Research note

Supply chain migration from lean and functional to agile and customised

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Abstract

Shows how the lean and agile paradigms may be selected according to marketplace requirements. These are distinctly different, since in the first case the market winner is cost, whereas in the second case the market winner is availability. Agile supply chains are required to be market sensitive and hence nimble. This means that the definition of waste is different from that appropriate to lean supply. The proper location of decoupling points for material flow and information flow enable a hybrid supply chain to be engineered. This encourages lean (efficient) supply upstream and agile (effective) supply downstream, thus bringing together the best of both paradigms. The paper concludes by proposing a cyclic migratory model which describes the PC supply chain attributes during its evolution from traditional to its present customised "leagile" operation.

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What is agility?

Agility is a business-wide capability that embraces organisational structures, information systems, logistics processes and, in particular, mindsets. A key characteristic of an agile organisation is flexibility. Indeed the origins of agility as a business concept lie in flexible manufacturing systems (FMS). Initially it was thought that the route to manufacturing flexibility was through automation to enable rapid change (i.e. reduced set-up times) and thus a greater responsiveness to changes in product mix or volume. Later this idea of manufacturing flexibility was extended into the wider business context (Nagel and Dove, 1991) and the concept of agility as an organisational orientation was born.

Agility should not be confused with "leanness". Lean is about doing more with less. The term is often used in connection with lean manufacturing (Womack *et al.*, 1990) to imply a "zero inventory", just-in-time approach. In practice Minimum Reasonable Inventory (MRI) is a more relevant philosophy (Grunwald and Fortuin, 1992). Paradoxically, many companies that have adopted lean manufacturing as a business practice are anything but agile in their supply chain. The car industry in many ways illustrates this conundrum. The origins of lean manufacturing can be traced to the Toyota Production System (TPS) (Ohno, 1988), with its focus on the reduction and elimination of waste.

Whilst the lessons learned from the TPS principles have had a profound impact on manufacturing practices in a wide range of industries around the world, it seems that the tendency has been for the benefits of lean thinking to be restricted to the factory. Thus we encounter the paradoxical situation where vehicle manufacture is extremely efficient with throughput time in the factory typically down to 12 hours or less, yet inventory of finished vehicles can be as high as two months of sales. Furthermore, as Marshall Fisher (1997) has demonstrated in spite of advertising campaigns to the contrary, the customer still has to wait for weeks or even months to get the car of their choice!

Whilst leanness may be an element of agility in certain circumstances, by itself it will not enable the organisation to meet the precise needs of the customer more rapidly. *Webster's*

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Dictionary makes the distinction clearly when it defines lean as "containing little fat" whereas agile is defined as "nimble". We need an interpretation of these definitions which translates into the supply chain scenario. A convenient interpretation of both paradigms is due to Naylor *et al.* (1999) as follows:

> 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 enable a level schedule.

We shall now further explore the commonalities and differences between these two paradigms. The paper ends with a historical description of the transformation of the PC supply chain. From this the transition from "traditional" to "lean" and then "agile" may be clearly identified.

Market qualifiers and market winners

Hill (1993) has earlier developed the concept of "order qualifiers" and "order winners" against which it is advocated that manufacturing strategy should be determined. As these labels suggest, it is important for every business to understand what the baseline is for entering into a competitive arena – these are the "order qualifiers". To actually win the order requires specific capabilities and these Hill termed the "order winners". The definition of order qualifiers and order winners then logically leads to the specification of the appropriate manufacturing strategy.

We can borrow from these important ideas to develop a wider supply chain oriented concept of "market qualifiers" and "market winners". The notion here is that to be truly competitive requires not just the appropriate manufacturing strategy, but rather an appropriate supply chain strategy. As Christopher (1997) has pointed out "it is supply chains that compete not companies".

The connection between these ideas of "qualifiers" and "winners" and "lean" and "agile" is critical. At its simplest the lean paradigm is most powerful when the winning criterion is cost; however, when service and customer value enhancement are prime requirements for market winning then the likelihood is that agility will become the critical dimension.

Figure 1 illustrates the crucial differences in focus between the lean and agile paradigm depending upon the market qualifiers and the market winners based upon the work of Mason-Jones *et al.* (2000).

One helpful model in taking these ideas forward is provided by Johansson *et al.* (1993) who sought to express the value delivery of a business in terms of a simple equation:

$$\text{Total value} = \frac{\text{Quality} \times \text{Service level}}{\text{Costs} \times \text{Lead-time}}$$

This equation is particularly helpful as it emphasises the futility of improving one performance measure at the expense of worsening another. Additionally it is possible via the four components of the equation to make a major distinction between lean and agile supply in terms of the qualifiers – winners concept as shown in Figure 1.

Whereas quality, service level, and lead-time are market qualifiers for lean supply, with the market winner then being cost, the latter benchmark is merely an important qualifier in agile supply. The market winner herein is service level because as Fisher (1997) has indicated, the total costs for the Product delivery process (PDP) are given by a further formula showing that:

$$\text{Supply chain total PDP costs} = \text{Physical PDP costs} + \text{Marketability costs}$$

where "Physical costs" includes all production, distribution, and storage costs and "Marketability costs" includes all obsolescence and stockout costs.

The first cost source (PDP) dominates lean supply whereas the second cost source (marketability costs) dominates agile supply. Note that lost sales are gone forever in the agile supply chain whether the cause is due to stockouts or obsolescence. This is because it

Figure 1 Market winners – market qualifiers matrix for agile versus lean supply

	Market Qualifiers	Market Winners
Agile Supply	1. Quality 2. Cost 3. Lead Time	1. Service Level
Lean Supply	1. Quality 2. Lead Time 3. Service Level	1. Cost

Source: Mason-Jones *et al.*, 2000

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is an extremely harsh and competitive marketplace with little brand loyalty. We shall now undertake a detailed comparison of lean and agile supply by comparing specific attributes which highlight the specific problems to be overcome in enabling the appropriate business strategy to be adopted.

Attributes of lean and agile supply

Both agility and leanness demand high levels of product quality. They also require minimum total lead-times defined as the time taken from a customer raising a request for a product or service until it is delivered. Total lead-time has to be minimised to enable agility, as demand is highly volatile and thus difficult to forecast. If a supply chain has long end-to-end lead-time then it will not be able to respond quickly enough to exploit marketplace demand. Furthermore effective engineering of cycle time reduction always leads to significant bottom line improvements in manufacturing costs and productivity (Towill, 1996).

Lead-time needs to be minimised in lean manufacturing as by definition excess time is waste and leanness calls for the elimination of all waste. The essence of the difference between leanness and agility in terms of the total value provided to the customer is that service is the critical factor calling for agility whilst cost, and hence the sales price, is clearly linked to leanness. However, whereas the Total Cycle Time Compression Paradigm (Towill, 1996), when effectively implemented, is a sufficient condition for achieving lean production, it is only one necessary condition for enabling agile supply.

Table I illustrates the comparison of attributes between lean and agile supply. In the volatile unpredictable marketplace for "fashion" goods, both stockout and obsolescence costs are punitive. Consequently the purchasing policy moves from placing orders upstream for products moving in a regular flow to that of assigning capacity to finalise products in rapid response mode. As Fisher *et al.* (1994) have indicated this means forecasting via "intelligent" consultation so as to maximise inputs from "rich" marketplace insider sources. Mason-Jones and Towill (1997) argue that "information enrichment", i.e. immediate sharing of marketplace data throughout the chain is not merely desirable, but obligatory. This must be achieved in a process integration scenario as we move towards the Seamless Supply Chain (SSC) in which all "players" think and act as one (Towill, 1997).

Table I Comparison of lean supply with agile supply: the distinguishing attributes

Distinguishing attributes	Lean supply	Agile supply
Typical products	Commodities	Fashion goods
Marketplace demand	Predictable	Volatile
Product variety	Low	High
Product life cycle	Long	Short
Customer drivers	Cost	Availability
Profit margin	Low	High
Dominant costs	Physical costs	Marketability costs
Stockout penalties	Long term contractual	Immediate and volatile
Purchasing policy	Buy goods	Assign capacity
Information enrichment	Highly desirable	Obligatory
Forecasting mechanism	Algorithmic	Consultative

Source: Mason-Jones *et al.* (2000)

Agile logistics

As Table I suggests, to be truly agile a supply chain must possess a number of distinguishing characteristics. Firstly, the agile supply chain is market sensitive. By market sensitive we mean that the supply chain is capable of reading and responding to real demand. Most organisations are forecast-driven rather than demand-driven. In other words because they have little direct feed-forward from the marketplace by way of data on actual customer requirements they are forced to make forecasts based upon past sales or shipments and convert these forecasts into inventory. The breakthroughs of the last decade in the form of Efficient Consumer Response (ECR) and the use of information technology to capture data on demand direct from the point-of-sale-use are now transforming the organisation's ability to hear the voice of the market and to respond directly to it (Christopher, 1998a). The use of information technology to share data between buyers and suppliers is, in effect, creating a virtual supply chain. Virtual supply chains are information-based rather than inventory-

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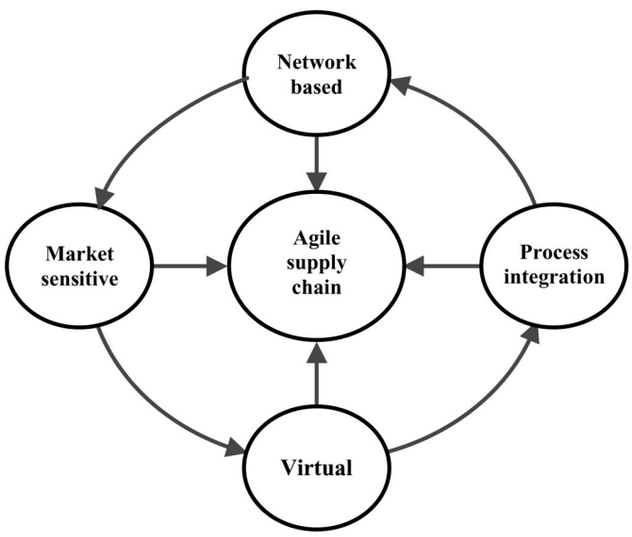
based and lead to the structure suggested in Figure 2 (Harrison *et al.*, 1999).

Conventional logistics systems are based upon a paradigm that seeks to identify the optimal quantities of inventory and its spatial location. Many complex formulae and algorithms exist to support this inventory-based business model. Paradoxically, what we are now learning is that once we have visibility of demand through shared information, the premise upon which these formulae are based no longer holds. Electronic Data Interchange (EDI) and now the Internet have enabled partners in the supply chain to act upon the same data, i.e. real demand, rather than be dependent upon the distorted and noisy picture that emerges when orders are transmitted from one step to another in an extended chain (Hewitt, 1999).

Shared information between supply chain partners can only be fully leveraged through process integration. By process integration is meant collaborative working between buyers and suppliers, joint product development, common systems and shared information. This form of co-operation in the supply chain is becoming ever more prevalent as companies focus on managing their core competencies and outsource all other activities. In this new world a greater reliance on suppliers and alliance partners becomes inevitable and, hence, a new style of relationship is essential. In the "extended enterprise" as it is often called, there can be no boundaries and an ethos of trust and commitment must prevail. Along with process integration comes joint strategy determination, buyer-supplier teams, transparency of information and even open-book accounting.

Figure 2 The information based agile supply chain



Source: Harrison *et al.*, 1999

This idea of the supply chain as a confederation of partners linked together as a network provides the fourth ingredient of agility. There is a growing recognition that individual businesses no longer compete as stand-alone entities but rather as supply chains. We are now entering the era of "network competition" where the prizes will go to those organisations which can better structure, co-ordinate and manage the relationships with their partners in a network committed to better, closer and more agile relationships with their final customers. It can be argued that in today's challenging global markets, the route to sustainable advantage lies in being able to leverage the respective strengths and competencies of network partners to achieve greater responsiveness to market needs (Christopher, 1998b).

Seeking to obtain the best of both worlds – the role of the "decoupling point"

A major problem in most supply chains is their limited visibility of real demand. Because supply chains tend to be extended with multiple levels of inventory between the point of production and the final marketplace, they tend to be forecast driven rather than demand driven. The point at which real demand penetrates upstream in a supply chain may be termed the decoupling point and is the echelon at which market "pull" meets upstream "push". Previously, this idea has been termed the "order penetration" point (Christopher, 1998b). However, the issue is not how far the order penetrates, but how far real demand is made visible. Orders are aggregations of demand, often delayed and distorted due to the actions and decisions of intermediaries (Burbidge, 1989). On the other hand, demand reflects the ongoing requirement in the final marketplace in as close to real-time as possible.

The decoupling point separates that part of the supply chain geared towards directly satisfying customers' orders from that part of the supply chain based on planning (Hoekstra and Romme, 1992). It should also dictate the

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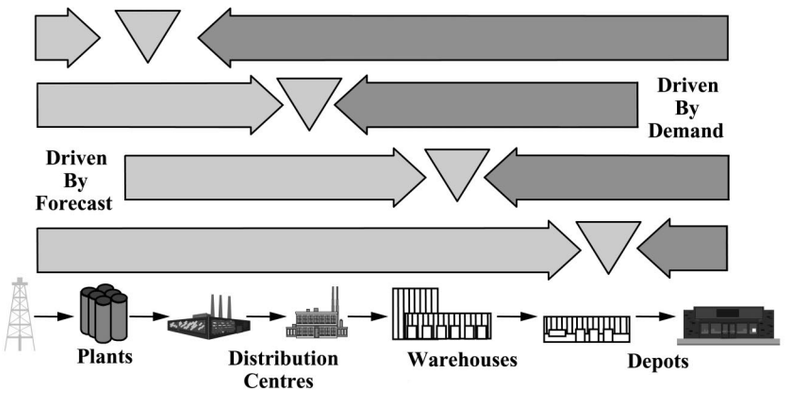
form in which inventory is held. Thus, in the uppermost example in Figure 3, demand penetrates right to the point of manufacture and inventory is probably held in the form of components or materials. In the lower example, demand is only visible at the end of the chain. Hence inventory will be in the form of finished product. The aim of the agile supply chain should be to carry inventory in as generic a form as possible that is, standard semi-finished products awaiting final assembly or localisation. This is the concept of "postponement", a vital element in any agile strategy. Postponement, or delayed configuration, is based on the principle of seeking to design products using common platforms, components or modules but where the final assembly or customisation does not take place until the final market destination and/or customer requirement is known.

The advantages of the strategy of postponement are several (Van Hoek, 1998). Firstly, inventory can be held at a generic level so that there will be fewer stock-keeping variants and hence less inventory in total. Secondly, because the inventory is generic, its flexibility is greater, meaning that the same components, modules or platforms can be embodied in a variety of end products. Thirdly, forecasting is easier at the generic level than at the level of the finished item. This latter point is particularly relevant in global markets where local forecasts will be less accurate than a forecast for world-wide volume. Furthermore, the ability to customise products locally means that a higher level of variety may be offered at lower total cost, enabling strategies of "mass-customisation" to be pursued.

An important point to recognise is that in real-world supply chains there are actually two decoupling points. The first is the one already referred to, i.e. the "material" decoupling point where strategic inventory is held in as generic a form as possible. This point ideally should lie as far downstream in the supply chain and as close to the final marketplace as possible. The second decoupling point is the "information" decoupling point. The idea here is that this should lie as far as possible upstream in the supply chain – it is in effect the furthest point to which information on real final demand penetrates. Mason-Jones and Towill (1997) have demonstrated through simulation the beneficial impact that information feedback can have on reducing upstream amplification and distortion of demand. By managing these two decoupling points a powerful opportunity for agile response can be created. At the same time the notorious "bullwhip" or Forrester effect (Forrester, 1961) can be reduced. Billington and Amaral (1999) suggest that the combined effect of shared information in a supply chain and delayed configuration through postponement can significantly improve responsiveness. Furthermore a separate study has shown that the effect of optimal delayed configuration is actually even greater than the impact created by shared information (Gavireni and Tayur, 1997). Hence the fundamental importance of product design on agile supply chain performance.

Figure 3 Material flow decoupling points and strategic inventory



Source: Hoekstra and Romme, 1992

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The personal computer supply chain

The challenge to supply chain management is to seek to develop "lean" strategies up to the material decoupling point but "agile" strategies beyond that point. In other words by using generic or modular inventory to postpone the final commitment it should be possible to achieve volume-oriented economies of scale through product standardisation. The flow of product up to the decoupling point may well be forecast driven; after the decoupling point it should be demand driven. A good practical example is to be found in the PC supply chain. This has been well documented during its various phases of development, including the Hewlett-Packard (Lee and Sasser, 1995; Davies, 1993), IBM (Beal, 1988; Laurent, 1992) and Dell (Dell and Fedman, 1999) supply chains. Relevant generic models describing dynamic behaviour according to the various stages of re-engineering such PC supply chains have also been verified (Hiebeler *et al.*, 1998).

Dell in particular has become the master of the vertical distribution channel by being the sole distributor of its products and services (Dell and Fedman, 1999). A customer initiates the sales process by contacting the company via telephone or the Internet. There are three ways of selling: face-to-face; ear-to-ear; and keyboard-to-server. A customer can order from Dell on-line 24 hours a day or by phone from early morning until late in the evening. A Dell representative is available to make suggestions and help customers determine what systems will best meet their needs. Through the Web site, customers can access product information and receive price estimates instantaneously. Dell then confirms the order and verifies the financial credit charge. Usually the representative promises that the computer will arrive within five business days although the customer often receives the product quicker than this. The Dell factory receives a printout of the order and begins manufacturing within hours. Each computer is customer-built and put through several hardware and software tests in less than one day. After a final inspection the computer is boxed by Dell and sent to a distribution centre that ships it by carrier in time to arrive with a monitor that is built ahead of time by a separate supplier.

Thus customer orders are satisfied by an agile execution-based, direct model driven business operation without any finished inventory. One way Dell Computer beats its competitors on prices is by also keeping component inventories to a minimum. Vertical integration has helped the company further reduce costs. Monitors, for example, are relatively standardised and built by an agile supplier. So today Dell may need as many as 8,752 monitors from the supplier; tomorrow they might need as few as 962. One of their carriers simply picks the monitors up at night, matches them up with the PCs by purchase order, and the next day delivers them to the customers. The rule on working with suppliers is to keep it simple, with fewer than 40 vendors providing 90 per cent of material needs. This justifies close working relationships and reduces cost and further speeds up new products to market. A financial analysis showed that "supplier proximity pays". Hence as Dell became a global manufacturer their preferred suppliers were expected to follow suit.

Fast feedback from customers' enables Dell suppliers to rapidly change product mix and maintain their inventory velocity. To make the required breakthrough on supply strategy, Dell shares its goals and objectives with suppliers. By shipping as required (hourly or daily depending on the product), Dell has bought more components and assemblies from the suppliers faster and paid them quicker, so everyone benefits. The company has totally integrated the distribution channel by clearly identifying its markets and by designing products and services to fit the needs of its customers. Hence the direct contact with customers gives Dell minute-by-minute input from the largest customer down to the individual purchaser in terms of what products they want and what new services they would like to see Dell develop. This information on present demand and future requirements is shared with Dell suppliers in a real-world example of effective supply chain partnering and is a key enabler in achieving agility.

Migratory model summarising the transition in PC supply chain operations

In proposing the four key business metrics of quality; lead-time; cost; and availability,

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Johannson *et al.* (1993) also argued that their relative importance changes with time. The implication of this is that companies continually need to adjust their supply chain strategy. Hence periodically a new market winner emerges and downgrades the previous market winner to a market qualifier. This cyclical interchange is clearly related to the initial emergence of the lean paradigm followed later where appropriate by the agile paradigm.

Thus in the early stage of a market it is often the lean paradigm that prevails for example, the Model T Ford enabling market penetration to be achieved on the basis of a "penetration" pricing policy (i.e. low cost production). As the market matures and demands for higher levels of variety grow then the agile paradigm replaces it. Thus Ford in the 1980s and 1990s offered a theoretical ten million plus combinations of models and options. Now, however, as we enter the third millennium we see the emergence of global supply chain strategies in which Ford seeks to achieve local differentiation whilst at the same time standardising by common "platforms". This is the era of hybrid lean/agile strategies or what may conveniently be referred to as the "leagile" model (Naylor *et al.*, 1999).

These ideas may be brought together in the migratory model shown in Table II (Murakoshi, 1994). Thus in the early 1980s the market winner was quality, which for Western industry was needed to combat Japanese imports, and was achieved within the lean internal process scenario. This was followed by the implementation of the lean supply chain impacting on cost, but still pushing products onto the marketplace in the sense of not responding to specific needs. Then came the era enabled by correct positioning of the material flow de-coupling point in the particular hybrid lean-agile supply chain termed "leagile" by Naylor *et al.* (1999). This chain is agile enough to respond to what is actually selling with availability as market winner. Finally, as instanced by present-day Dell we have the customised leagile supply chain. By further streamlining the supply chain front end, Dell supplies exactly what the individual customer selects. Lead time is now the market winner with a maximum of seven days allowed for pulling off the requisite sub-assemblies, finalising the PC, adding the exact peripherals, packaging, and delivery to the individual customer. It is clearly at the supply chain front-end where spare capacity must be reserved against particular nimble product requirements

Conclusions

The lean paradigm requires that "fat" be eliminated. However the agile paradigm must be "nimble" since sales lost are gone forever. An important difference is that lean supply is associated with level scheduling, whereas agile supply means reserving capacity to cope with volatile demand. Whereas information transparency is desirable in a lean regime, it is obligatory for agility. Lean forecasting is algorithmic, but agile forecasting requires shared information on current demand captured as close to the marketplace as possible. Real world supply chains are cyclical in character. This means that this year's market winner is next year's market qualifier.

Table II Migratory model summarising the transition in PC supply chain operations

Supply chain evolution phase	I	II	III	IV
Supply chain time marker	Early 1980s	Late 1980s	Early 1990s	Late 1990s
Supply chain philosophy	Product driven	Market orientated	Market driven	Customer driven
SC type	Lean functional silos	Lean supply chain	Leagile supply chain	Customised leagile supply chain
Market winner	Quality	Cost	Availability	Lead time
Market qualifiers	(a) Cost	(a) Availability	(a) Lead time	(a) Quality
	(b) Availability	(b) Lead time	(b) Quality	(b) Cost
	(c) Lead time	(c) Quality	(c) Cost	(c) Availability
Performance metrics	(a) Stock turns	(a) Throughput time	(a) Market share	(a) Customer satisfaction
	(b) Production cost	(b) Physical cost	(b) Total cost	(b) Value added

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Hence lean chains are under pressure to become agile, and in some markets, such as the personal computer, further pressure to become customised. As we have seen from the migratory model, the challenges during each transition are significantly different.

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