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Lean, agile or leagile? Matching your supply chain to the marketplace

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Many enterprises have pursued the lean thinking paradigm to improve the efficiency of their business processes. More recently, the agile manufacturing paradigm has been highlighted as an alternative to, and possibly an improvement on, leanness. In pursuing such arguments in isolation, the power of each paradigm may be lost, which is basically that agile manufacturing is adopted where demand is volatile, and lean manufacturing adopted where there is a stable demand. However, in some situations it is advisable to utilize a different paradigm on either side of the material flow de-coupling point to enable a total supply chain strategy. This approach we have termed the *Leagile Paradigm*. This paper therefore considers the effect of the marketplace environment on strategy selection to ensure optimal supply chain performance. Real-world case studies in the mechanical precision products, carpet making, and electronic products market sectors demonstrate the new approach to matching supply chain design to the actual needs of the marketplace.

1. Introduction

The success and failure of supply chains are ultimately determined in the marketplace by the end consumer. Getting the right product, at the right price, at the right time to the consumer is not only the lynchpin to competitive success but also the key to survival. Hence, customer satisfaction and marketplace understanding are crucial elements for consideration when attempting to establish a new supply chain strategy. Only when the constraints of the marketplace are understood can an enterprise attempt to develop a strategy that will meet the needs of both the supply chain and the end consumer.

Supply chain performance improvement initiatives strive to match supply and demand, thereby driving down costs simultaneously with improving customer satisfaction. This invariably requires uncertainty within the supply chain to be reduced as much as practicable so as to facilitate a more predictable upstream demand. Sometimes, however, uncertainty is impossible to remove from the supply chain due to the type of product involved. If a product is highly fashionable then, by its very nature, its demand will be unpredictable. Hence, specific supply chains are faced with the situation where they have to accept uncertainty but need to develop a strategy that enables them still to match supply and demand.

Those companies who design business strategies that acknowledge the presence of uncertainty and provide mechanisms for pro-actively tackling it are rewarded by an opportunity to enable best practice ahead of competitors whose responses are

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purely reactive (Mason-Jones and Towill 1999). The message here is that supply chains need to adopt a strategy that suits both their particular product and marketplace. This paper analyses the lean, agile and 'leagile' paradigms and their roles in tackling differing marketplace uncertainty scenarios. It includes case studies illustrating the approach and representing real-world supply chains in three different market sectors.

2. Supply chain uncertainty

Much uncertainty evident in supply chains is system induced and magnified by the 'Bullwhip effect', as opposed to being present in the marketplace. The supply chain dynamics wave propagation observed by Forrester (1961) used to be called 'demand amplification'. Nowadays it is more commonly termed the 'Bullwhip effect' (Lee *et al.* 1997) due to the characteristic of increasingly magnified and hence worsening behaviour observed upstream from the source of the disturbance. System induced uncertainty is inherent within many supply chains due to the strategies and relationships involved and is therefore within the direct control of the companies involved. Hence, it is our experience that many of the detrimental effects of uncertainty can be alleviated by working hard to reduce the system-induced effects (Towill and McCullen 1999). Done properly, this leaves the supply chain to develop a strategy that needs only to deal with marketplace uncertainty.

The combined effect of system-induced and marketplace uncertainty typically leads to the type of Bullwhip effect supply chain dynamics shown in figure 1 (Fisher, 1997). This shows the resultant behaviour due to a system-imposed uncertainty resulting from a supplier discount scheme operating in a retail supply chain. As can be seen, the enticement of a discount offered to the retailer caused an unpre-

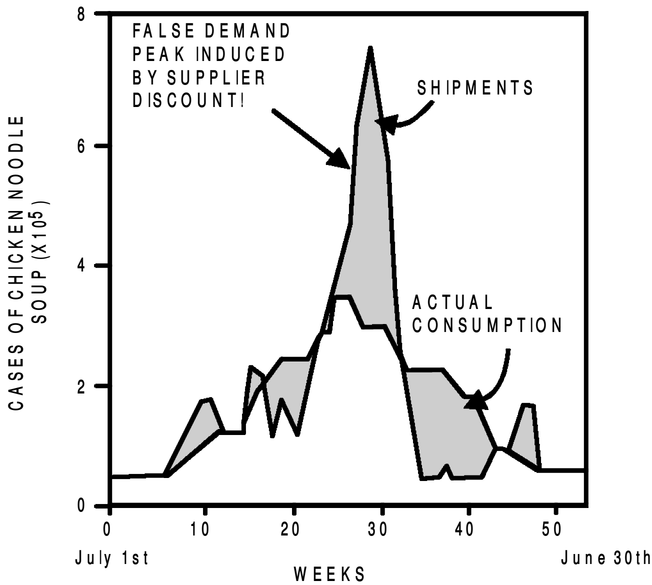

Figure 1. An example of a system-induced bullwhip effect in a commodities supply chain. [*Source*: Fisher 1997.]

dictable change in behaviour that was magnified throughout the chain by the Bullwhip effect. This produced a typical dynamic profile with demand being amplified as it is passed upstream. The resultant on-costs are considerable for all 'players' in the chain, including overtime, shift premiums, quality variances, and additional distribution, handling and storage charges. However, the situation is made even more inexplicable by the realization that true marketplace demand could have been satisfied with a very simple order placement profile consisting of just a few ramps and plateaux. In other words, by responding to true marketplace demand, a series of level schedules placed on suppliers would have sufficed, a situation ideally suited to lean supply (Suzaki 1987). Instead, the supply chain operated in the unnecessarily costly agile mode.

3. Coping with differing product types

In his seminal paper, Fisher (1997) stated that when developing a supply chain strategy that will facilitate matching supply and demand, the relationship between product type, supply chain and sales predictability is pivotal to ensuring that the optimal approach is adopted. He classified products into two generic types, fashion and commodities.

- Fashion products have a short life cycle and high demand uncertainty, therefore exposing the supply chain to the risks of both stock out and obsolescence. A good example of a fashion product is trendy clothing. The challenge faced by a supply chain delivering fashion products is to develop a strategy that will improve the match between supply and demand and enable the companies to respond faster to the marketplace.
- Commodities that are basic products, such as tinned soups, have relatively long life cycles and have low demand uncertainty due to the fact they tend to be well-established products with a known consumption pattern. The driving force for basic product supply chains is therefore cost reduction.

Note that in terms of Hill's (1993) manufacturing strategy metrics, there is a considerable difference between the two groups of products. For example, in the classification matrix of figure 2, the market winner for fashion products is availability, whereas the market winner for commodities is price. Quality and lead-time are market qualifiers in both cases: price and availability are market qualifiers for fashion products and commodities respectively. What figure 2 emphasizes is that the supply chain must excel at the market winner metrics *and* be highly competitive at the market qualifier metrics, i.e. the minimum standard for entry into the marketplace.

These two product types respond to distinctly different marketplace pressures and hence require a different supply chain approach to address their specific characteristics. Only through understanding the particular characteristics of the product type, marketplace requirements and management challenges can the correct supply chain strategy be designed to ensure optimal performance and to establish competitive advantage. This can be achieved via developing strategies that will reduce the effect of the system-induced uncertainty, thereby reducing the Bullwhip effect and, at the same time, actively coping with the particular marketplace uncertainty pressures.

	Market Qualifers	Market Winners
Fashion Goods	• Quality • Price • Lead Time	• Service Level
Commodities	• Quality • Lead Time • Service Level	• Price

Figure 2. An example of using the classification matrix based on market winners and market qualifiers. [*Source*: the present authors.]

4. Matching supply chain strategies with product type

Many organizations have adopted the lean thinking paradigm (Womack and Jones 1994) in their drive to optimize performance and improve competitive position. Recently, the agile manufacturing paradigm has been highlighted as an alternative to leanness (Richards 1996). It has also been suggested in some quarters that agility is the next step after leanness. This could mean that, once leanness has been achieved, an enterprise should strive for agility or even that agility should be the goal of an enterprise and leanness as a primary objective should be forgotten. These discussions oversimplify the situation as they fail to take into consideration the generic product type and hence the business environment and response requirements needed to match adequately supply chain design to the required structure.

The following definitions relate the agile and lean paradigms to supply chain strategies and were developed to emphasize the distinguishing features of each (Naylor *et al.* 1999).

- **Agility** means using market knowledge and a virtual corporation to exploit profitable opportunities in a *volatile* marketplace
- **Leanness** means developing a value stream to eliminate all waste, including time, and to ensure a *level* schedule.

It should be noted that what may be regarded as 'waste' in lean production may conversely be essential in agile production. As McHugh *et al.* (1995) have emphasized, one example is the question of capacity requirements. In lean production, the customer buys specific products, whereas in agile production the customer reserves capacity that may additionally need to be made available at very short notice.

As can be seen from the above definitions, the commodities are very well suited to the lean environment as demand is relatively predictable and therefore facilitates the level schedule requirements necessary for a lean supply chain (Suzaki 1987).

Conversely the characteristics of fashion products are more suited to the agile environment where the unpredictability of the demand is accepted as a business risk and the strategy is developed to optimize performance in such an arena. A blanket approach across the whole supply chain may, however, not be appropriate. Leanness and agility can sometimes be combined with the strategic use of a de-coupling point, thereby capitalizing on the benefits of both paradigms as shown in figure 3. Thus, there are some instances where there is an economic justification for engineering a 'Leagile' supply chain, thereby getting the best of both worlds.

This combined approach is known as 'Leagility' and, as a consequence, the supply chain can thereby adopt a lean manufacturing approach upstream, enabling a level schedule and opening up an opportunity to drive down costs upstream while simultaneously still ensuring that downstream of the de-coupling point there is an agile response capable of delivering to an unpredictable marketplace. The formal definitions required are as follows.

> '**Leagile i**s the combination of the lean and agile paradigms within a total supply chain strategy by positioning the decoupling point so as to best suit the need for responding to a volatile demand downstream yet providing level scheduling upstream from the marketplace.' (Naylor *et al.* 1997)

> '**The decoupling point** is the point in the material flow streams to which the customer's order penetrates. It is here where order-driven and the forecast-driven activities meet. As a rule, the decoupling point coincides with an important stock point – in control terms a main stock point – from which the customer has to be supplied.' (Hoekstra and Romme 1992)

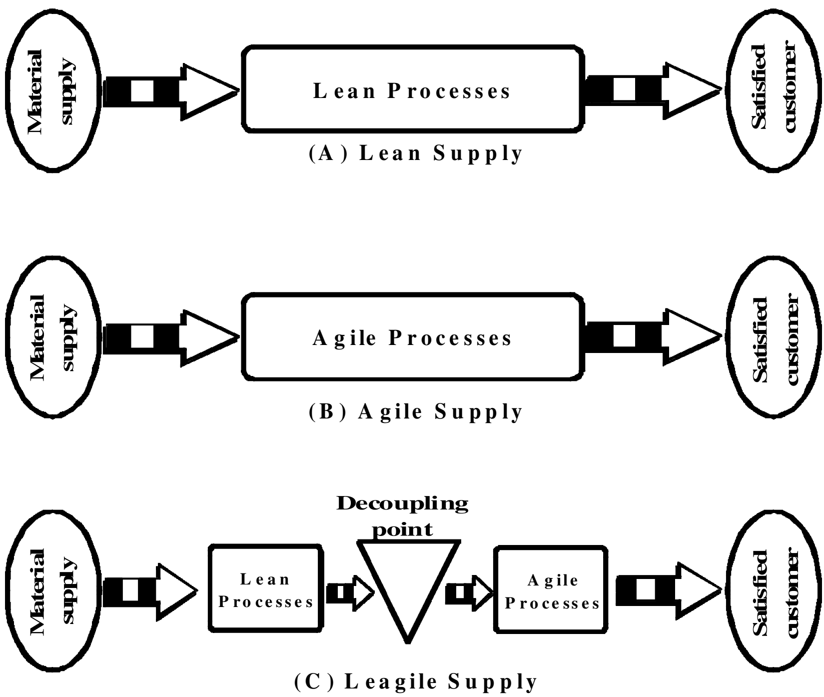

Figure 3. Block diagrams representing lean, agile, and leagile supply. [*Source*: the present authors.]

Why call it Leagile? First, because in a Leagile supply chain, Lean material flow is upstream of Agile material flow. Secondly, because to succeed as an Agile process it must be fully documented, understood and engineered. This is readily enabled by initially engineering a Lean process and then adapting it by removing specific constraints and capacity limitations, thus enabling Agility. Hence, Lean precedes Agile on two counts; geographically and temporally.

5. Minimize uncertainty to maximize competitive advantage

Despite the differences in the types of market uncertainty present in the lean, agile and leagile paradigms, the Bullwhip mechanism and resultant detrimental system induced uncertainties are the same for all the approaches. Therefore, it does not matter which paradigm is adopted, the system-induced uncertainty effects can still seriously hamper the effectiveness of the strategy. Therefore, it is crucial that system-induced uncertainty is reduced to ensure that the performance opportunities available via implementing a particular strategy are fully realized.

Fortunately, the removal of system-induced uncertainty is greatly aided by engineering streamlined material flow, and thus designing in good practise. A suitable set of tried and tested rules for simplifying and streamlining material flow is available as shown in table 1 (Towill 1999). These rules have been derived from a wide-ranging set of simulation studies and from industrial experiments and observations, and have clearly been adopted in whole or in part in the Case Studies that appear later in this paper. It is also possible to consolidate the rules into the following powerful set of Material Flow Control Principles, which have already found widespread application in supply chain BPR Programmes of proven effectiveness.

(1) *Selection of good Decision Support Systems*: if process lead times are reliable and operations information of high quality, then good, robust control systems can also be very simple.
(2) *Slashing of material flow and information flow lead times*: reduction of these is within the technological and organizational remit of individual echelons, thus requiring mainly internal action.

Rule 1	Only make products which you can quickly despatch and invoice to customers.
Rule 2	Only make in one period those components you need for assembly in the next period.
Rule 3	Minimize the material throughput time, i.e. compress all lead times.
Rule 4	Use the shortest planning period, i.e. the smallest run quantity that can be managed efficiently.
Rule 5	Only take deliveries from suppliers in small batches as and when needed for processing or assembly.
Rule 6	Synchronize 'Time Buckets' throughout the Chain.
Rule 7	Form natural clusters of products and design processes appropriate to each value stream.
Rule 8	Eliminate all process uncertainties.
Rule 9	Understand document, simplify and only then optimize (UDSO) the supply chain.
Rule 10	Streamline and make highly visible all information flows.
Rule 11	Use only proven simple but robust Decision Support Systems.
Rule 12	The Business process target is the seamless supply chain, i.e. all players 'Think and act as one.'

Table 1. Twelve rules for simplifying material flow necessary in lean, agile and leagile supply chains. [*Source*: Towill (1999).]

(3) *The widespread provision and integrity of operations information*: the quality and quantity of data available throughout the extended enterprise are, however, a political issue to be addressed and overcome by the supply chain product champion.
(4) *Elimination of redundant echelons*: this removes a source of distortion and delay but can give rise to ownership/political problems, which again need solution by the supply chain product champion.

Note that the problem of 'wide ownership' (especially of sales data) requires an attitudinal change on the part of all supply chain 'players'. Otherwise, the rapid feedback of vital information from further along the chain will be inhibited and dynamic performance considerably worsened. For example, actual sales data at one echelon need to be identified and transmitted alongside firm orders when placed higher up the chain so that false demand signals can be discounted (Wikner *et al.* 1991). We now proceed to demonstrate the 'Lean', 'Agile', and 'Leagile' concepts applied to real-world supply chains.

6. Case Study A: the lean global supply chain: precision mechanical products (source: Towill and McCullen 1999)

The OEM has three UK factories that manufacture complex mechanical systems and export mainly to the USA, Japan, Korea and Europe. There are approximately 300 major product families, 1500 minor products and around 2000 regularly stocked spares. The difficulty of the materials management task is compounded by the local mix of systems and components businesses. Due to delays in the supply chain, poor coordination, and bad decision-making, overseas stocks intended to provide off-the-shelf availability were significantly higher than planned. At the same time, customer service fell far short of market requirements due to the associated build-up of stocks being out-of-phase with market demand. In response to this situation, the company having recognized that improving forecast accuracy alone would not in itself solve these problems, instigated a long-term global supply chain BPR Programme. Hence, the execution of a major re-engineering programme requiring sustained effort over a period of years.

The BPR Programme has directly reduced manufacturing lead-times via kanban line side replenishment and changing over to unit flow assembly. Furthermore, the UK factories are now linked directly to international customer demand via an integrated Distribution Requirements Planning (DRP) system. The DRP generates an integrated production demand to cover customer requirements, replenishments, and forecast sales. Time compression throughout the chain enables the DRP to run on weekly (not monthly) time buckets. Consequently, present day planning is speeded up and is much more closely related to true demand. The cumulative information processing and manufacturing delays have been reduced from 23 weeks to 2 weeks (over 90% time compression). This, in turn, has enabled a substantial revision of the decision rules used to manage system inventory. These rules are now simpler and more robust. Consequently, physical distribution in the global supply chain is now much more streamlined and synchronized with actual requirements.

The BPR Programme visibly embraces the Material Flow Control Principles of time compression; echelon elimination; transparent information flow and selection of appropriate system controls. Observed results as a consequence of implementing change include 50% reduction in both demand amplification and stock fluctuations across a sampled range of products. There has also already been a doubling in stock turns of global inventory. Moreover, these performance metrics are still improving after two years of operation of the new system, with every indication that yet further significant gains may be expected. Customer service performance is greatly improved as a result of the BPR Programme. Finally, the average number of days late against customer due date has also been reduced by 90% and delivery variation similarly reduced by 74%.

7. Case Study B: parallel, lean and agile supply chains: the USA carpetmaker (source: Johansson *et al.* 1993)

There is a limit to the advances in performance enabled by a business becoming 'lean' through eliminating obvious *muda*. A good example, where substantial innovative process re-engineering is additionally needed, is the carpet industry. Here, the traditional supply chain requires some 16 weeks from raw material supply to the carpet being fitted in the end-customers residence. This total cycle time covers six major processes that add value. Elimination of *muda* reduces the cycle time to about four weeks. Impressive though this 75% reduction may be, it hardly helps carpet manufacturers respond in an agile mode to satisfy the current customer-imposed time window—this is one week from ordering a specific size, colour, pattern, and qualify of carpet, to fitting in the house. The one week cycle time means that the production process must be totally re-engineered so that manufacture is completed within three days, which is a far cry from the best 'lean' performance of four weeks.

The outcome of this marketplace pressure was a technology breakthrough with the invention of a revolutionary new process, named Solution Dyed Nylon. This enabled the fibre to be dyed prior to being woven into the carpet. Together with other essential re-engineering to reduce changeover times by 95% and downtime by 50%, plus integration of support processes, and streamlined material flow, the target cycle time window was achieved, coupled with the additional benefit of a slightly reduced cost to the end customer. However, a Pareto Curve based product analysis showed that the Agile Response Mode would only be justifiable for the top 10% of the product range, which contributed 52% of the volume leaving the mill. The remaining products have now been rationalized and are provided via an alternative Lean Supply Chain that does not offer the same one-week guaranteed delivery. This illustrates the importance of aligning the Agile Supply Chain with the business priorities driving the change.

8. Case Study C: the leagile global supply chain: electronics products (source: Naylor *et al.* 1997)

The Case Study company is a global player in a complex supply chain with at least five major echelons ranging from the hundreds of component suppliers through five sub-assembly businesses to four final assemblers. Depending on the particular product sold, goods may be delivered directly to customers, or via their administration centres, or via independent distribution centres and thousands of authorized dealers. In the mid-1980s, the OEM took the initiative in setting up a series of improvement programmes, covering a period of a decade, leading to the establishment of a leagile supply chain circa 1993. Initially, the supply chain consisted of a large number of interacting but unintegrated 'players'. The first re-engineering stage consisted of eliminating OEM *muda* and reducing plant lead-times, followed by vendors participating inconsequential 'best practice' initiatives including JIT.

The OEM then developed a simplified but integrated approach to materials planning at the supply chain level. This was supported by the simultaneous EDI transmission of requirements to all plants. The result was that more of the total chain was able to operate in the pull mode. Finally, this stage of the BPR Programme was completed by EDI integration of the whole vendor base into the supply chain, and hence greatly reduced lead times in the planning loop. Thus, the OEM has visibly exploited all four Material Flow Control Principles within the BPR Programme. To achieve leagility the de-coupling point was located at the final assembler, an action that usually requires associated product rationalization (Lee and Sasser 1995). Specific products are now pulled by current sales demand whilst upstream of the de-coupling point suppliers now work to level schedules, i.e. short term variations of roughly ±10% about the long term trend. The lean part of the supply chain is demonstrably much faster (by a factor of about 10 to 1 with all the consequential bottom-line benefits, Towill 1996). This is very important, since new component technology could otherwise result in rapid and costly obsolescence even upstream of the decouplng point.

9. Summary

We have seen that classifying supply chain design and operations according to the Lean, Agile and Leagile Paradigms enables us to match the supply chain type according to marketplace need. This results in three fundamental designs illustrated in the real world by mechanical precision products (lean); carpet manufacture (agile); and electronics products (leagile). Such a classification proves clear rules for supply chain engineering for each market segment. This enables us to apply lean principles, agile principles and leagile principles according to the real needs of the specific supply chain. However, for all three supply chain types it is essential to remove system-induced uncertainty, as typified by the 'Bullwhip' effect. This elimination is greatly assisted via the proven Material Flow Control Principles consolidated from a basic simplification checklist, and which are visibly applied in all three Case Studies. Leagile supply chains already exist in the real world. What is important is to recognize when the new paradigm is the best way forward for a particular supply chain so that it may be appropriately engineered from the outset.

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