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Designing a More Effective Supply Chain

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Supply chain can be considered as a series of linked inventories. This paper considers the impact of inventory on the economics of the businesses and the whole chain and discusses causes of inefficiency. In most supply chains the goods are inactive for the majority of the time, and this leads to longer term and therefore less accurate forecasting. The result is typically excess inventory, shortages, and inflexibility.

By analysing the wasted time and costs in the supply chain, a clearer view of the whole process can be created. Total supply time can be considered as three components, namely value added time, non-value added process time, and waste time. This basic approach shows where improvements should be focussed. Using this time-based measurement enables more relevant comparison between supply chains than the normal supply chain efficiency ratio.

Keywords: inventory; supply chain; inventory reduction; supply chain efficiency; process mapping; time analysis.

1. INTRODUCTION

There is significant concentration on making supply chains more efficient, and this has been mainly focussed on the improvement of the distribution processes. [1] Cost saving here is significant, but in the context of the whole supply chain, it may be missing the point. Reducing distribution costs is obviously beneficial, but does it have a major impact on the whole supply chain?

The supply chain moves goods from primary material extraction to use of the final product. Is the distribution the major issue or cost in this whole process? This is unlikely as the costs of production and stockholding are normally greater and have a disproportionate effect on cash flow. The supply chain should therefore be considered as a series of transformation processes and intermediate stockholding points instead of a distribution network.

Viewing the supply chain as a continuous "lean" process, both Inventory and Distribution are "wastes" [2] in a lean environment and therefore to be avoided.[3] Although inventory enables short term flexibility within the breadth of stock available, it lengthens the time between demand and resupply, thus increasing the total supply lead time and reducing its agility. This causes the initial processes to be carried out a long time ahead of the user application, and resulting in high operating costs, poor cash flow and also obsolescence of superseded and perishable goods.

Transport only results because the original processes are distant from the user, which ideally they are not. Just-in-time supply requires agile local suppliers and minimal transfer cost, which are only achieved in localised parts of most supply chains.

- The development of just-in-time supply and supplier parks [4] acknowledges this fact. Unfortunately, there are two forces opposing each other:
- JIT supply reduces inventory and improves flexibility but it requires local suppliers, short lead times, frequent deliveries and the partnership that support this.
- Globalisation enables low cost, bulk manufacture in distant lands for universally acceptable products but it requires longer lead times, increased inventory and more cash available.

2. BENEFITS FROM INVENTORY REDUCTION

As inventory is the result of delay between arrival and despatch of goods, it should be managed carefully and provide a competitive advantage for that supply chain. An illustration of financial and cash flow implications of inventory is given in table 1 for a single stage in the supply chain.

Table 1. Inventory and profitability.

	Plan 1 values in millions	Plan 2 values in millions
Turnover	100	100
Inventory	10	60
Fixed Capital	10	10
-		
Trading Profit	***10***	***10***
Cost		
Inventory & Warehousing	3	8
Total profit	***7***	***2***
Return on Turnover	**7%**	**2%**
Total Assets	***20***	***70***
Return on Assets	**35%**	**3%**

In table 1. the data can be applied to an individual company or the whole supply chain. The two plans have the same turnover, capitalisation, and operating efficiency, the only difference is that plan 2 includes significantly more inventory. The additional cost of inventory reduces profit, but it has a much larger effect on the return on capital, and therefore on the share price if it is a private sector company. If this logic is applied to each stage within a supply chain, then there is a great opportunity to decrease both the total time of supply and the cost of the product as well as improve profits.

3. CAUSES OF INVENTORY

It is the management of inventory levels that is the key to an effective supply chain. Inventory exists because it is not currently required: it is there to avoid risk and cost. Root causes of inventory are:

- Poor Forecasting,
- Bulk production or transfers,
- Inaccurate control.

A normal balance of warehouse inventory shows that the actual causes can be categorised as:

- Batch quantity - supply in quantities more than the immediate requirement (non-JIT supply),
- Safety stock – compensates for uncertainty chiefly in demand, but also for supply and quality,
- Market Change – unexpected change in demand level (e.g. un-forecast loss of major customer),
- Obsolescence – caused by internal communication – design change, supersession, marketing focus),
- Company Policy – Build up to demand peak (hedge inventory), or level agreed with customer or supplier,
- System Operations – caused by data inaccuracy, input delays, poor integration or operating practice.

It is for the management of this inventory to identify which of these contributes to the most disruption, delay and cost, and then to prioritise improvement.

The inventory should mainly consist of batch quantity and safety stock which can be reduced through control of supply and more accurate forecasting.

To improve the situation requires the normal management "plan do check act" cycle [6]:

1. Set Performance Standards and Key Performance Indicators.
2. Measure actual performance.
3. Analyse deviations.
4. Make improvement action.

4. SUPPLY CHAIN EFFICIENCY

An overall view of the supply chain can be taken by considering the efficiency of the supply chain. This can be measured as:

$$\text{Supply Chain Efficiency} = \frac{\text{Useful time}}{\text{Total Time}} \tag{1}$$

This ratio can be applied to the whole of the supply chain, just a part of it, or even a company or single process. When considering just a part of the supply chain, it is important to also consider the effectiveness. (making 1000 units may be efficient, but not effective if the demand is for 10!). However, the solution to this may lie in the definition of "Useful time". It can be considered as "***Time taken in the essential processes that***

transform the original input material into the output material". The problem with ineffectiveness can be avoided by defining this as the work carried out *on the required output quantity*. (In the example, the 10 is the required output not the 1000).

The prime use for this definition of supply chain efficiency is for an individual company or supply chain, although it also enables a comparison across different industries. Standard definitions of the term "useful" is essential. It equates to "added value", with the caveat that the value added should be based on the quantity required immediately (thus covering the 'effectiveness' perspective). Useful time therefore is the time required to make the offering more valuable to the end user. Considering the ultimate goal, it does not include time taken for the processes in table 2.

5. IMPROVED MEASUREMENT OF SUPPLY CHAIN EFFICIENCY

When applied to the whole supply chain, or as a monitor over time for the same process, this ratio is good indicator. When used as a comparison of one industry against another it can be misleading. This is because of the influence of long processes. For example, making a jug from plastic granules is a fast process requiring the single stroke from the moulding process in seconds. Making the equivalent jug in ceramic material requires a fast shaping process followed by firing in a furnace which takes several hours. Using the ratio ((1) above), under the same good operation practices, the ceramic process will look a lot more efficient just because the useful process time is much greater.

Table 2. Causes of supply chain inefficiency.

Cause	Examples	Requirement to achieve improvements
Storage	Raw material stock	Employ JIT processes
Quality Assurance	Awaiting Quality checks or sign off	Ensure Right first time
Process set-up time	Machine changeover time	Improve SMED [7] & sequencing
Process waiting time	Daily work lists	Smarter planning & system operations
Non-added value processes	De-rusting ferrous materials	Use when new
Transport	International Freight	Source near requirement

Each of the processes in table 2 is common in supply chains and has been improved or reduced in many businesses. There is a valid argument that these waste times are inevitable in a real situation so the efficiency can never approach 100%, but this is not a reason for aiming towards the goal and reaping the benefits. The option of Additive Manufacturing [7] can avoid many of the inefficiencies, although, of course, there are still the same inefficiencies associated with the supply of the powders for the 3D printing.

There is a general problem where the sources of raw materials are remote from the user, or the process plant has a customer base which is widely spread. The economics will almost inevitably mean that inefficiencies as defined here are necessary. Processes such as wrapping goods for transfer to the user site are theoretically non-value added, as is unwrapping before use, but the consequences of not doing these processes can be very bad. By following the 'plan, do, check, act' cycle (list 1-4 above), an industry can continuously improve its performance and move toward the maximum efficiency it believes is possible.

A more appropriate measure of the efficiency would therefore be "Ideal Time" in hours or days, rather than a ratio. Instead of considering the ratio of useful to total time, the data can be used to consider the actual useful and wasted time. One of the normal mapping tools for improving operations is process mapping [8], and one form of this is mapping the delays in "added value" for a product.* Figure 1 shows a typical cumulation of costs over time for manufacturer or a supply chain. The vertical blocks show the timing and the amount of the total costs incurred. (This illustration shows when the process take place, so each process duration is shown as one unit of time).

The costs for each activity are based on the time taken for each activity and these are illustrated in figure 2, again showing the time at which the activities happened. The spaces in between the blocks is time when no activity is taking place, the solid blocks are the time when there is added value activity being carried out and the hashed blocks are the activities that are considered non-added value.

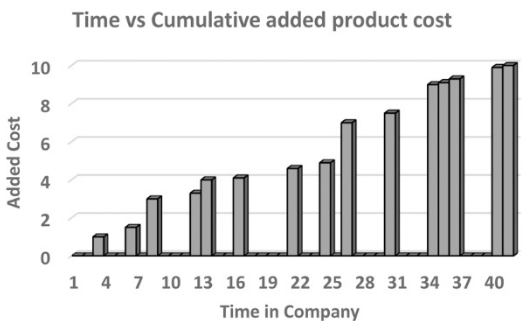

Fig. 1. Mapping the timeframes for added process costs.

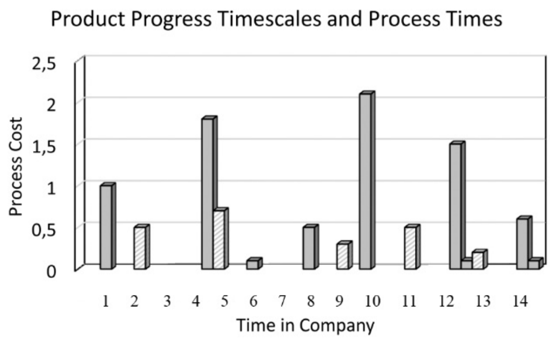

Fig. 2. Individual Activity Timing and Process Time.

Ignoring the time sequence, the activities can be collected into the three types (See figure 3):

- Added Value
- Non-added Value
- Non-active

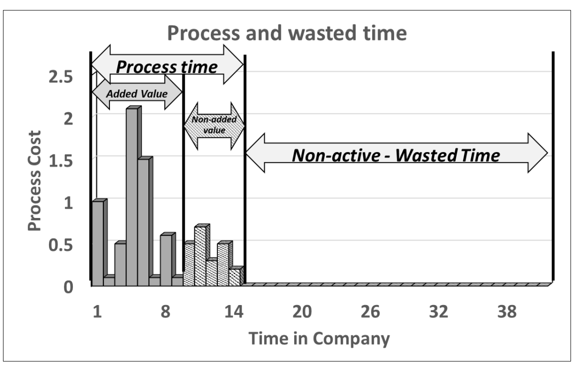

Fig. 3. Classification of time spent.

The identification of Non-added Value activities is somewhat subjective. It is true that quality inspection is Non-added Value. However, supplying defective goods is even worse, and until a process becomes defect free some inventory or capacity is required. The short-term answer is therefore likely to be different from the long term ideal total cost.

There are also operational issues to consider. If a raw material is only available in one part of the world and the demand is in another, then the transport cost is likely to be added value. However, if the ultimate use is back in the country where the raw material originates, is this still true? Economics and ideal added value may view the optimum differently. In practice, a supply chain can decide on what processes it considers to be added and non-added value and get a consistent view of the waste.

In most cases, the non-active portion of the time taken (figure 3) provides the best opportunity for reducing supply chain timescales and improving flexibility. Not only is it the longest time, but also it is the easiest to decrease. This idea is opposed to the traditional concept, as companies have buffered uncertainty by holding inventory at each stage of the process to reduce risk and give flexibility. Co-ordination of planning and forecasting enables the supply chain to function better without this delay and inventory. The concept should be to decide for the supply chain where the best place in the supply the risk stock should be held, taking into account user expectations of time, variety and volume. In reality, there are complications through uncertainty of demand for the variety of final products, unless the whole supply chain is only for one product.

**Footnote: The concept of added value itself is simplistic and erroneous. Raw materials have an identifiable value, as do finished products. In most cases semi-finished goods are worthless until finished (or at least do not have the value claimed, since legally the "realisable value" is less than the cost at that stage).*

6. APPROACHING THE ISSUES

By creating the diagram, figure 3, there is a clear illustration of the major causes of time spent, which is the root cause of extra cost and inflexibility. The issues to consider when reducing the time are obviously:

- ✓ eliminate processes, particularly the non-added value times by re-engineering the processes,
- ✓ reduce time taken in processing,
- ✓ decrease the non-active time.

In most circumstances the non-active time is the major element, both within companies and for the total supply chain. [Exceptions are often found in the fast food industry, or where make-to-order items require international sea transport].

When approaching improvements in the timescales there are two aspects to consider:

- How large is the effect?

- How easy is it to reduce or eliminate?

Taking the Kaizen approach [9] and making many small improvements can be easier than eliminating some major causes of delay. Using table 2, it is then possible to analyse the time wasted and estimate a percentage time attributed to each cause. Then looking into the detail enables changes to be focussed on the area of most potential.

A third factor may also be taken into consideration which is Motivation. If the people involved are keen to make improvements, then there is a higher chance of rapid, successful improvements. The involvement of operating personnel and the commitment of management are a pre-cursor to action.

Each company in the supply chain can identify the wasted time. Normally it results from lack of trust and poor planning. Companies react to demand rather than making plans and carrying them out. As a result, the better organised customers lose out in favour of those who make high pressure demands at the last minute. This can be considered as resulting from a combination of idealistic planning and a misguided view of customer service.

Attacking the problem of non-active time can be achieved through a variety of changes, depending on the root cause of the waste. The areas to consider are normally improved where the businesses:

- Understand the end user demand and co-ordinate supply to achieve it,
- Do not keep changing plans – improve the forecasting,
- Give better service to customers who plan ahead and stick to the plan,
- Arrange the flow of supplies, with reliable quality and on time delivery,
- Consider stockholding as a problem, not an insurance,
- Use the same batch size along the supply chain to aid simplicity and avoid inventory.

The Benefits

Using the time analysis tool gives insight into the potential for speeding up the supply chain. In this case time is money. This approach has been used in a variety of different industries. Comparison is fair where the operation value added times are similar. More commonly, comparing improvements in the supply chain over time or benchmarking the supply of similar products for competing supply chains can be used. On the basis of this simple analysis, like many other basic tools, it forms the framework for implementing significant improvements in operating efficiency. This provides a means for major increase in 'return on assets', which delights the stakeholders and improves competitiveness.

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