Small Batch Manufacturing in the Age of Disruption to Reduce Slow Moving, Obsolete and Deteriorating Finished Goods in Fast Moving Consumer Goods Industry

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Abstract — **Disruptions caused by fast technology innovation in the modern world need solutions on a wide level. In supply chains, an issue of abundant stocks has not been addressed, despite the opportunity to reduce industry-wide holding costs in inventory. The fast-moving consumer goods (FMCG) industry is characterised by many stock keeping units held in hypermarkets, supermarkets, minimarkets, convenience stores, smaller sundry shops as well as in centralised or decentralised warehouses supplied from batch manufacturing. In the process of manufacturing and distributing a large range of items, a portion of slow-moving items result in obsolete stocks being held. These slow-moving items often sit on shelves for long periods of time and upon reaching their expiry dates, some deteriorate too. We can deduce that this is an unsustainable practice. Many Just-in-time (JIT) approaches have been developed to eradicate waste in supply chains but product availability is a desired objective for fast moving consumer goods, so this waste inventory problem exists. In these circumstances, the supply chain manager may then decide to dispose or write such inventory off at a loss. This study aims to show how analysis of such inventory and their demand popularity could be used to install small batch capacity, applying a make to order policy in the FMCG industry for non-popular items. Supply chain managers may also transfer finished goods and move single units of finished goods from an opened carton between retail outlets and warehouses before applying a make when zero policy to reduce and eliminate such unsustainable practices. The approach uses big data, particularly transaction data from Enterprise Resource Planning (ERP) systems and uses modelling and simulation to develop inventory to capacity scenarios.**

Keywords—*finished goods deterioration, inventory/capacity simulation, obsolescence, order frequency, slow moving inventory, small batch capacity, unsustainable practices.*

1. Introduction

The term fast moving consumer goods (FMCG) can be defined as consumer-packaged goods (CPG) for products that are sold quickly and are high in demand and affordable [1]. This definition is actually a misnomer because a portion of such finished goods actually become slow moving, obsolete or deteriorate on shelves in warehouses or in supermarkets. Slowing down of demand can be attributed to economic, festive and climatic conditions or cyclical and seasonal factors. Traditionally, all items in the fast-moving consumer goods business are made for stock and held in warehouses or supermarket shelves and common features of this make for stock environment are huge amounts of working capital tied up in a business, resulting in the high probability of a portion of slow-moving stock being held [2]. According to Ref. [3], process industries excluding pharmaceuticals, account for €2750 billion in revenues globally and inventories make up 56.7% of working capital for global industries. There is therefore much scope to manage slow moving items differently by applying the recommendations in this study. It can be deduced that since these items are slow-moving items in view of its low order frequency [4], customers may not notice its low product availability when inventory is zero. At the point of replenishment for such items, a supply chain manager may transfer inventory between warehouses and move single units of finished goods from an opened carton or manufacture a small batch to be produced and replenish to warehouse inventory quickly before the next customer places an order.

In make for stock environments, for the fast - moving consumer goods industry, operations managers need to

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understand that demand patterns change in size and regularity, hence constant review of re-order points and quantities to be ordered are needed periodically. In addition, as replenishment rules change, many inventory items may become overstocked, slow moving or obsolete. Supply chain managers need to be on top of this and manage such items well, to reduce tied up working capital and space.

In make to order industries such as electronics, automobile assembly and even fast food, the emphasis for supply chain managers is to manage materials, capacity and procurement effectively. The recommendation in this study, recommends that excess capacity of small machines need to be installed in make for stock industries, so that labour and material resources can be added quickly when such unexpected demand arrives.

2. Days of Inventory Outstanding (DIO)

We live in a world of abundance and in the fast-moving consumer goods (FMCG) business, a high level of inventory or days of inventory outstanding (DIO) exist in batch process industries [5]. Table 1 shows the DIO for notable sectors in 2015, for most of the FMCG sectors in the US [6].

Table 1. Summary of DIO for notable batch manufacturing companies in the US (2015)

Sectors	**Days of inventory outstanding (DIO)**
Food manufacturing	58.5
Chemicals and gases	79.2
Apparel and Shoe manufacturing	122.4
Mass Merchants and Departments stores	87.5
Consumer Packaged Goods	66.2
Computer and Peripherals	66

Note: Formula for DIO = end of year inventory level in value / [total revenue/365],[8]

As recently as 2019, the 1000 largest US non-financial companies collected cash from customers more slowly and held slightly more inventory (Figure 1), causing overall working capital performance to decline after some years of improvement [7] & [8].

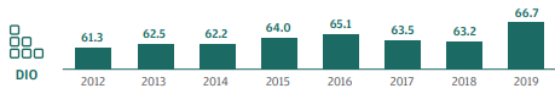

Figure 1. Days Inventory Outstanding (DIO) 2012 vs 2019, [8].

Days of Inventory Outstanding is therefore an important component of working capital and money tied up in Accounts Receivable and Inventory need to be managed well so that organizations can generate cash to pay suppliers for purchase of material and other operating payments (Figure 2).

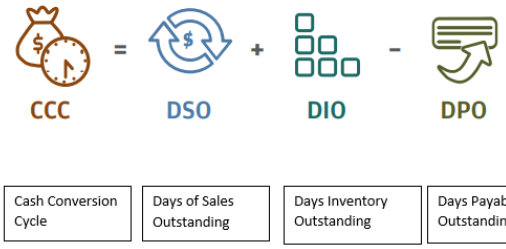

Figure 2. Components of working capital in days

3. Use of Simulation in Manufacturing

According to many authors, manufacturing systems provide one of the most important applications for simulation and it has been used as an aid in the design of new production facilities. Ref. [9] highlighted that models of manufacturing systems must consider several aspects and take into account a number of characteristics (Table 2).

Table 2. Characteristics of Simulation Models for manufacturing systems.

Manufacturing systems characteristics	
Physical Layout	Make to order and make for stock schedules
Shift schedules & job duties	Production control
Capacity rates and breakdowns	Supplies, receipt and storage
Maintenance, resources and tooling	Work-in-process and finished goods
Work centres	Packing and shipping
Product flow and routing	Customer orders and stock keeping units

In a simulation study comparing actual days of inventory to target days, Ref. [10], wrote that days of inventory may be reduced by identifying ‘D’ categories of finished goods in addition to ABC inventory categories. This can be done by supplying most D items from small batch capacity. D items are defined as items that are not popular and can be

determined using order frequency as a variable [11], to separate them from regular make for stock items. According to Ref. [11], various scenarios of inventory replenishment versus capacity can be modelled using the order frequency variable, so that supply chain managers may reduce days of inventory held. Many researchers have studied inventory models for deteriorating items that become waste or obsolete for fast moving consumer goods and simulation showing results for manufacturing have been researched widely.

4. Approach Used in this Study

It has been found that scheduling of production orders for on-demand items generally do not consider limited capacities of production resources. Ref. [12] & [13] wrote that supply chain managers need to match capacity planning with uncertainties on demand. In the planning of make to order wafer production over multiple time periods within a single facility, there was a need to ensure that proper demand forecasts are known for each wafer type for each period [14] & Ref. [15] found that there is an impact of lean production practices on operational and financial performance for manufacturing firms.

The approach in this study is to use a Sales & Operations Planning (S & OP) tool to compare capacity planning at aggregate levels versus the need for small batch capacity. The type of data used comes from the Enterprise Resource Planning (ERP) system from an organisation.

Table 3. Type of transaction data used in the study

Data name	Description of data
SKU data	A snapshot of inventory held in terms of sales units for the end of the period under review by warehouse location and related stock keeping unit (SKU) information.
Order History Data	The orders (or invoiced/sales demand) by date in sales units for SKUs for a period (1 year) by warehouse.
Forecast History	Last year actual weekly forecast in Sales Units. This is the original budget for the year and not the adjusted quarterly forecast.
Capacity Data	The configuration of machine sizes and operating hours that exist within the manufacturing facility for various batch processes.

Aggregate planning can be defined as determining the quantity and scheduling of production for the mid-term future normally from 3 to 18 months [16]. Big data was used to derive capacity simulation based on the Sales & Operations Planning (S & OP) process, which involved developing forecasts, inventory categories, inventory replenishment, master production schedules, material and capacity plans. The number of records used are shown below in Table 4.

Table 4. Number of records used in the study, [17]

Description of data	Number of records
Number of warehouses	28
Number of unique stock keeping units (SKUs)	944
Number of warehouse/SKU records	7442
Number of unique order records	7,530,192

When analysed at the aggregate level, it may look as if there is sufficient capacity to meet the total needs of a manufacturing and distribution type organization but a closer look may reveal a lack of small batch capacity to manage the trend of less frequently ordered demand.

Before we obtain the results for both scenarios, a tabulation of characteristics of slow moving, obsolete and deteriorating inventory with small batch capacity installation show the following comparisons (Table 5).

Table 5. Slow moving inventory and small batch capacity comparisons

Keeping slow moving, obsolete and deteriorating finished goods.	Installing small batch capacity
Tend to exceed target days of inventory. May apply transfer between retail stores & warehouses policy before making more inventory.	Need demand planning tool to determine number of small batch machines required
Many causes for such inventory but main cause is incorrect batch size capacity installed, lack of small batch machine capacity and incorrect demand planning analysis.	Need a Sales & Operations Planning (S & OP) approach to balance demand and supply, with emphasis on accurately determining small batch capacity.
Also caused by infrequent analysis and disposal of such inventory	Need periodic S & OP analysis since demand patterns tend to fluctuate
Categorized as D items as opposed to ABC categories of big, medium and small, frequently moving items	Usually install more machines of small batch capacity than medium and big capacity.
Unable to quickly recover inventory investment. May need to discount heavily to dispose or recycle and salvage main material.	Need to ensure capacity matches highest demand peak for slow moving demand, hence need equipment asset investment.
Occupies space in warehousing and warehouse employees tend to store such inventory on mezzanine floors due to slow moving nature	Need highly flexible and responsive manufacturing workforce

5. Findings

The study developed two scenarios for comparison. The first scenario used aggregate data on a broad product level. The second scenario developed detailed capacity projections at stock keeping unit (SKU) level, showing impact of demand on small batch capacity.

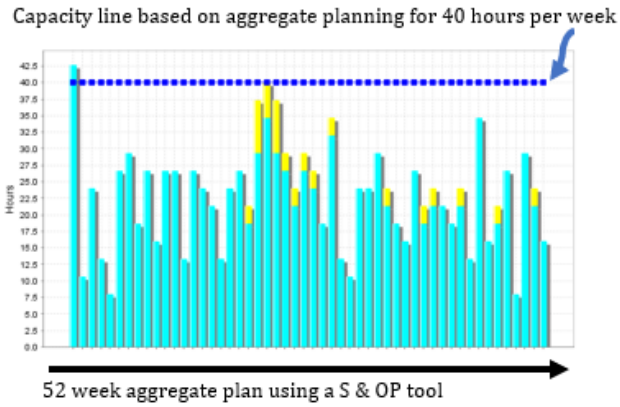

Figure 3. Scenario 1-Capacity planning using aggregate planning

In the first scenario (Figure 3), the annual demand of an organization at product level was used to develop an aggregate plan of inventory replenishment orders impacting overall capacity.

The second scenario (Figure 4) identifies the inventory replenishments for small batch slow moving demand received for finished goods.

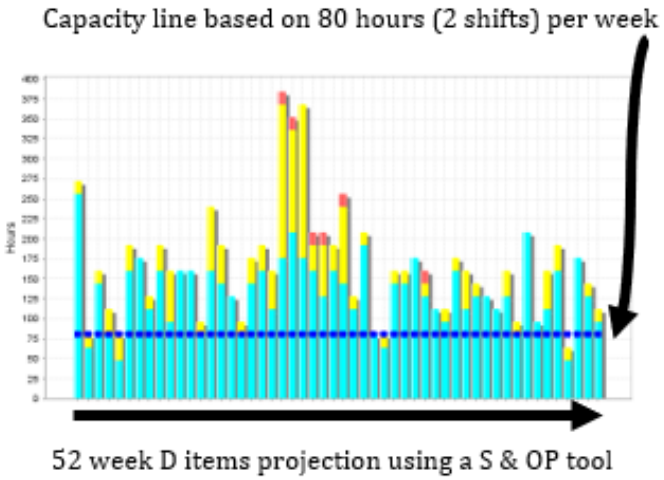

Figure 4. Scenario 2 - Small batch capacity planning for D make to order items

These findings suggest that supply chain managers could consider a quick response replenishment of slow-moving inventory by replacing inventory with capacity based on Figure 4 projections.

6. Discussion & Conclusion

We have seen from Figure 3, that when organisations view capacity using aggregate plans, it appears that overall capacity is sufficient, based on continually working say 40 hours of production (one 8-hour shift for 5 days) per week. However, upon viewing demand for smaller volumes of D items in the fast-moving consumer goods industries, it appears that there is insufficient capacity for small batch machines despite continually working 80 hours or two 8 hour shifts for 5 days, (Figure 4). The supply chain manager may also consider using Saturday/Sunday overtime working during the week to meet demand for such small batch production. Over the longer term, more small machines may need to be installed to meet projected demand for D items if the demand so requires it.

The findings in this study can be used by supply chain managers to adopt inventory strategies that will reduce incidence of excess slow-moving inventory. Supply organizations may be able to respond to orders instead of keeping excess inventory. Organizations may apply a make-to-order strategy if the customer is able to wait long enough. This is applicable in the case of McDonalds, where customers are able to wait just long enough in the queue from ordering of product to receiving the product during drive-ins, in particular. However, inventory related importance among companies tend to focus on product availability as a main objective [17], because consumers will not wait for the product when they attempt to make a purchase especially from supermarkets but consumers in make- to- order environments may wait for products after an order has been made, for example in laptop assembly or car manufacture.

The findings in this study supports potential savings in inventory held and the simulation results can be applied to process industries globally, but available small batch capacity must be installed for these make when zero (MWZ) items. This finding will allow supply chain managers to reduce slow moving finished goods using a make to order approach when inventory reaches zero. Ref. [18], wrote that on average, there are about 87.4 days of inventory in value (DIO) that are being held across industries in the US and there is great scope to apply the approach in this study to reduce slow moving and obsolete inventory. Ref. [3] wrote that while the major reductions have come from the consumer electronics and automotive industries in the last 40 years, process industries such as primary metals and pharmaceuticals have lagged behind (Figure 5). Technology is disrupting many industries [19] & [20] and many processes need to be redesigned for greater sustainability. Ref. [21] wrote that if you want sustainability in this age of disruption, you will need to design more efficient supply chains.

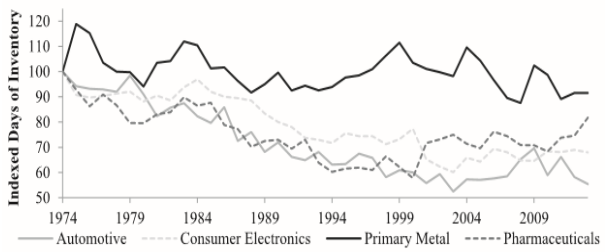

Figure 5. Days of inventory over 4 decades for automotive, consumer electronics, primary metal and pharmaceuticals,[3]

The ongoing challenges presented by the global trade disputes and the COVID-19 outbreak have put immense pressure on working capital levels of businesses worldwide. The Working Capital Index rose significantly in 2019, reaching its highest level in nine years during the first half of the year, as the uncertainties surrounding the U.S.-China trade tensions prompted companies to hold more inventory to mitigate the impact from supply chain disruptions.

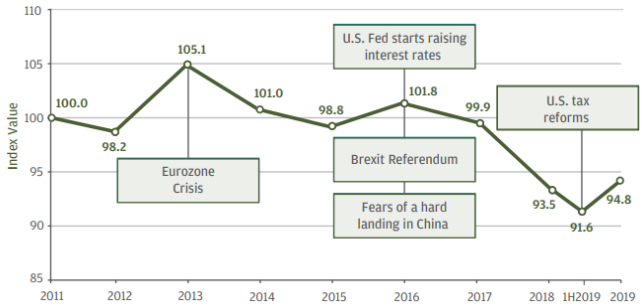

Figure 6. Working Capital Index last decade impacted by political events, [22]

It has been found that supply chain integration involving product and process relationships will improve delivery performance in a supply chain [23]. Manufacturing sizes for slow moving finished goods tend to become smaller and smaller over time, resulting in additional small batch capacity in batch manufacturing. This study highlighted that Supply Chain Managers in batch process industries may use simulation of inventory policies to yield different scenarios for an optimised inventory policy resulting in lower days of inventory by installing responsive small batch capacity. In make to order industries such as electronics, automobile assembly and even fast food, the emphasis for operations managers is to manage materials and procurement effectively. In capacity planning, excess capacity may be needed so that labour and material resources can be organised when unexpected demand arrives.

7. Limitations & Future Research

Researchers have considered dedicated machines with flexible manufacturing modules under budget restrictions [24], but access to real time costs is almost non-existent [25] and forms the main limitation of this study. Although flexible and responsive systems may alleviate the unfavorable effects of demand uncertainties, they require higher investment costs compared to dedicated systems [26]. The complexity of global capacity planning combined with large capital expenditures to increase factory capacity makes it important to incorporate optimisation methodologies for cost reduction and long-term planning [27]. Hence, this study can be further researched to show savings from eliminating slow moving, obsolete and deteriorating inventory versus investment in small batch capacity. A point to note is that many small medium enterprises (SMEs) may not have the S & OP know how to implement demand planning scenarios versus small batch capacity projections. However, the recommendations in this study will allow supply chain managers to effectively develop scenarios that will convert slow moving inventory towards a make-to-order category, thus keeping a close eye on a manufacturing strategy to reduce or eliminate slow moving inventory altogether. Greater understanding on how to reduce inventory waste will help mankind become thrifty and less wasteful [28].

Acknowledgements

The authors would like to thank all participants who have contributed to the publication of this article.

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