# The strategic integration of agile and lean supply.

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**Abstract**

Lean supply is closely associated with enabling flow and the elimination of wasteful variation within the supply chain. However, lean operations depend on level scheduling, and the growing need to accommodate variety and demand uncertainty has resulted in the emergence of the concept of agility. This paper explores the role of inventory and capacity in accommodating such variation and identifies how TRIZ separation principles and TOC tools may be combined in the integrated development of responsive and efficient supply chains. A detailed apparel industry case study is used to illustrate the application of these concepts and tools.

**Keywords**: agile, trade-offs, lean , quick response

## Introduction

Outsourcing manufacture to low cost overseas suppliers is an attractive lure in our global economy, but often undertaken without adequate regard for the market needs and the corresponding demands on the associated delivery systems. Products compete in different ways in different markets and delivery systems need to be designed with this in mind. Offshore supply offers attractive cost benefits, but the trade-off is often high levels of inventory to support a slower response capability. When these higher

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levels of inventory are combined with volatile demand the trade-off is more significant, with resulting obsolescence and shortages. However, what is commonly assumed is that one solution fits all and the consequence of the mismatch is not appreciated until it is too late. The Griffin Manufacturing Company [1], an apparel manufacture in North America, is an unusual case in that they survived the initial loss of work to Honduras and have now emerged with a hybrid delivery system that integrates the low cost Honduran supply with the fast response capability of the local supplier, Griffin.

More generally, the need to distinguish between stable functional products competing on price and volatile fashion or innovative products dependent on fast response, is now widely accepted [2, 3]. The terms lean and agile supply have emerged to reflect this distinction and various generic hybrids have been defined to clarify means and ways of, at least partially, satisfying the conflicting requirements of low cost and fast response [4, 5].

The industrial relevance is clear, but there is a need to unpack these ambiguous terms, if strategically focused integration of these conflicting paradigms is to be logically developed to meet specific business needs.

This paper interprets the lean and agile paradigms in terms of dependency, variation, inventory, and capacity before using these parameters to more clearly define the nature of the trade-off and systematically link such trade-offs to the development of established hybrids.

Although generic hybrids are useful illustrations, the solution needs to be logically developed and tailored with broad involvement. Effect-cause-effect analysis is used in this process, verifying both the negative effects of the conflict and subsequently the positive benefits of the solution.

The paper concludes with these concepts and tools being applied to the Griffin Manufacturing case.

## Lean and agile supply

The origins of Just in Time (JIT) management is closely associated with the Toyota Production System (TPS) and the work of Taiichi Ohno [6] with a clear emphasis on eliminating excess, waste and unevenness in the supply chain. More recently lean manufacturing [7] and lean thinking [8] have demonstrated the broad potential of the elimination of waste in improving business performance. The emphasis on waste elimination is closely associated with reduced inventory and one of the key concepts is enforced problem solving, which is very effectively portrayed by the ubiquitous ship and rocks analogy. In the analogy as the inventory (water level) is lowered, the sources of waste (the rocks) are exposed in the form of late delivery, poor quality conformance, long set-ups, unreliable processes, etc. The elimination of these sources of waste and unevenness enables the inventory to be lowered further without impeding material flow (the ship). The JIT management system was found to simultaneously improve customer service and efficiency by focusing on eliminating variation in the system and enabling flow. Through set-up time reduction, statistical process control, supplier development, total productive maintenance, etc., sources of variation internal to the supply chain were progressively reduced, so reducing the need for the inventory previously used to protect the flow.

For this design of delivery system to work well it is also necessary to stabilize the overall output rate and so decouple the effect of market demand variation. This is commonly achieved by what is termed 'level scheduling' and some automotive suppliers stabilise their schedules over periods of months.

| Distinguishing attributes | Lean supply | Agile supply |
|---|---|---|
| Typical product | Commodities | Fashion goods |
| Market place demand | Stable | Unstable |
| Product variety | Low | High |
| Product life cycle | Long | Short |
| Mfg task | Low cost | Delivery Speed |
| Delivery penalties | Long term contractual | Loss of order |
| Purchasing policy | Product specific | Assign capacity |
| Information enrichment | Desirable | Important |

Table 1
Comparison of lean supply with agile supply: the distinguishing attributes
Source: [4] modified

Agility has less clearly defined industrial origins, but has emerged as a generic term with distinctly aspirational tendencies [9,10]. Agile supply is more pragmatically defined and closely associated with 'quick response' but is commonly referred to as a distinctly different paradigm to lean supply. Agile supply drivers are typified by innovative products and unstable demand, as commonly found in the fashion sensitive apparel industry. Whereas, with lean the focus is on eliminating waste and achieving low cost delivery of a standard and stable product, the agile paradigm focuses on the need to deliver a variety of products with uncertain demand.  Table 1, typifies the distinguishing attributes of the associated supply chains.

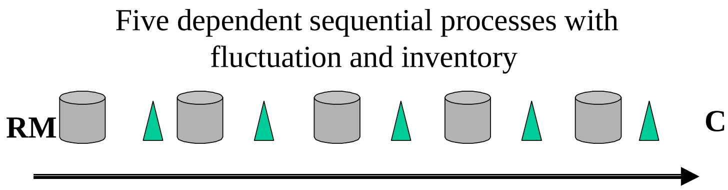
**The effect of dependency and fluctuation**

To explore the lean-agile perspective further, let us look more closely at the underlying parameters that define the flow characteristics of a system and then relate this to these generic approaches.

In any operating system, there exists the phenomena of dependency and fluctuation [11] and when these are combined in a delivery system, they define the fundamental characteristics of production flow, which may be viewed at the factory or supply chain level.

Consider a simple delivery system with five dependent resources processing material. Each resource has the same process time, so the line is balanced. Every 6 minutes the process advances and the output from the line is 10 units per hour exactly. In reality, however, there is always variation in the system due to various factors, such as machine failure, process adjustment, quality problems, set-up delays etc. If we now acknowledge the existence of these fluctuations, not only will the disruption directly affect the event concerned, but more importantly, there will also be a knock-on effect down the line of dependency.

The traditional means of overcoming this is to place inventory between each process, so effectively decoupling the impact of the fluctuations, as shown in figure 1.




(RM: Raw Material ; C: Customer)
Traditionally inventory has been used to decouple the line of dependency from the system fluctuations such as set-ups, breakdown, process reliability, defective raw material etc.

Fig 1. Dependent Events and Fluctuations

The functions of inventory, such as cycle, decoupling, buffer, etc can be directly traced back to such system fluctuations and, in combination, to the supply chain amplification effects. An alternative to investing in inventory to protect the flow under these conditions is investing in additional capacity.

This option has traditionally been avoided in efficiency focused volume manufacture, but excess capacity on most resources is an implicit feature of functional batch and cellular manufacture. The use of what is called protective capacity, rather than protective inventory to enable flow, is also the norm in the service industry where people otherwise form the inventory queues.

Having introduced the nature of the interaction of dependency, fluctuation, capacity and inventory, let us consider how lean and agile strategies relate to these parameters. With the introduction of lean manufacturing, excess inventory is quickly reduced to the point where the remaining inventory levels act to smooth out the effect of the various sources of fluctuation. As this inventory is progressively reduced via ‘enforced problem solving’, the system fluctuations in the form of process variation, set-up delays, and plant reliability, ect., are identified as wasteful and targeted. In this way the inventory reduction exposes the sources of fluctuation and consequential wasteful activity within the supply chain, which is then targeted. However, action is needed to prevent the impact of demand variation on the supply chain. Figure 2 (a) illustrates the lean system operating with low levels of variation and internal inventory, but potentially high levels of inventory being used to decouple the production system from variations in market demand, as is the practice of level scheduling. This accumulation of finished parts inventory is common in the volume automotive industry, where market demand for a standard product is relatively stable and finished stock is not sensitive to obsolescence.

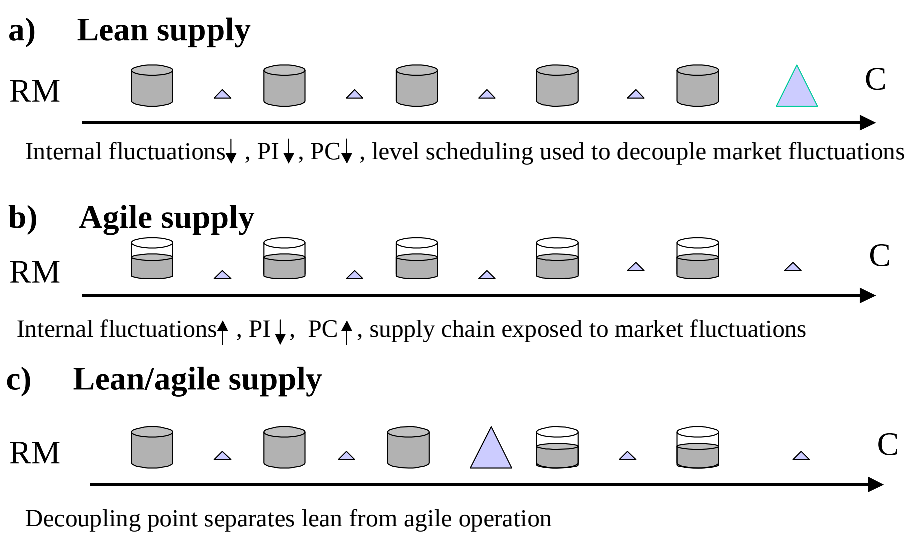



Fig. 2 Lean, Agile and Lean/agile supply viewed in terms of dependency, fluctuation, protective capacity (PC) and protective inventory(PI)

In the case of agile supply there are two major distinctions:

1) The non-standard nature of the product will inherently result in higher levels of internal fluctuation.

2) The unstable nature of market demand precludes the effective use of finished stock inventory to decouple the supply system.

These distinctions can be diagrammatically represented in the Demand-Product Matrix, Figure 3.

| Demand / Product | Volatile | Stable |
|---|---|---|
| Special | Agile | |
| Standard | | Lean |

Fig. 3 The Demand-Product Matrix for agile and lean supply Source: [12].

Distinction 1 is common with low volume, high variety manufacture, which is inevitably more susceptible to internal variation and a mixture of protective inventory and protective capacity enables flow. Distinction 2 limits the effective use of inventory and hence emphasizes the role of protective capacity, Figure 2(b), which often takes the form of the purchasing function assigning capacity rather than purchasing specific products or components from a supplier, as attributed in Table 1.

The use of common components, or modules, often delays the level of product differentiation and Figure 2(c) is more representative, with decoupling inventory leveling the upstream supply and feeding the capacity rich final configuration.

Explicitly acknowledging the use of capacity to enable flow, instead of inventory, is central to distinguishing between the lean and agile paradigms and the trade-off conflict between low cost and responsive manufacturing. Put more explicitly, the choice is between investing in capacity or inventory with the associated risks. This simple, but explicit, means of conceptualizing lean and agile supply, presents the distinctions as more of a continuum, as even lean operations have to manage variation and the JIT concept of ‘under capacity scheduling’ uses capacity to protect flow. Having established the nature of the trade-off, it is now necessary to develop the role of trade-offs in innovative design before using this in the creative development of hybrids.

**Trade-offs and systematic innovation**

It is over 30 years since Skinner [13] used the concept of mechanical design trade-offs to help acknowledge and manage conflicting performance parameters associated with manufacturing. This extract from his seminal work graphically illustrates the mechanical analogy.

*'For instance, no one today can design a 500 passenger plane that can land on a carrier and also break the sound barrier. Much the same is true of manufacturing. The variables of cost, time, technological constraints, and customer satisfaction place limits on what management can do, force compromises, and demand an explicit recognition of a multitude of trade-offs and choices.'*

From this and subsequent papers the strategic trade-offs associated with manufacturing investment and decision-making became explicitly acknowledged. The term manufacturing strategy emerged with a new awareness of performance conflicts and the need to make strategic choices between competitive criteria, such as speed and efficiency or quality and cost.

As has already been mentioned the emergence of the lean paradigm resulted in the simultaneous improvement of quality conformance, delivery speed, delivery reliability and cost. This brought into question the long-term value of the trade-off concept, however, the development of the agile paradigm reinforces the need to acknowledge trade-offs once more.

Developing the mechanical design analogy

Over the past ten years, an approach to inventive problem solving in mechanical engineering has emerged from Russia entitled 'the theory of inventive problem solving' or TRIZ for short. The approach consists of a number of principle-based solution systems empirically developed over 50 years by Altshuller et al. [14] . This work is having a significant impact on structuring innovative engineering developments in the West [15], but what is of particular interest here, is the fact that the solution systems centre on trade-offs as a focal point for innovation. Altshuller's analysis of past patents identified the link between significant innovation and the breaking of trade-offs, or as Altshuller referred to them engineering contradictions.

For one of his solution systems Altshuller discovered that, if he could define a trade-off explicitly, there were four generic separation principles that repeatedly led to patentable solutions. To use this approach he had to define the trade-off as an explicit contradiction. That is, identifying a parameter that is subject to opposite requirements, as in the case of thick but also thin, high but also low, hot but also cold, etc. He called these explicit trade-offs physical contradictions.

To help resolve this form of contradiction four separation principles were identified that can be seen to embody many of the 40 inventive principles from his earlier solution system.

These separation principles can be summarised as:

1-Separation of opposite requirements in space

2-Separation within a whole and its parts

3-Separation of opposite requirements in time

4-Separation upon condition

A simple illustration of these separation principles applied to Skinner's aircraft example would be the use of variable wing geometry. In this case the conflict between the need for large and small wing area is addressed through separating out these requirements in time; that is, large wing area for low speed flight and small wing area for high speed flight.

Another approach to innovation, also centred on resolving trade-offs, or conflicts, has emerged in the past 20 years under the title of the Theory of Constraints (TOC). In TOC the contradiction is presented in what is called an Evaporating Cloud (EvC), sometimes known as a Conflict Resolution Diagram [16]. Figure 4 illustrates such a diagram where the conflict or contradiction is stated explicitly as the prerequisite D and D' in a similar way to the physical contradiction in TRIZ.

To construct the diagram the logic linking the pre-requisite to the common objective is defined by an intermediate requirement. It should be noted that the requirements B and C are necessary (but not sufficient) to achieve the objective A. Similarly the prerequisites at D and D' are necessary (but not sufficient) to achieve the requirements at B and C, respectively. It is normal with the EvC to formulate the problem from the prerequisite conflict and to then work from there, clarifying the thinking behind the causal links along the way, through B, C and finally A. This is, however, usually an iterative process.

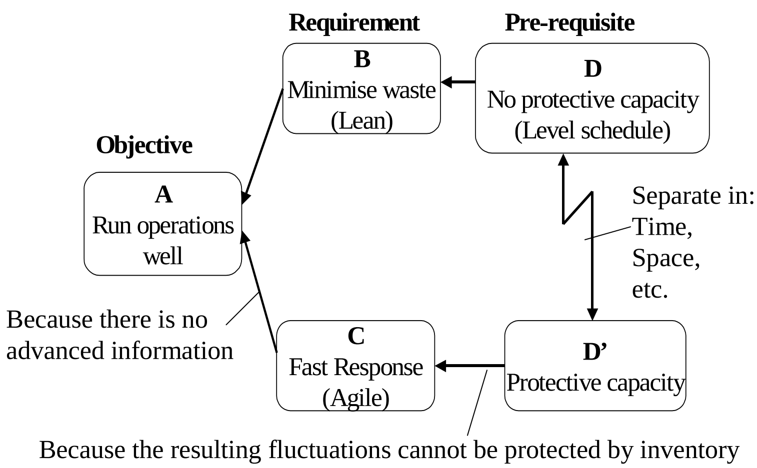



Figure 4 Agile/Lean Logistics Cloud

The subject of the cloud in Figure 4 should be familiar, as it picks up on the concept of protective capacity and the explicit nature of the contradiction, in how it is utilized to achieve requirements B and C. The cloud diagram is designed to challenge the logic underpinning the perceived conflict as represented by arrows AB, AC, BD and CD. To achieve this the diagram is read, 'In order to [tip of arrow] I must [tail of arrow], because...'. Completing the statement is intended to expose the false assumptions.

In Figure 4, for example, the assumption underpinning AC may be challenged through the use of point of sales data or some other form of information enrichment [17]. The main assumption underpinning CD' is, 'In order to have fast response, I must have protective capacity, because the resulting fluctuations cannot be protected by inventory.' This may raise questions as to how inventory might be used further upstream.

The TOC and TRIZ approach to breaking such conflicts or contradictions are highly complementary.

The evaporating cloud is designed to challenge the very existence of the conflict, and if a false assumption can be exposed the conflict 'evaporates', which is often the case in business where policies are based on outdated assumptions. However, in the physical world contradictions are more substantial and the TRIZ separation principles therefore address the contradiction directly across DD' as indicated in Figure 4.

**Practical integration of lean and agile supply**

A test of the applicability of this conceptual development is the links between these separation principles and the practical approaches currently used, to eliminate or mitigate the conflict between these two paradigms.

1 Separate in space

Skinner [13] and Hill [18] have advocated the need to separate out different business requirements through the use of focused manufacturing, acknowledging that different product/market combinations compete in different ways and physical separation in line with these conflicting needs is necessary.

Fisher [2] makes the distinction between functional products, with predictable demand, and innovative products, with unpredictable demand, in stressing the need to distinguish between the conflicting supply chain design needs. The innovative products, as with agile supply, risk loss of sale if demand exceeds supply, but also risk obsolescence if supply exceeds demand. Hence, with agile supply the focus is on response and for lean it is efficiency. Figure 5 simply illustrates the need to match product types with the supply chain focus. This is exemplified in the apparel industry by the distinction between basic products (which sell all year round) and fashion products (which sell for a single season). In the same way the conflict is dealt with via physical separation.

## 2 Separate within a whole and its parts

The concept of a decoupling point [19], or order penetration point within the supply chain, utilizes the opportunity to postpone the design configuration and therefore reduce the impact of variation further upstream. This concept of postponement is now widely used to minimize the consequences of market differentiation and the associated risks of holding inventory in its final differentiated form [20]. Hewlett-Packard advocate postponing the final product configuration until the latest point in the supply network and in the case of the DeskJet printers [3] they opted to customize the printers at the local distribution centres. Thus, stabilizing the upstream supply chain with decoupling inventory and investing in a responsive capability downstream. This form of separation requires careful cross-functional integration involving modular design to ensure the market order winners and qualifiers are satisfied.

| | Functional Products | Innovative Products |
|---|---|---|
| Efficient Supply chain | Match (Lean) | Mismatch |
| Responsive supply chain | Mismatch | Match (Agile) |

Figure 5. Matching Supply Chains with Products (Source: [2] modified

Figure 2C illustrates the use of protective inventory as a decoupling point in the line of dependency. This point enables upstream demand to be leveled in the same way as lean supply is decoupled from market demand variation through level scheduling. Beyond the decoupling point, the demand variation is primarily managed through investment in protective capacity rather than inventory.

MacDonald's restaurants provide a familiar illustration of this form of separation. Burger meals are produced by dedicated lines and the heated chutes provide decoupling inventory, in this case limited to a shelf life of 10 minutes. Specific customer orders being customized via batch assembly at the service tills.

In TRIZ separation terms, this is easily viewed as 'separation within a whole and its parts'. In this case designing the product and delivery system to stabilize upstream delivery, so utilising decoupling inventories to enable a form of level schedule to be implemented upstream.

## 3 Separate in time

Global supply of fashion clothes suffer the undesirable combination of volatile demand, short life cycles and long supply lead times, which often results in excessive obsolescence or shortages, as was the case with Sports Obermeyer [21]. Sports Obermeyer produce fashion ski wear and traditionally commit to production in October, with sales feedback not being received until February. The demand uncertainty was resulting in high levels of surplus and shortages as they attempted to use inventory to level the production schedule. Following analysis they changed their supply chain focus from efficiency to speed of response. They separated out early and late production runs based on the predicted level of uncertainty and were ready to respond with top-up orders once demand levels could be established in February. In this way, the balance between efficiency and responsiveness was improved by separating out the supply of product lines over time. The early production runs are efficiency focused and the later top up orders are delivery speed focused, in response to customer sales data. In the first case, investment in protective inventory enabled the efficient early production runs and in the second, investment in protective capacity, in the form of fast response measures, enabled the supply to much more accurately meet the uncertain demand.

## 4 Separate upon condition

This principle is more generic, encompassing the other three principles, but also applying to more abstract parameters, such as order winning criteria, protective capacity and variation.

For instance, from a structural perspective order winning criteria, such as price and delivery speed, are used to define focused business units [18]. Similarly, the concept of protective capacity is effectively used to separate out conflicting operational requirements that often result. For example, the conflict between whether to centralise or decentralise, as with focused manufacturing, can be resolved by separating out the resources that are constraining throughput and using capacity availability as the condition for a mixed functional and cellular organisation. In this way cellular manufacture effectively substitutes protective capacity for protective inventory and where there is limiting capacity it often needs to remain central as a shared resource.

From an infrastructure perspective, many Advanced Planning and Scheduling (APS) systems similarly focus on resolving the batch size conflict by separating out the conflicting requirements of maximising throughput and delivery speed based on the availability of protective capacity in the system, as is the case with Drum-Buffer-Rope [11].

This principle is also evident in the other strategic business functions, as in the practice of market segmentation and product design modularisation.

**Strategically focused improvement**

The above examples demonstrate the link between established practice and these separation principles, but the real benefit is in the use of these principles to creatively explore alternative means of resolving specific business conflicts.

As illustrated above, it is common for the undesirable effects, associated with a trade-off conflict, to be remote from the supply chain echelons that have contributed to them. Fisher [2] quotes similar examples of local decisions having unseen implications across the supply chain. The practice of price promotions on grocery products is brought into question once the implications of production overtime and inventory holding are taken into account considering the supply chain as a whole. Mobil [22,p35] came to realize the need to consider retailers and distributors as components of its overall strategy designed to satisfy the end user, and changed its stance to one of cooperation in its search for win-win solutions.

Therefore, it is important to take a supply chain perspective in defining the underlying supply chain conflicts and this often requires rigorous analysis and dialogue across the echelons. Effect-cause-effect analysis is an effective means of mapping the links between these undesirable effects and core issues, and this tool will be used to illustrate the case analysis that follows.

**The Griffin Manufacturing case [1]**

Griffin traces its roots to A & A Manufacturing, which was founded in 1938. In 1990, foreseeing competitive offshore pressures, Griffin Manufacturing changed its mission to the production of athletic apparel and working with a small, innovative company, Griffin produced some of the first-ever jogging bras. Griffin invested in new machinery and by 1993 was producing 20,000 garments per week.

*The Offshore Crisis*

A dramatic change occurred in 1993 when one of Griffin's major customers was taken over by a large, multinational corporation that immediately attempted to move the manufacturing to Honduras. Griffin now looks back on several cycles in which new managers attempted to eliminate the domestic manufacturing. Orders would abruptly fall to zero, but within weeks would start to flow again. “Unexpected events” had occurred which necessitated quick response.

At first, the work that moved offshore was basics. “Basics” are the ongoing styles in a few colors that sell all year round. It made sense to move basics offshore because with just a few styles, the training requirements were less. However, for the remaining “fashion” styles, the required response time was much shorter. Twice a year the design department created entirely new lines that involved managing colours through lab dips, constructing prototypes, making pattern changes to ensure correct fit and producing sales samples. Griffin’s ability to respond quickly to these issues was an asset. In addition, assigning fashion production to Griffin allowed the design department to compress the schedule. However, Griffin’s customer’s manufacturing department was indifferent to the relation with the design group. It took considerable work on Griffin’s part to educate their customer’s senior management in the entire scope of their complex relationship.

For several years, Griffin averaged 10,000 to 20,000 garments per week; the variations were huge and disrupting to manufacturing efficiency. Griffin assumed that the domestic production would eventually fall to zero. However, by 1998, Griffin’s share of production had leveled off at 20% of the total, and a completely new business model had emerged. Griffin's manufacturing operation had gradually evolved to provide quick response manufacturing. This required significant investment in technology, including CAD for patterns and markers, automated cutting, and information system improvements including a factory-wide network. Concurrently, the staff expertise grew to include planning and logistics.

Griffin still employs roughly the same number of sewing machine operators as in 1990, but now Griffin cuts around 100,000 garments per week, sending 80% offshore. Interestingly, Griffin has always had a very strong relationship with their customer's design team. They like the instant turnaround for their prototypes, samples, and pattern changes that we exchange via email. However, Griffin's relationship with the manufacturing arm was not always so smooth, and the evolution of the eventual working agreement is interesting.

*The Cost Problem*

It was impossible for Griffin to compete directly on a cost basis with Honduras. To emphasize the scale of the problem let us analyze one typical garment, a medium-range jogging bra. Let us assume that this bra requires six minutes of sewing labor. Using average New England labour rates of approximately $7.50 per hour, results in a direct labor cost of $0.75. However, labour rates in Honduras are around $0.29 per hour, resulting in an assembly cost of $0.03. These are direct labour costs, and since overhead costs are typically at least twice labour costs, a reasonable estimate for the total labour costs are:

| | |
|---|---|
| Griffin | $1.50 |
| Honduras | $0.06 |

Of course, transportation and logistics costs add to the Honduras labour costs. Transportation is one of the great modern bargains. Filling a 40-foot container with these bras, and shipping them to Honduras costs less than a $0.01 per garment. However, after allowing for these costs, it is quite reasonable to assume that a savings of $1 per garment can be realized. If one can make the garment in Honduras for less than five cents, why even consider making it in the USA? The more interesting question then becomes, "Why is Griffin still manufacturing approximately 500,000 per year?"

*Developing the solution*

Over time, Griffin gradually educated their customer about the value of keeping a percentage of the manufacturing onshore. However, Griffin's management had to learn to quantify their value, and to actively promote their capabilities. That is, Griffin had to learn to negotiate with both the customer and supplier tiers of the supply chain. Griffin's eventual survival depended on recognizing that there are three problems with the Honduran $1-per-garment cost savings argument. Let us now look at each of these in turn.

*i) Hidden Offshore Manufacturing Costs*

The Honduras labour cost of six cents is nowhere near the real cost of manufacturing there. Operator efficiency is significant lower than in the USA. This efficiency (slowly!) improves over time as operators learn and companies invest in new machines. Turnover in Caribbean factories can be very high, and rates of 40% per year are not unheard of. Staff turnover dramatically affects both throughput and quality. Logistics problems arise continually, and additionally, expensive staff are required to manage the import and export of fabric and garments. The very expensive express airmail of trims (and occasionally even fabric) becomes a frequent occurrence. Finally, significant expenses accrue as staff members travel offshore to correct problems.

While these costs are significant, the offshore savings are so valuable that considerable staff growth in logistics and substantial inefficiencies in manufacturing can be absorbed. However, based on Griffin's experience, we conclude that a realistic assessment of these issues is that they increase variability in the manufacturing process.

*ii) Fluctuating Demand – the 500 White Shorts Problem*

There is a significant trend in the retailing industry towards instant delivery, which the following example dramatically illustrates. One day, Griffin received an emergency order for 500 white shorts with a 48-hour delivery schedule. Griffin had the required fabric on hand, and the infrastructure in place to complete the order: markers, trained operators, etc. Griffin cut and sewed the shorts, shipping them out a few days later as requested.

While the order itself was not unusual, the stress and concern expressed by Griffin's customer was. After some investigation, the economic analysis of the "500 White Shorts" problem provided Griffin with the first quantifiable cost justification of their quick response manufacturing capability.
It turns out that Griffin's customer had received an order worth $950,000 with a delivery date only 5 days later. What made this order so unusual were the conditions: either completely fulfill every item (i.e., every style, color, and size), or nothing was to be delivered. Inventory analysis showed that the only items not in stock were 500 white shorts. Here was an example where Griffin's customer could generate almost a million dollars in sales only because Griffin was around to make the 500 white shorts. The extra cost of one dollar per garment ($500 in this case) was inconsequential compared to the opportunity to generate $950,000 in sales.

After some discussion, Griffin's customer analyzed their sales history to determine the number of such occurrences, and their value. From Griffin's perspective, the results were extremely encouraging. Between 5 and 8 times a year, one-shot, fast turnaround orders arrived with a value of $8-$10 million, and accounted for some 10% of sales. However, those sales were critical because they frequently represented new accounts. For the first time, Griffin had found an economic lever to move their customer away from their dedication to moving everything offshore.

*iii) The Dramatic Costs of Forecast Errors*

It is not unusual for both retailers and manufacturers to make a 25% error when forecasting sales. The following example, Figure 6, illustrates the impact of this problem. Suppose that the forecast for a particular style is 1,000 units. The current trend of manufacturing everything offshore means that an order for 1,000 units must be placed some 6-9 months in advance, but only when the selling season begins, is the true customer demand realized.

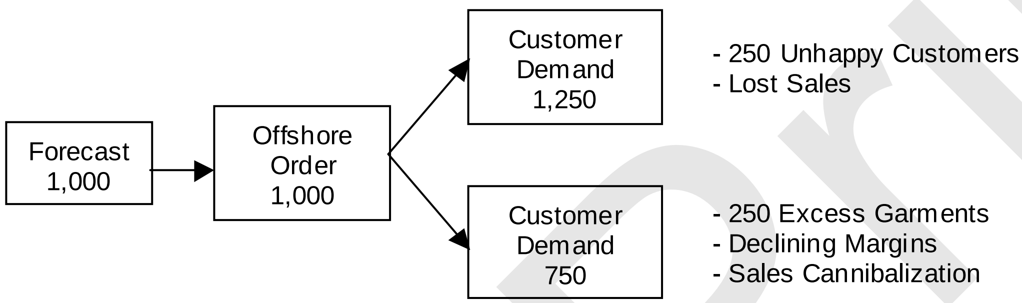



Figure 6. The consequences of forecast errors. [1]

If the demand is high, the store will not have the inventory to satisfy their customers. Not only will the store lose sales, they run the risk of turning off the customers who come to buy. If the demand is low, the store will have an excess inventory. Some excess is acceptable because the store can draw in customers with sales and discounts.

Forecast errors are very costly, and the Griffin jogging bra demonstrates the scale of the problem. The retailer ordered 1,000 units, but consumers only purchased 750. The retailer is left with 250 garments, at a cost of $2,500 in excess inventory. It is interesting to compare the excess inventory to the savings from offshore manufacturing. Griffin used the benchmark of $1 per garment in labour savings, so the potential savings from offshore manufacturing is $1,000, significantly less than the excess inventory cost.

Selling these items at a discount recovers some of the costs, but the overall margin declines. There is also a hidden cost associated with selling the excess inventory at a discount. A customer who buys two items does not need to come in next season to buy another one. The industry refers to this a "cannibalization of sales." The conclusion is that forecast errors can be much more expensive than the savings from manufacturing offshore.

*The Solution*

Despite the goal of Griffin's customer to move everything offshore, and the dramatic potential cost savings, Griffin still manufactures approximately 20% of the volume in the USA. Griffin struggled to educate their customer to the quantitative value of quick response, domestic manufacturing, and finally evolved a working relationship in which they are somewhat less than, legal partner, and yet more than just a vendor. The agreement is real, if imprecise. Griffin's customer provides a baseline of 10,000 – 15,000 garments per week, while Griffin agrees to make whatever they order. In addition, Griffin provides a whole range of (non manufacturing) services. Griffin maintains an entire infrastructure that their customer can call upon. In return, Griffin is provided with a manufacturing base that can support the infrastructure.

Meanwhile, the athletic wear business was becoming more competitive. The result was a dramatic increase in the diversity of fabrics, the number of styles, and the complexity of the styles themselves. The trends demanded that Griffin continue to invest in automation technology. Through the introduction of CAD and automated cutting, the number of garments cut each week grew from 20,000 to over 150,000. Also, the cutting machine doesn't care how complicated the pattern is. Automated cutting also improved the sewing quality, since every cut part is identical and the operators do not have to adjust the pieces to match. Computer aided design of markers significantly improved the fabric utilization, saving one customer over $1,000,000 in fabric the first year that automated cutting went into production. A significant evolution in Griffin's management philosophy also occurred, evolving to think of themselves as agile manufacturers providing a quick response capability.

Using Hill's [18] terminology, Table 2 identifies three business requirements with distinct order winners and corresponding process choice, as illustrated in Figure 7.

**Order winning criteria and process choice**

| **Business Requirement** | **Process Choice** | **Order Winning Criteria** |
|---|---|---|
| New Product Introductions | Jobbing | Capability, Fast response |
| Volume Orders | Large batch | Price |
| Fill-in Orders | Small batch | Fast response |

Table 2 Griffin's mix of process and order winning criteria

The concept of process choice helps clarify the nature of the tradeoff decision associated with the different supply requirements and the conflicting demands for responsive and efficient supply, as illustrated in Fisher's [2] supply chain matrix (Figure 5).

With this comes the realization that Honduras was a supply chain partner rather than a competitor. Fully exploiting this opportunity requires a deeper awareness of the customer needs and then looking for means of establishing a more appropriate fit between the Honduran and Griffin

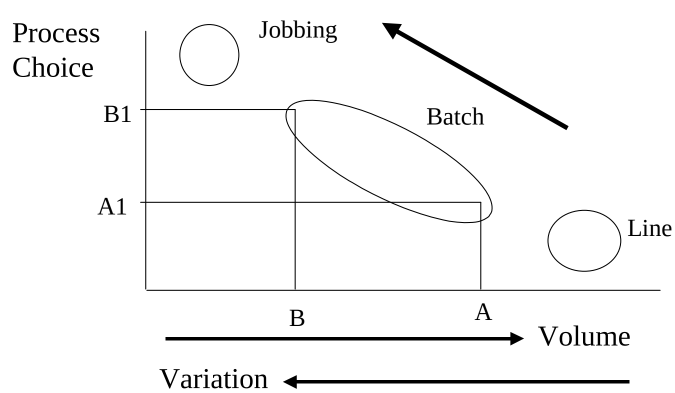



Figure 7 The shift in process choice for Griffin indicating the variation and volume dimension.

contributions to the supply chain.

Whereas Figure 7 presents the process choice in relation to product volume and the related variation, Figure 8 explicitly presents the three business requirements in relation to both product and demand variation.

Once Griffin realized that they could demonstrate a quantitative cost justification for their existence, they were able to articulate the Order Winning Criteria (OWC). In turn, the OWC help direct Griffin's investment in technology that expands their quick response capabilities, and allows them to provide a full range of non-manufacturing services. However, Griffin still seeks a base level of manufacturing with their customers.

**Relating the Griffin case to the proposed concepts and tools**

The Griffin case portrays the evolutionary development of a successful strategy, repositioning the company firmly in a reconfigured supply chain in the wake of manufacturing being largely sourced overseas. The question now to be addressed is how these concepts and tools could have helped in this development and can help in the future.

| Demand / Product | Volatile | Stable |
|---|---|---|
| Special | Griffin (NPD) | |
| Standard | Griffin (Fill-in orders) | Honduras (Volume) |

(NPD: New Product Development)

Fig. 8 The demand product matrix for agile and lean supply related to Griffin and Honduras.

The Griffin case throws an interesting light on the offshore manufacturing trend, suggesting that there might be a valid, cost-effective strategy when offshore production levels off at about 80%. The strategy is based on the following observations:

- A significant portion of orders require "instant" response.

- Forecasting accuracy is quite poor for a significant percentage of styles.
- Excess inventory is very expensive.

The process begins with a forecast of the sales for each style, and assigning most of the production to an offshore facility. Since offshore production is less expensive, the amount produced there should be as much as possible. On the other hand, since forecast errors result in excess inventory, which is very expensive, not all of the production is assigned offshore. When the season begins, and actual consumer orders flow, projections are made for the final sales. In concert with a domestic manufacturer, new replenishment orders are placed to meet the changed demand. The situation is summarized in Figure 9, below.

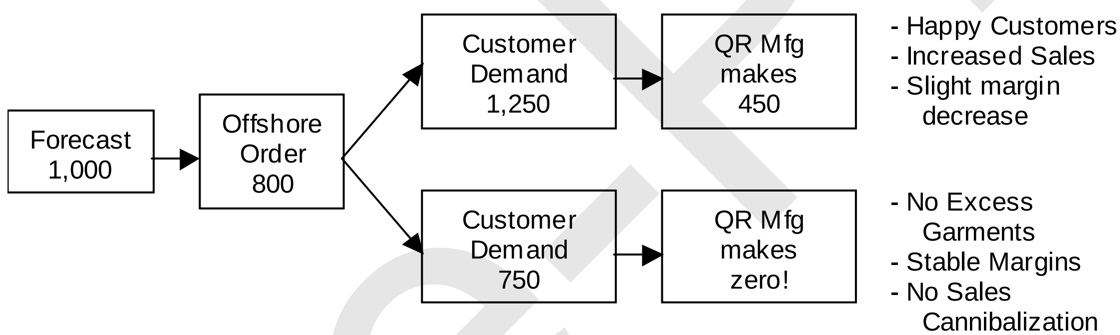



Figure 9 The quick response case [1].

A typical forecasting accuracy is that 70% of the styles have a forecast within 25% of their goal. An organization should be encouraged to analyze its forecast history and determine which styles are likely to have inaccurate forecasts. For products with uncertain forecasts, it is reasonable to assign a lower percentage to offshore production and reserve capacity at a quick response manufacturer. On the other hand, for basic styles that sell throughout the year, a much higher percentage of offshore production can be assigned. There is a clear case, that for typical forecast accuracies, the margins for a mixed offshore-onshore production strategy is competitive with the offshore only case [23]. Margins improve and sales increase because the quick response manufacturer can take advantage of the early sales information to produce more of the styles the customers are demanding.

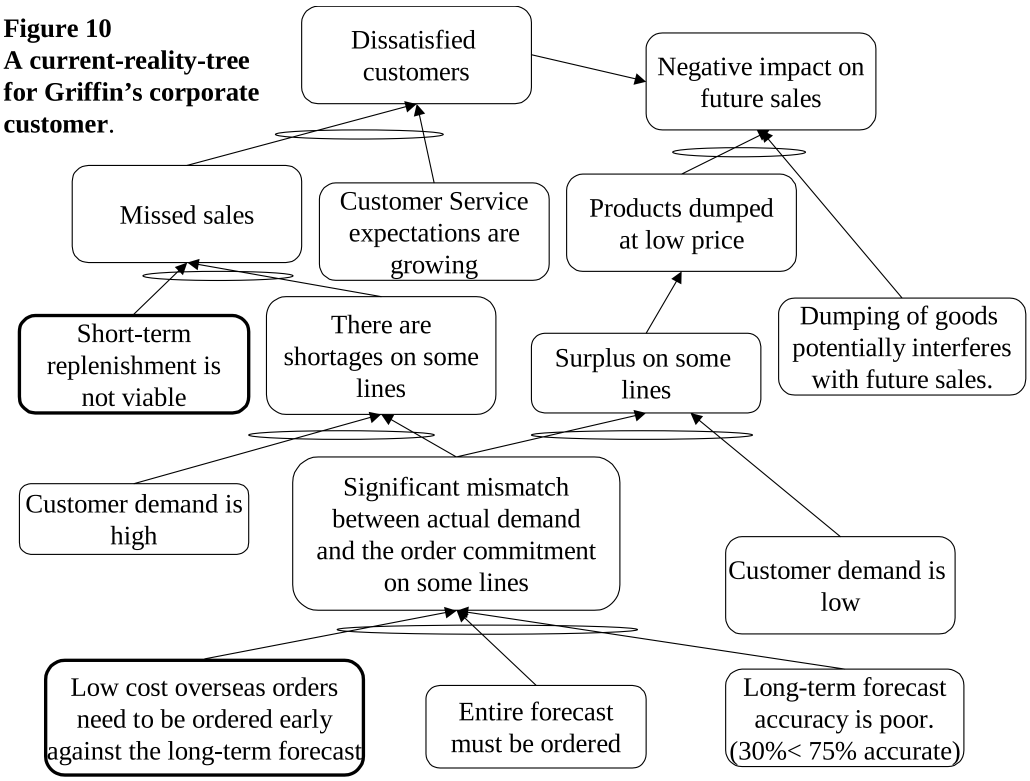
There are a number of challenges associated with the proposed strategy. First, it is a much more complex and uncertain approach. Rather than ordering to forecast, the retailer has to analyze forecasts, decide on offshore commitments, and team up with a domestic manufacturer. Retailers must share their sales data and continuously work with manufacturers to get the inventory they need. When sales increase, everyone will benefit. The retailer sells more products with fewer markdowns, resulting in less excess inventory. Also, the manufacturer can make minor adjustments (e.g., fill in sizes) to further tailor the inventory to the actual demand. Finally, there will be less cannibalization of future sales.

However, there is a much more difficult issue that must be addressed early on in the teaming arrangement: when sales decline, the temptation for the retailer is simply to order nothing from the domestic team member. If that happens, the domestic manufacturer ceases to exist. It is important for the retailer to realize that they are trading capacity for inventory. By ordering 80% from offshore, the retailer is asking the domestic manufacturer to assign capacity. If the full forecast for sales does not materialize, then the retailer is obligated to fill the capacity with some type of manufacturing.

The challenge is to find something that fills the reserved capacity and yet is cost effective for both parties, as the partnership cannot survive otherwise. In the Griffin case, their customer occasionally assigns black or navy jogging bras or shorts to fill a manufacturing void. These basic items sell all year round, and represent a small inventory risk. Retailers must recognize that while forecast errors are expensive, planning to deal with them can be cost effective.

## The current reality tree

**Figure 10**
**A current-reality-tree for Griffin's corporate customer**.




In identifying the underlying conflict it is important to reach agreement across the supply chain and the internal business functions. This dialogue is an essential part of the process, but there is also merit in being able to map the logic that underpins this collective understanding, as shown in Figure 10. This form of an effect-cause-effect diagram is called a current-reality-tree (CRT) [16] as it presents the current problem situation. Such diagrams are read from bottom to top reading each entry in turn, 'if [bottom of arrow] then [top of arrow]. Where two or more arrows pass through an ellipse the causal statements are linked by an 'and'. For example, reading from the bottom left entry, 'If [low cost overseas orders need to be ordered early against the long-term forecast] and [entire forecast must be ordered] and [long-term forecast accuracy is poor], then [significant mismatch between actual demand and the order commitment on some lines]'.

The diagram is used to verify and communicate deeper-seated issues often associated with policies in one supply chain echelon constraining business performance in another. What must be understood is that this diagram only shows the negative side of policies, which have been created with other requirements in mind, hence the conflict.

The problem presented in Figure 10 was an ongoing problem for Griffin's customer, which was made worse with their decision to move all production offshore. Griffin management had symptoms of the problem; illustrated by the white shorts problem and an awareness that they could participate in a long-term solution to their customer's problem emerged. Appreciating the core problem of having to order early naturally leads to summarizing the logic behind the conflict cloud.

**Resolving conflicts with clouds**

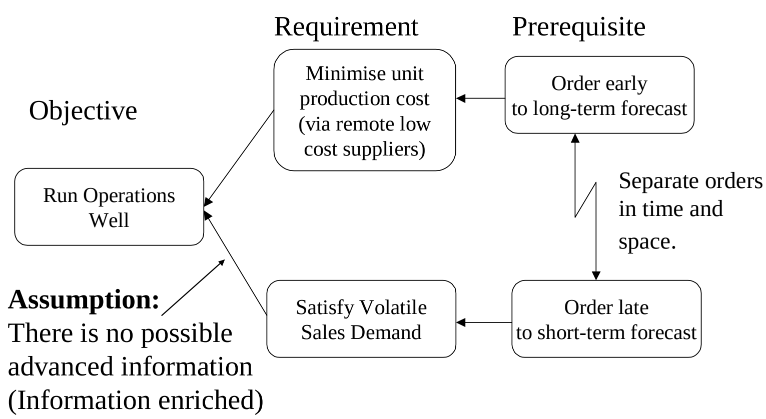



Figure 11 The Griffin-Honduras supply cloud

From the CRT the core problem of ordering early to long-term forecast provides the basis of the cloud in Figure 11. The clearly conflicting prerequisites naturally imply conflicting investments in inventory and capacity. As covered earlier in the paper, the arrows linking the prerequisites to the objective are now subject to challenge. The assumption identified as underlying the AC arrow is closely linked to improving visibility of demand through information enrichment [17] and the use of point of sale data is built into the future-reality-tree (FRT) below. The TRIZ separation principles are again effectively used here with the principle of separation in time and space. As with the Obermeyer case, the orders are separated in time, but in this case, there is also a physical separation between Honduras and Griffin. This acknowledges the alignment of Honduras with a low cost manufacturing focus and Griffin with fast response.

**Developing and selling an innovative solution**

Having developed the cause and effect logic of the current-reality-tree, similar logic is used to communicate and develop the rigor of the proposed solution through what is called a future-reality-tree (FRT). Figure 12 shows the logic with the inputs emphasised. The FRT shows three significant changes to the way the retailer currently operates, and although Griffin has achieved this with their main corporate customer, they want to develop similar relationships with other retailers. As can be seen, as well as establishing a volume split between them and the remote low cost supplier, there needs to be a commitment to maintain a minimum level of work, if the assigned capacity is to remain available. In addition to this, access to point of sales data is required to enable the successful lines to be identified early and so reduce the uncertainty in demand. All of this requires a long-term close working relationship.

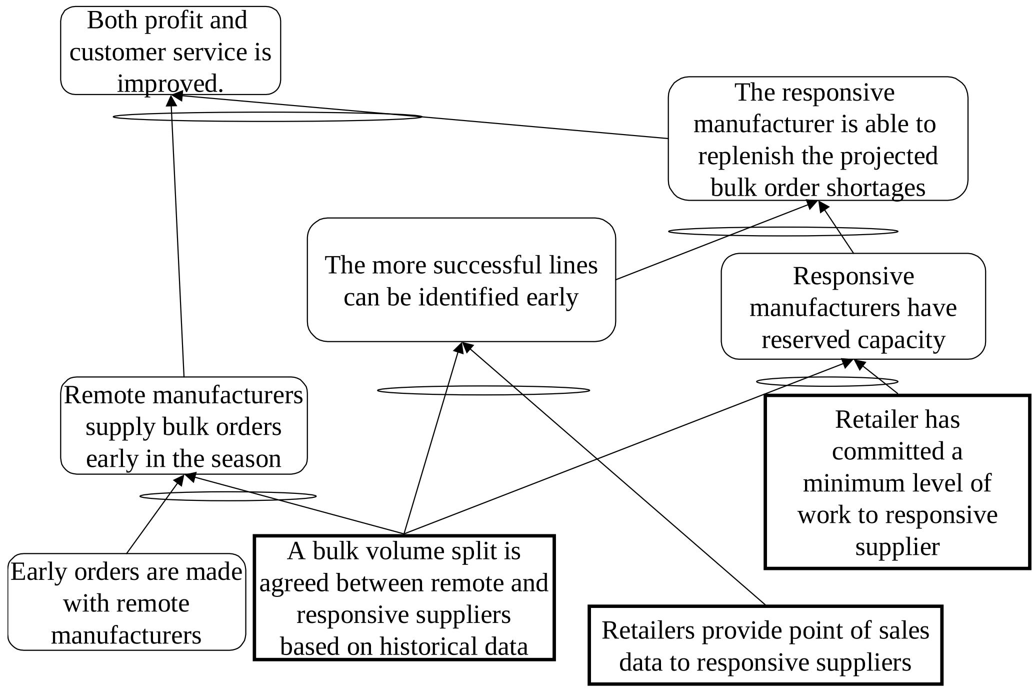



Figure 12  A simplified future-reality-tree for Griffin

The case portrays Griffin's corporate customer and large retailers moving their manufacturing supply base offshore on-mass, which has become the norm in the Western apparel industry and indicative of current developments in many others. The case demonstrates how the focus on direct cost reduction can obscure the indirect implications of such policies, with serious consequences for the entire supply chain. This shows the importance of understanding how such policy changes impact on the order winning and qualifying criteria and influence the trade-off balance for the different products and markets across the supply chain.

**Conclusion**

The lean supply paradigm has taught us the importance of reducing variation and enabling flow, so reducing the need for protective inventory and capacity. However, with the growth in product innovation and demand uncertainty, supply chains now need to strategically locate inventory and capacity to enable flow. This requires a holistic perspective, especially as locally driven decisions often induce further fluctuation and waste. Investment in capacity to protect material flow rather than inventory is central to the agile supply paradigm and the use of separation principles provides a practical approach to exploring innovative approaches to mitigating the impact of the conflict. Although the agile/lean supply conflict is generic, it is important to define business specific conflicts through data analysis and dialogue. The Griffin Manufacturing case illustrates one of many ways of separating out conflicting business needs and more closely integrating the supply chain to enable both timely and efficient delivery in line with market needs.

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