these key buffers effectively disconnect the internal (or external) customer and supplier operations. The supplier manages them such that withdrawals of products by the customer trigger the manufacture of replenishments. Thus as products are taken to demand, the empty space left by the withdrawal provides the 'requirement' to replenish. Hence the term 'pull' as internal manufacturing processes pull work from earlier workstations or work is pulled from suppliers.

The opposite of the 'pull' system is that of 'push' and the traditional approach of launching batches into the primary processes of the factory and 'pushing' them from the primary processes to the final and then the distribution system. Under the 'push' system, materials are expedited to meet expected 'due dates' when the products must be shipped to the expectant customer. The kanban system therefore allows the deliberately managed stock buffers to be used as points at which there is a complete availability of materials required by the next conversion. These positions are deliberately managed and kept to a minimum needed to satisfy the demand for the product.

The use of 'pull' techniques allows lead times to be reduced and improves the flow of materials within and between organisation. The application of pull production on a supply stream scale means that material flow, throughout the entire population of suppliers, can be employed to increase the synchronicity of manufacturing products **to order** rather than the 'best guessing' involved with most forecasts that are by nature inaccurate and inflated.

Principle Five: The Pursuit of Perfection

It is now over 50 years since the embryonic production system was introduced at Toyota yet in 1994, the annual report led with the headline "**How we saved $1.5 billion**". These savings were real and not luck. They involved all Toyota's employees and suppliers in an effort to look for cost savings in a pre-emptive measure to address poor economic conditions and an appreciating 'Yen' price. To put these figures into context around 164,000 people are employed at Toyota sites worldwide. It is this passion for the 'zero loss' factory and supply chain that distinguishes Toyota and other lean factories from those that are not. The pursuit of perfection takes many forms and is a function of the employee. In lean organisations the number of ways in which the employee can contribute to the improvement of their activities and the performance of the firm are much greater than the traditional forms of employee integration in the UK. The 'lean approach' goes far beyond the suggestions scheme and includes a lifetime of continuous improvement by every worker, by every manager and by every supplier upon whom the lean plant is dependent. Within this context, improvement ideas flow – safe in the knowledge that people will not be made redundant as a result of a given improvement (but they may be reassigned within the firm). Each of these classes of input, to the manufacturing firm, is capable of improving material flow (including retraining of employees in new skills to release this potential) but can only do so when there is collaboration and trust throughout the factory and a participative management style. Lean producers therefore develop the mechanisms required to promote and capture innovations throughout the factory and

to implement these quickly to improve the overall flow of material in the factory (to ensure a high quantity of improvement ideas). To benefit from these innovations the lean organisation invests in widespread training especially in the processes of asset management (to ensure the quality of improvement suggestions) and develops forums appropriate to integrate innovations proposed by suppliers and customers.

Endorsing the Lean Approach

Throughout the 1990s a number of organisations around the world have begun to translate the 'lessons' of the lean approach for their own businesses. From it's inception in 1997, lean thinking at Alcoa had yielded corporate savings of $1.1 billion by the close of accounts in year 2000. These improvements were not the result of economic conditions or 'breakthroughs' in technology but the consequence of developing a 'lean capability' at every manufacturing site and allowing middle management personnel to redesign their own production systems to eliminate waste. The benefits for Alcoa were not purely operational but included strategic advantages resulting from the ability to exploit the new systems for customers and to synchronise manufacturing with consumption. By 1999, the corporation had protected key accounts, such as the Boeing 737 value stream, and had developed systems that offered significant advantages to both customer and supplier in an industrial sector that is subject to commodity material price movements and had traditionally managed the supply stream based on 'price'. The proof of the Alcoa history is reflected in the corporation's share price and the performance of the corporation relative to others in its sector.

The lean approach has also been adopted by many UK organisations at all levels of the value stream and across a wide variety of industrial sectors. Retailers and their associated value streams, such as Tesco Stores, Unipart, and RS Components, have all gained benefits from the approach. Large manufacturers have also integrated the lean approach to the evaluation and selection of suppliers and, within the primary processing sector, 'heavy' industries have, often as a result of the Alcoa experience, begun to engage 'lean' systems to exploit the benefits available under the new approach. In parallel, the UK government has, through the funding provided to the UK universities, allocated funds to promote and implement the lean approach in sectors as diverse as aerospace, shipbuilding, machine tools and the metals industry to services such as government departments and the hospital sector. Therefore, lean has begun to get a foot hold in the minds and models of UK senior managers motivated by proactive attempts to improve the performance of the manufacturing process and also increasingly as major companies and customers (at the head of large supply chains) begin to promote the lean model with their large supply bases. So far, no industry segment has remained untouched by the approach although many remain at 'awareness' rather than implemented stages of development.

The Implications of 'Lean Thinking'

For business executives the implications of the lean approach are numerous and broad ranging. One of the first lessons of lean thinking is to understand the application of the five lean principles to your business, its key customers and suppliers. The application of the approach will be influenced by a number of factors including the distribution of factory capacity and volume to key customers (ones that must be secured) and the dependency of the purchasing budget on a few key and strategically important suppliers.

Often the initial improvement areas concern quality and information exchange. The focus on these issues helps to prioritise improvements within the factory and does reap major benefits as customers are secured and stock turns improve. Likewise the same issues will assist with the development of the suppliers to the manufacturing firm (using a club forum approach to save on time invested).

The methods of integrating the supply chain are another important aspect of lean thinking. For most manufacturers, product costs are heavily influenced by 'bought in' materials and in most markets, where sales prices are relatively fixed by competition, the management of these costs becomes a strategic capability for manufacturing organisation. In addition, there is a 'rule of thumb' that suggests of all employees the purchasing agents of the firm account for less than 1% of total employment yet control vast centres of company costs.

To unleash the potential of these improvements senior managers will have to develop the necessary support infrastructure and gather the skills necessary to make the transformation and break customary practices such as 'fire-fighting'. The lean approach promotes 'collaboration' between internal business department such as purchasing, production planning and operations in order to improve material flow. The design of these systems, to integrate the manufacturing business, will involve the careful mapping of products and the information exchanges between departments in order to highlight the absurdity of the current system and to lower the barriers to change. The senior manager upon whose shoulders the 'mandate for change' is accountable must support these actions.

Finally the pursuit of perfection by all employees of a lean organisation means that sooner or later less labour is consumed in the manufacture of the product. However, continuous improvement will never be sustained if these improvements mean that job losses result from the actions of improvement. For the executive of a lean manufacturer, the only way of improving the firm and sustaining the improvement process is to grow the business itself and to develop workers who can be transferred within the factory to new jobs and improvement activities. Business growth relies upon new products and opening new market segments that in turn result from a greater integration and understanding of customer 'value'. The latter is also a strategy to move away from saturated and price sensitive markets to stretch into new segments.

Thus it is vitally important to conduct an audit of the 'human resources' within the factory in order to assess the level of change that can be undertaken by these personnel and the support needed by these individuals during the company-wide change process. The class of employee that is critical to success during the implementation of change is the middle management level of the firm. These individuals have not traditionally had to manage beyond departmental boundaries but under the lean organisation must work as an integrated team if material flow is to be optimised throughout the factory. All lean producers exhibit a keen interest in their human resource capabilities and the retention of staff throughout the life of their employment as this element of the lean manufacturing puzzle is the source of all innovations at the factory and across the supply chain.

The Origin of the Lean Approach & the Benchmarking Studies

The origin of the lean approach is the automotive industry and the Toyota Motor Corporation in particular. Toyota was faced with a highly competitive market for automobiles in Japan, from the 1950s onwards, that resulted in a new form of business organisation as the company developed its manufacturing capability to form a powerful competitive weapon. Today Toyota operates with a highly integrated system of supply, manufacture and distribution and this system has evolved to withstand the harshest of competitive environments from bitter domestic market competition to the global production of vehicles. Domestic competition forced Japanese producers, like Toyota, to attack export markets and then later to locate production facilities in Western markets. The internationalisation of Japanese manufacturers, including Toyota, Honda and Nissan, and the establishment of UK production facilities, brought with them the practices of their Japanese parent organisations and an expectancy that Western suppliers would implement new forms of production to meet the demands of the vehicle assemblers.

The successful internationalisation of the Japanese automobile manufacturers occurred during the late 1980s and stimulated interest in their approach to manufacturing and management. This interest was supported by the findings of a global study of comparative vehicle production performance reported in the business best seller, "The Machine That Changed The World" (Womack, Jones and Roos, 1990). It was in this publication that the term 'lean production' was coined to describe the system of manufacturing developed by Toyota. The findings rocked the automotive industry and reported performance differentials with Western producers calculated to be a 2:1 productivity advantage and 100:1 quality advantage against traditional mass production facilities. The term 'lean' was used to refer to the high performance Toyota production system that required less effort, less investment and incurred less costs, defects and wastes than the mass production system.

An Overview of 'The Machine That Changed the World'

The publication, 'The Machine That Changed The World,' resulted from a five-year global study of the automotive assembly industry involving every vehicle manufacturer that commenced in 1985 and cost $5 million. The research programme (International Motor Vehicle Programme) was designed to assess the level of performance in the different automotive manufacturing regions of Japan, America and Europe and followed fears that the Japanese producers held a significant performance advantage over the rest of the world. These fears proved to be founded and Japanese car producers were found to operate with a 2:1 productivity advantage and a 100:1 quality advantage over their global rivals and the exemplar corporation that had mastered high quality and high productivity manufacturing was found to be the Toyota Motor Corporation. In a simple box score of plants, the Toyota Production System and its supporting organisation structure subsequently became termed the 'lean approach' as it used less of everything (labour, space, materials, rework activities) and 'outperformed' the traditional systems of mass production that had evolved in the West. In a simple 'box score' the authors highlight these differences using two established manufacturing sites (GM Framingham and Toyota Takaoka).

The Performance Differential

Performance in 1986	General Motors Framingham (USA)	Toyota Takaoka (Japan)
Gross Assembly Hours per Car	40.7	18.0
Adjusted Assembly Hours per Car	31	16
Assembly Defects per Car	130	45
Inventories of Parts (average)	2 Weeks	2 Hours

Source: Womack, Jones and Roos (1990)

The differences in the organisational logic of the lean and mass-producers was investigated and the researchers found a highly disciplined lean system within the factory and beyond to include customers and suppliers in a lean supply chain system of equally high productivity and quality.

A Summary of the Lean Organisation

- High levels of team working at management, and operations, levels of the firm that is based upon the consensus management approach to the control of key business processes that provide customer service.
- A commitment to a lifetime of employment and the elimination of all forms of waste and cost in the factory.
- A commitment to continuous improvement and TQM at all levels of the firm including devices to detect instantly the production of a defect and the elimination of this failure source by targeted problem-solving by factory teams.
- An integrated approach to the management and visual communication of information in the factory allowing a logical approach to autonomous work groups.
- The team based organisation as the basic building block of the firm.
- The development of a stable, reliable and 'pulled' production process that operated with minimal batch sizes and low reasons to intervene in the material flow process.
- A highly integrated approach to the design of products involving customers, the firm and its suppliers to achieve superior results through collaboration and the integration of specialist skills.
- The integration of the supply chain using a much smaller network of closely collaborating suppliers each focused on high levels of material flow (just in time deliveries) of perfect quality parts and modules.
- The integration of distribution channels and supply of vehicles using highly developed dealers committed to a lifetime of customer service.

The differences between the major automotive assembly regions was however over-shadowed when the researchers began to investigate the performance of an American-Japanese joint venture facility located in the United States (NUMMI). This factory was an alliance between General Motors and Toyota that employed the lean Toyota Production System. The results positioned the NUMMI factory, using American

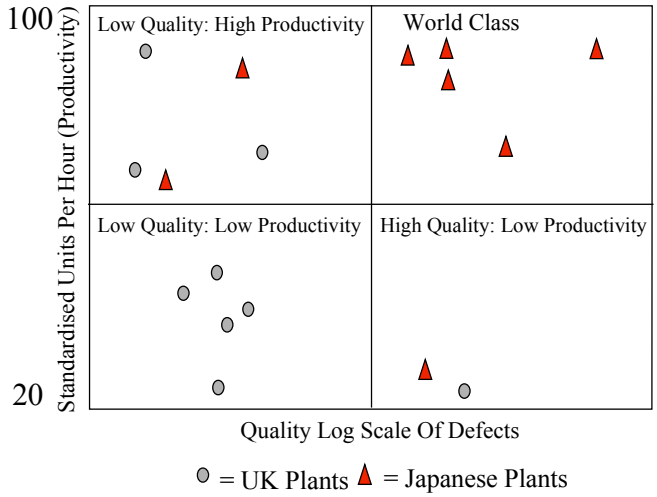
labour, at a performance level that was significantly better than the traditional American facility and close to the performance achieved by the established Japanese manufacturing sites in Japan. These performance measures included quality, productivity, batch sizes and the rate of shipments to and from the factory. The findings provided strong support that the correct design of the 'lean production system' could be transferred to the West and would result in the same levels of performance benefits.

At the end of the publication, the authors contend that the lean approach was transferable between automotive installations but, more importantly, in the authors opinion, the system could be adapted to suit the needs of other industries and for all manufacturing concerns. "We've become convinced that the principles of lean production can be applied equally in every industry across the globe and that the conversion to lean production will have a profound effect on human society - it will truly change the world" (1990).

The 1990s: The Era of Component Supplier Benchmarking

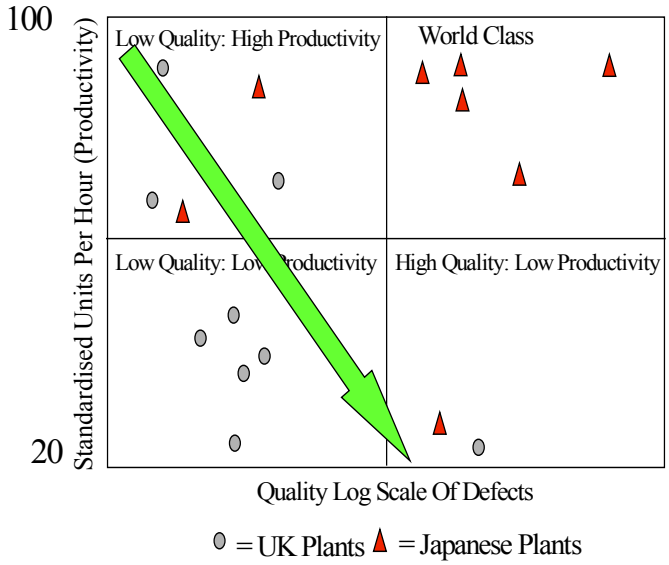
The success of the benchmarking of vehicle assemblers led directly to a parallel series of benchmarking activities to assess the performance of the immediate supply chain of first tier automotive component manufacturers. On average, 80% of a vehicle is produced by suppliers ready for final assembly and the hypothesis was that lean assemblers were supported by equally 'lean' and 'world class' suppliers. The Cardiff Business School and Andersen Consulting (1993) conducted a research programme involving UK and Japanese producers of brakes, seats and exhausts and found a consistent 2:1 productivity and 100:1 quality advantage for 'world class' facilities (all of whom were Japanese). However the survey also found that not all of the Japanese organisation could manage to combine high levels of productivity and quality simultaneously.

The Component Benchmarking Findings



The axis for the quality of the organisation had to be a log scale as the best and worst performers could not be plotted on a single chart revealing the vast differences in performance between the cases concerned. Another interesting finding was that the 'non-world class' companies appeared to have the traditional manufacturing trade-off between high speed or high quality – they could manage one but not the other. The 'line of best fit' in the figure below illustrates this.

The 'Line of Best Fit'



The 'world class' organisation achieved despite a much higher product variety, 75% less raw materials in the production system and incurred 1/3rd the levels of re-work associated with the 'non world class' organisation.

In terms of the human relations within the factory, *'the world class have much more active structures for shop floor problem solving and improvement; production team leaders play a particularly significant role in these plants'* (1993). The shop floor structures, and importantly, the delegation of decision making authority to the team leader and team was therefore an important consideration for the design of factory roles and responsibilities and the day-to-day management of the factory systems for the world class companies.

The human resource management section of the survey found little evidence to suggest that the world class companies operated a vastly different approach to the non-world class companies. The world class companies all 'used salary and individual merit schemes which included production operators on the shop floor. They also had company-wide performance appraisal schemes. Their employment practices were measurably more progressive in areas such as single status terms and conditions and employee benefits. Among the non-world class plants, hourly pay based on job classification predominated' (1993). The survey also discovered that the level of unscheduled absenteeism in the world class, more productive, factories was around 0.8% and this figure was four times higher in the non-world class companies suggesting that a 'world class' company may be a more pleasurable working environment.

Features of the World Class Manufacturer

- World class organisation operated with less employees than the non world class
- World-class organisation engaged in much higher levels of subcontracting (even accounting for these figures the world class organisation still employed less people.
- The production and material requirements were pulled through the manufacturing plant based upon key buffers (called kanbans) unlike the non-world class factories that worked to self-determined schedules.
- Economies of scale did not benefit the world class plants
- The world class plants were more automated than the non-world class but this accounted or only 10% advantage in productivity terms.
- World-class factories held only $1/7^{th}$ the amount of total site inventory than the other companies and received/despatched goods more frequently.
- The team leader was a key position for the world class factories and these individuals orchestrated the factory-wide improvement processes. The team leader position did suggest that the role of the empowered operator may well have been overstated in the management literature and that it was in fact the team leader who was instrumental in achieving high productivity and high quality within the factory setting.
- World-class factories made extensive use of problem-solving activities involving over 80% of the workforce in this process and with teams meeting on a weekly basis. The result was that 25% more improvement suggestions were recorded at world class plants than in the non-world class even though the average payment for each improvement was little over £5 (£14 in non-world class factories). 79% of suggestions were implemented by the world class companies as opposed to only 13% of non-world class companies)
-

In the context of its supply chain, world class companies delivered finished products every 3 hours whereas the other organisation shipped only once every 18 hours. The world class companies also received materials from their suppliers every 7 hours rather than the non-world class average of every 47 hours. These figures did not result from the close proximity to the customer or suppliers of the world class factories despite the popular belief that Japanese companies are all co-located in the same geographical area.

In terms of the informational elements of supply chain integration, the research demonstrated that the variability in customer schedules (measured one month before actual consumption date and compared with actual quantity taken) resulted in a volatility of plus or minus twelve per cent for non-world class companies. The figure for world class companies was less than half of this volatility. The volatility of orders was also 'dampened' for the suppliers to the world class component makers. These indirect suppliers to the vehicle assemblers also benefited from an extensive network of supplier clubs with clubs operated by the vehicle assembler, the component maker and the indirect suppliers. At these monthly 'forums' information and strategies were shared along with actual techniques for the self-improvement of the supplier. Furthermore many organisation *'ran specialist sub-committees in areas such as quality improvement and cost reduction'* (1993).

The findings
The supply chain, for a world-class organisation represented a network of companies that continuously improved material flow performance and gained from lower costs and additional sources of competitive advantage. In short, each company reinforced the performance of the total system of supplying vehicles through an integrated supply chain (treated as a extension of the assembler), close working relationships (including strategy sharing) and provided, through mutual co-operation, tangible improvements in performance at each point of the chain. The benchmarking activity also highlighted the differential between UK organisations and their international counterparts and led directly to various initiatives taken by the government to promote improvements in the UK component sector.

The World-Wide Benchmarking Study (1994).
Following the stark findings of the first supplier benchmarking study, a second phase was commissioned, and the University of Oxford joined the original investigators. The survey was extended to include 71 brake, seat and exhaust manufacturers from 9 countries.

The Countries Involved in the Survey

France	United Kingdom	Spain
Germany	Japan	United States of America
Italy	Mexico	Canada

The same methods were employed as in the first survey of UK and Japanese manufacturers but this time the survey allowed UK performance to be compared with other major manufacturing centres as well as by technology-employed.

By performance, 13 factories achieved the title 'World class' and held a superior productivity and quality advantage and these factories were located in Japan, France, USA, and Spain. Again the survey confirmed the productivity advantage of 'world class' factories to be an impressive advantage and *'we consistently found a 2:1 difference in performance between the world class plants and the rest. This 2:1 difference appeared over a wide range of measures including productivity, inventories and schedule variation'* (1994). The gap in quality was also a major source of advantage to the world class organisation with advantages of *'9:1 in seats, 170:1 in exhausts and 16:1 in brakes'* (1994). Again the survey found that highly performing companies maintained a strict control within and beyond the factory in terms of the performance of their own, and the performance achieved by the suppliers, conversion processes. From a management perspective, some interesting sources of differentiation were highlighted by the study and the authors contended that *'there is a distinct divide in management practice between Japan and the rest. All of the Japanese use work teams under the control of a team leader and have extensive problem-solving structures. The Western world class plants use a variety of organisational structures on the shop floor, suggesting that there is 'no one best way' to manage people, and that the presence of teams in and of themselves is neither a prerequisite or detractor from the ability to be world class'* (1994).

The ranking by country performance found that a rank order of Japan, the United States and Europe and the survey states that *'what is surprising is the wide range*

between the best and worst in Europe' (1994). Japan and Spain dominated the productivity level comparisons and the UK languished with Italy and Germany as some of the least efficient factories in the sample. This dominance of the Japanese manufacturing systems was reinforced when the issue of quality was examined and the survey found that Japan enjoyed a 30% advantage of their closest competitors, the Americans. The Japanese, in six major measures of performance, held a first or second ranking in five and a lower ranking in one measure. The superior measures productivity, incoming defects, internal defects, customer complaints and stock turns and the lower measure (a world-wide ranking of 3,4, or 5) was held in terms of labour costs per unit produced. The USA held only two superior performances (customer complaints and stock turns) whilst the UK did not manage to hold a first or second position in any of the six measures. Indeed, the survey found that, of the nine factories in Japan, five companies set the standards for 'world class' and a further plant, located outside Japan but owned by a Japanese company, reached world class levels.

Features of the World Class factories

The survey demonstrated that the world class production systems, many based on that originated by Toyota achieved very high levels of productivity and quality within the context of high utilisation rates within the factory. The researchers proposed that these results were achieved by an attention to the manufacturing process itself and a disciplined approach to the basics of manufacturing equipment management. Again, the level of factory automation was not found to offer a major source of competitive advantage but instead, for the manufacture of exhausts (which tends to be more automated) the productivity levels were achieved by the extensive use of "fail proofing"' devices.

The high levels of production system control at the world class factories resulted in much lower inventory needed to protect the internal and external supply chains so there was less inputs stocks, less in process stocks and much less finished product awaiting despatch. Again, the world class companies gained from a frequent system of shipments within and beyond the form (in world class factories deliveries were received every shift as opposed to every two days for the non-world class). At the end of the world class production process, deliveries were made within the day (seat assemble is an operation which happens at the site of the vehicle assembler and a delivery was made every 0.9 hours by the world class supplier). For non-world class companies the deliveries tended to be every two days or more. This closely integrated supply chain, allows the manufacturing company to respond quickly to changes required by the customer

From the human resource management research it was found that the world class manufacturers employed polices that complimented the manufacturing system but were not the true only source of advantage for these businesses. The survey found that the average age of employee for all sites was between 33 and 35 years old and that the world class sites enjoyed a slightly longer tenure and much less unscheduled absenteeism. The survey found that almost all companies engaged in the socialisation of new workers and that few differences, other than in the amount of time spent being socialised, between companies.

The world class companies demonstrated again a preference for small group working structures and confirmed the influential role of the team leader in terms of workplace discipline and control.

Team Structures within the Factory

	Team With Team Leader	Team Without Team Leader	No Team Structure	In Transition
World Class Japanese Plants	5	0	0	0
Other World Class	2	1	4	1
Non-World Class	23	5	23	7

Source: Andersen Consulting (1994)

Overall though the differentials between world class and non-world class organisation was not clearly distinguished by the survey and would suggest that the human resource management of the business is not the major source of competitive advantage. Instead the survey suggested that these polices and structures supported the discipline and control of the production process as the primary means of competitive advantage. These findings were confirmed by an investigation of team leader time allocation and the amount of time dedicated to the improvement of the production system and autonomous maintenance activities of the assets employed.

Once again the survey found that the world class organisation operated a factory suggestion scheme and the Japanese organisation averaged 47 suggestions per employee per year. This figure was nearly fifty times higher than the other world class sites and twenty five times the level of non-world class factories. The survey did suggest that the high numbers of suggestions resulted from a process of management targets. All companies were found to pay for suggestions although the remuneration levels differed substantially.

The second survey also found that all companies engaged in problem-solving activities although, once again, the Japanese ‘world class’ organisation enlisted over 95% of the workforce (meeting for only 1 to 2 hours per month) in this activity. Only 57% of the other ‘world class’ and around 37% of non-world class companies used these processes.

The Box Score of World Class Performance (1994)

	Seats	Exhausts	Brakes
Units Per Labour Hour	1.44	9.71	12.51
Outgoing Quality (parts per million)	237	8	9
Internal Defect Rate	1.8%	0.7%	0.6%
Incoming Quality (parts per million)	4.1	3.9	2.0
Hours Of Incoming Parts	12.6	57.9	31.6
Hours Of Work-In-Progress	10.5	25.8	15.5
Hours Of Finished Goods	2.0	21.9	26.1
Stock Turn Ratio (turns per year)	135	34	55
Assembly Automation	11%	52%	56%

Source: Andersen Consulting (1994)

The Findings

Concluding the survey, the research team determined that, unlike the first study which clearly demonstrated the benefits of employing the Toyota Production System, the second research programme did not demonstrate such a large gap. The inability to determine the full advantage of the Toyota 'pull' system was hampered by buoyant Western markets, simpler Western products and high volumes as a result of local economies. As such the impact of the Toyota system could not be fully tested. Another conclusion was that many of the Western manufacturers had begun to emulate the Toyota lean system and that this action had narrowed the performance differentials considerably. As a result the survey concluded that it was the combination of process discipline and control with a highly integrated approach to supply chain management that differentiated the 'world class' from the rest of the sample. In addition the team proposed that the disadvantage of the non-world class organisation resulted from poor internal efficiency and improvements combined with a lack of supply chain capability especially related to issues of internal and external quality performance.

The survey also confirmed that for the non-world class organisation much management and team time were spent 'fire-fighting' problems but these actions failed to eliminate these sources of failure. Also the authors proposed that the management of such businesses need to stop employing short term interventions and crisis solutions in favour of a long term and strategic vision of the manufacturing system and performance improvement. They added *'the real benefits of problem solving structures lie in the long-term continuous improvement of a basically sound system; they cannot of themselves bring order to chaos. Imitating practices from other countries or indiscriminately devolving responsibility to the shop floor and hoping that problems will disappear is clearly not going to work'* (1994).

The second benchmarking report again demonstrates the advantages enjoyed by the 'lean organisation' and its connected supply chain in terms of productivity and quality. A participative management approach and a development of the production team under the team leader reinforced the discipline and control of the firm. A final observation of the team included a direct comment on the progress of the UK and Japanese companies involved in both the first and second survey. It was found that, on average, the UK companies made gains in productivity (up 19.1% in the number of units per hour produced) between surveys. However in the same period, the Japanese companies made a gain of some 38.4% in the number of units per hour produced in their factories. So Britain was perceived to be improving but still at a lower rate than the world class lean systems.

Final Words

The lean approach is not a short term 'fix' applied to the organisation as some form of 'sticking plaster'. It is an systems approach that creates a 'divine dissatisfaction' with your own business as the more waste you remove the more you will uncover. No firm has therefore reached 'perfection' in what it does, yet for businesses that aspire to be lean, this goal is central to the workforce, the middle management and the executives. It is also a goal that is shared with carefully selected suppliers that are treated as any other business department within the firm. The approach is also supported by a broad range of operational techniques employed by 'lean exemplars', such as Toyota, and these are relatively well known to middle managers. Such techniques are powerful when combined and focused on the improvement of the entire business and supply chain systems. However it is the use of these portfolios of techniques for interdepartmental working that has prevented meaningful progress to date and served to sub-optimise the firm as business departments improved themselves but ransomed the ability of other departments to improve. Thus, for senior managers, an official 'mandate for change' must be developed to promote, endorse and police these cross-functional improvements. Until such a mandate exists then the commercial exploitation of these middle management innovations is unlikely to occur and middle managers will return to optimising their own departments (and measures) rather than the total flow of materials throughout the firm. The essence of the lean approach is therefore the total optimisation of the firm, its operational and financial performance. It is not an easy option but does provide an environment that is innovative and enjoyable for all employees from the most senior of managers to the newest of recruits. Few firms that have begun this journey to lean have decided to stop.

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Signposts for More Information
The following section represents a list of web sites and publications that are worthy of a visit if you wish to find out more about the 'lean approach' and research undertaken in this area.

Site	Reference
Deloitte and Touche web site	www.deloitte.co.uk
Lean Organisation Research Centre web site	www.cf.ac.uk/uwc/carbs/
Lean	www.lean.org

About The Author
Nick Rich is the Deloitte and Touche Senior Research Fellow at Cardiff Business School's Lean Organisation Research Centre (LERC). Nick was a founding member of LERC in 1994 and joined Professor Dan Jones and Professor Peter Hines as an expert in manufacturing and supply chain management. From 1994, Nick has worked with a wide range of manufacturing businesses from many different sectors and sizes of corporation.

He has also spent extended periods of research in Japan, hosted by the Toyota Motor Corporation (TMC), the leading members of the Toyota supply chain and other major Japanese manufacturing conglomerates in the automotive, engineering and fast-moving consumer goods sectors. From these experiences, Nick has written a number of papers and books. He is currently developing a range of 'Executive Briefing' papers for Deloitte and Touche clients. The series currently includes the Deloitte and Touche 'Manufacturing with a small e' comparative survey of 'e-Business' application in the UK and America as well as the 'Executive Guide to Supply Chain Management'. These guides can be found on the Deloitte and Touche and web site shown above.