UNDERSTANDING THE INVENTORY ICEBERG: BENCHMARKING A STEEL MANUFACTURER

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ABSTRACT

Inventory has been used for centuries to hide operational inefficiencies. In today's globally competitive environment, reducing working capital and therefore inventory is imperative. In order to reduce inventory however, it is important to understand what inefficiencies the inventory is hiding so that these can be resolved and inventory can subsequently be reduced. This study considered metal stock levels at a steel producer within South Africa. Prior to the study, it was believed that metal stock levels were excessive. There were also a number of perceptions regarding the reasons for these reported high levels. The purpose of this study was to benchmark the current inventory levels with similar producers globally and to develop correlations between inventory levels and key operational characteristics. The aim was to establish if inventory levels were high and to determine how the type, use and management of technology within the plant affected inventory levels. Four global benchmark partners were selected, based on the similarity of products offered and processes and technology used. It was found that there was a strong correlation between plant availability and inventory levels. There was a very weak correlation between inventory levels and the number of products produced. Other correlations considered the effect of plant age and the capacity of the plant. Some consideration was also made of the type of technology used and the effect that bottlenecks within the plant caused. Recommendations were made to address the inventory drivers that were identified in the analysis. Ultimately, this understanding will enable the plant to manage their technology better, reducing operational inefficiencies and creating room for inventory to be reduced.

Key words: Inventory management, benchmarking, metal industry, equipment reliability

INTRODUCTION

The largest steel producer on the African continent has steel operations comprising of four major facilities, which produce both flat and long steel products. This paper focuses on one of this steel producer's facilities. The Facility has the capacity to produce 4.4 million tonnes of liquid steel per annum, which constitutes 78% of South Africa's flat steel requirements. Its product range includes hot rolled steel in coil and plate, cold rolled, hot-dipped galvanised, electro-galvanised, colour coated, and tinplate coil and sheet. The steel producer has a revenue to total inventory ratio in excess of 3.5. The Facility that forms part of this study, has had an average of 400 million tonnes of steel in their inventory throughout a year, with a minimum of 237 million tonnes and maximum of

615 million tonnes. Metal stocks include work in progress and finished goods i.e. slabs, hot rolled coils, pickled coils, cold rolled coils, plates and finished products.

It has been claimed that the Facility has among the highest metal stocks to raw material stocks ratio within the steel producer group. For one reason or another, each plant seeks to maintain a certain level of metal feedstock for its process. The architecture and organisation of the Facility site together with the diversity of the product range means that from steel making, a slab can follow one of many routes as it goes through different plants being processed to become a final product. The result is that the metal inventory stock levels can easily get out of hand.

In their study of 94 manufacturing firms in Pakistan, Raheman and Nasr (2007) observe a negative correlation between profitability and inventory levels in a company's production pipeline. In a study of 2000 Belgian firms, Deloof (2003) also found a significant negative correlation between gross operating income and inventory levels. Shin and Soenen (1998) found a strong negative relation between the cash conversion cycle which is a function of inventory levels and corporate profitability for a large sample of listed American firms for the 1975-1994 periods. It can therefore generally be accepted that excessively high levels of metal stocks will have a negative impact on the steel producer's profitability.

Given the 15% cost of capital value at the steel producer, a hypothetical reduction in inventories from the current levels, would free cash flows, thus significantly improving liquidity. This could potentially save R150 million in interest and equity expenses. The results of this investigation will assist the management of the steel producer in drawing up a metal stocks inventory policy for the Facility site aimed at reducing inventory levels and understanding and managing the drivers of high inventory levels.

OBJECTIVES

The aim of this paper is to answer the question, "How does the metal stock inventory levels at the Facility site compare to other sites within the steel producer group?" The specific indicator being bench marked in this study is the "ton of metal stock inventory held per ton of steel produced".

The paper seeks to understand the extent to which metal stock inventory levels at the Facility compare to those at other sites in the group and to use this understanding to make recommendations on improving the levels of metal stock inventories at the Facility site.

METHOD

Four benchmark sites were identified and selected based on similarity of products and processes. It only makes sense to benchmark plants that run similar processes and product lines, otherwise factoring in the differences in processes and product would have brought a new dimension of complexity in the study. Among all group sites that met these criteria, four that show superior inventory performance were then chosen. All of the benchmark peers were situated within the steel producer's European operations.

The supply chain managers at each of these sites were then interviewed. These interviews were used to understand the unique factors affecting inventory performance at each of the benchmark sites. The interviews were also used to identify the drivers, perceived or real, behind the inventory performance at each site. The interviews were conducted before the data was analysed so that perceptions and expectations of drivers could be identified. This enables the study to determine where there are gaps between actual drivers and perceived drivers.

The quarterly inventory performance of each of the benchmark sites was then compared to the Facility site. The inventory performance is separated into work in progress goods performance and finished goods performance. This is because the drivers of each of these types of inventory are different and unique, even at the same site. The ton of metal stock inventory level per ton of steel produced was also compared for all of the benchmark sites.

The drivers identified during the interview were then quantitatively tested against inventory using correlation analysis to determine the real relationships between the drivers and inventory levels.

The study concludes by making general recommendations that could be used to address the inventory drivers unearthed at the Facility site.

INTERVIEW FINDINGS - SOME MYTHS AND TRUTHS

During the course of the telephonic interviews, some themes or deeply held beliefs emerged, particularly from the Facility site management and employees. Whereas some of these beliefs are true, this study exposes some of them to be myths at best. Some of these have been used to explain or justify poor inventory performance at the Facility site for years.

Plant age

Across the entire spectrum of managers interviewed at the Facility, there was a general sentiment that inventory performance is hampered by the age of the plant. It was reasoned that because the facility is 60 years old, it is less reliable than newer plant and the lower reliability is compensated for by building inventory stocks if customer orders are to be met all the time.

Product range

The issue of product range was mentioned by several supply chain managers interviewed. There is a strongly held belief that the greater the product range held by a site the greater the amount of inventory that site will carry. This is indeed true from a theoretical supply chain perspective. Whether or not this holds true within the steel producer group will be investigated in the next section.

Inventory register gaming

One of the themes that emerged from the telephonic interviews is the issue of manipulating the inventory register. Some managers raised the issue that it is not beyond the realm of possibility that some of their colleagues could manipulate the inventory register process. At present, the inventory register records the inventory of metal stocks at the end of each quarter. By deliberately depleting the inventory levels towards the end of each quarter, a manager may be able to create a false impression of superior inventory performance.

Finished goods inventory

The managers at the Facility are aware that some of the European plants distribute their output through merchants. This means that these plants do not need to hold any significant levels of finished goods in their dispatch floors. Unlike the Facility which holds finished goods at its dispatch floors and waits for the customer to pick up their orders, these European plants dispatch all their finished goods to the merchant's warehouse. The inventory register of the Facility is therefore saddled by these finished goods whereas those of some of their counterparts are not.

Inventory vs. customer orders

There is a general sentiment amongst supply chain managers in the participating sites that minimising inventory in the pipeline could eventually disrupt sales and result in dissatisfied and lost customers. They feel that striking a good balance between low inventories and fulfilled customer orders is one task that should be left for each site to address independently. While too much pressure to lower inventory levels could deliver short term gains, it could result in lost customers in the long term.

The interview findings outlined above, were used as a basis to identify parameters that would be analysed quantitatively in order to prove whether common beliefs and practices were true or not.

QUANTITATIVE FINDINGS

In this section, the results of a quantitative analysis of the inventory levels at each of the benchmark sites are presented. In the graphs, the Facility site will be identified as the 'Case Study Site', and each of the benchmark sites will be identified as 'Sites A-D'. In order to meaningfully compare the Facility Site with the benchmark sites, a new method of comparing inventory levels that takes into account production volumes is introduced and applied.

The absolute volumes approach

This approach simply compares the metal inventory levels at each of the different sites, tonne for tonne. This absolute tonnage comparison lacks perspective and can therefore not provide useful information from a comparative perspective.

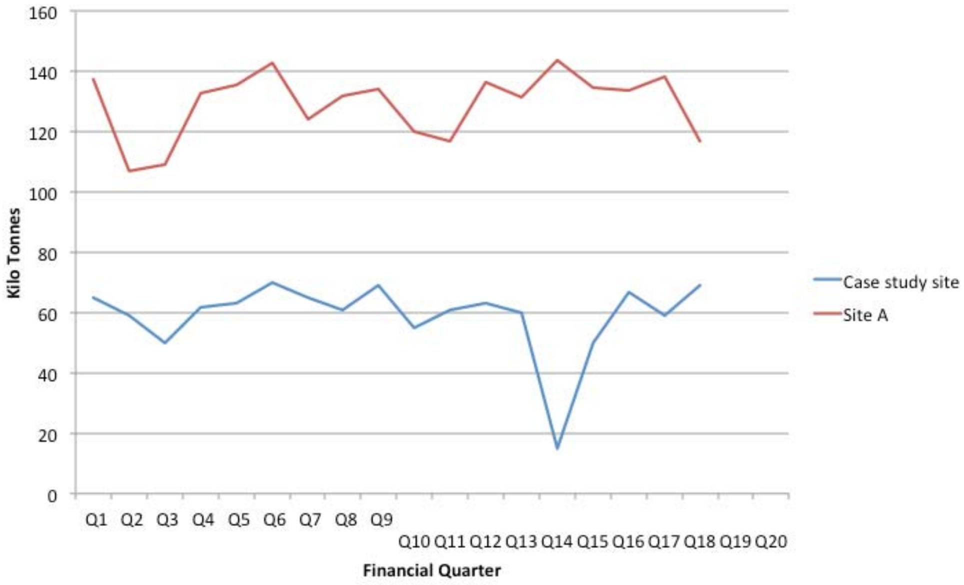

Figure 1: Quarterly metal inventory for Case Study Site and Site A

Figure 1 shows the quarterly total metal inventories over the past 5 years at the Case study site and Site A. The 5 year period has been split into 20 financial quarters, with the quarter ending 31 March 2010 being Q 1 and the quarter ending 30 June 2014 being Q 18. Although a quick glance at this chart reveals that the Case Study site is maintaining much lower levels of inventories compared to Site A, this does not suggest superior inventory management at the Case study site as it does not take into account the production tonnages of the two sites. To get a more realistic picture of inventory performance, this study will use the inventory index, which is a ratio of the inventory tonnages at the end of each quarter to the total tonnage produced at a plant in that quarter. In general, higher levels of inventories can be expected as production output increases due to a build-up work in progress inventory in the production pipeline and inventories at the dispatch floors. Thus the inventory index will paint a better picture of inventory performance at the different sites under consideration despite differing output volumes.

The inventory index approach

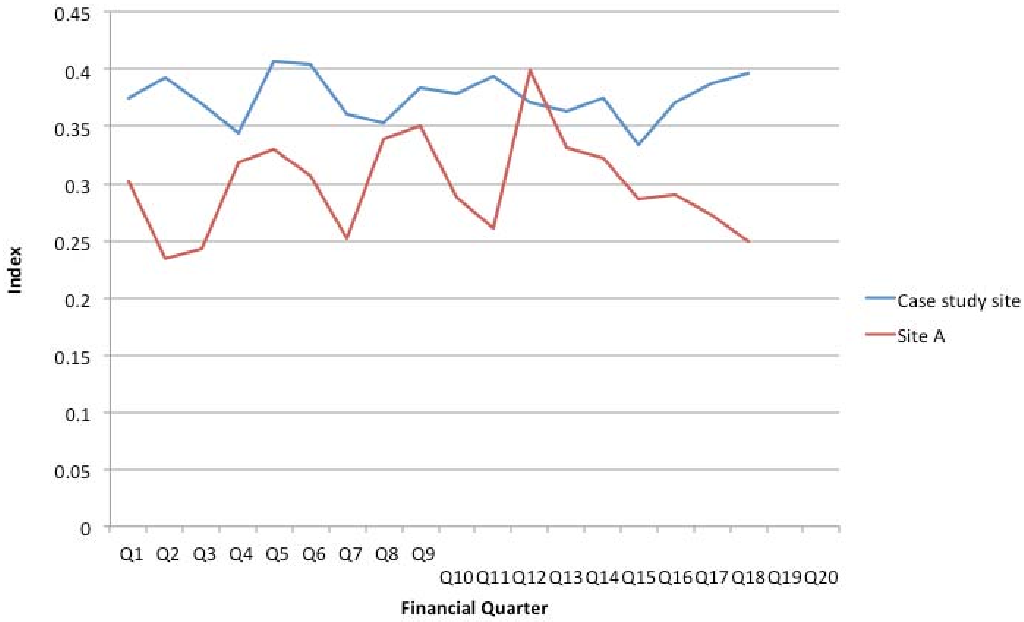

Figure 2: Quarterly gross inventory index for Case Study Site and Site A

The higher the inventory index, the poorer the performance exhibited by the site in question. By definition, the inventory index of any site will be a value between 0 and 1. The closer this value is to 0, the better the inventory performance of the concerned site.

Figure 2 shows relatively steady indices over the 5 year period under consideration for both the Case Study site and Site A. However, by using the inventory index instead of absolute value, it becomes apparent that the Case study site is not actually outperforming Site A as Figure 1 suggested. A consistently higher index shown by the Case study site throughout the 5 year period implies that this site is not performing as well as Site A in inventory management. Because the inventory index is a more robust measure of performance which allows one to see relative performance at a glance, it will now be applied to the rest of the sites.

Gross inventory index

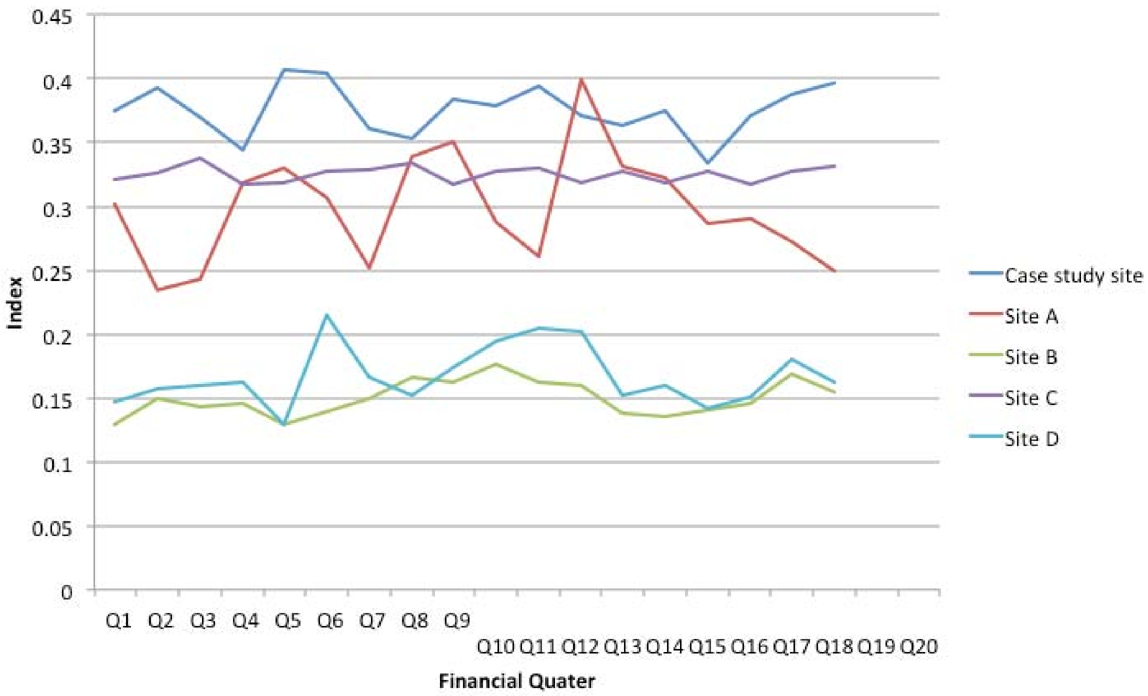

Figure 3: Quarterly gross metal inventory indices for all 5 sites

Figure 3 shows the gross inventory index for all 5 sites. By far, the two best performing sites can be seen to be Site B and Site D. Site A and Site C both outperform the Case study site but each have an index that is about twice that of the top performers. The gross index considers metal stock inventories in their entirety, with no consideration of the split between work in progress and finished goods inventories. Without further looking at the contribution of work in progress and finished goods individually in these indices, this information will be of little use in policy formulation. To get to the root of these discrepancies, the two charts that follow will look at the inventory indices of work in progress and finished good separately. These are two distinct contributors to the total metal inventory levels and have distinct sets of inventory drivers. For instance, work in progress can be reasonably assumed to be proportional to production volumes as more material in the production pipeline can be expected when production volumes are high. The same is not so obvious for finished goods.

Finished goods inventory index

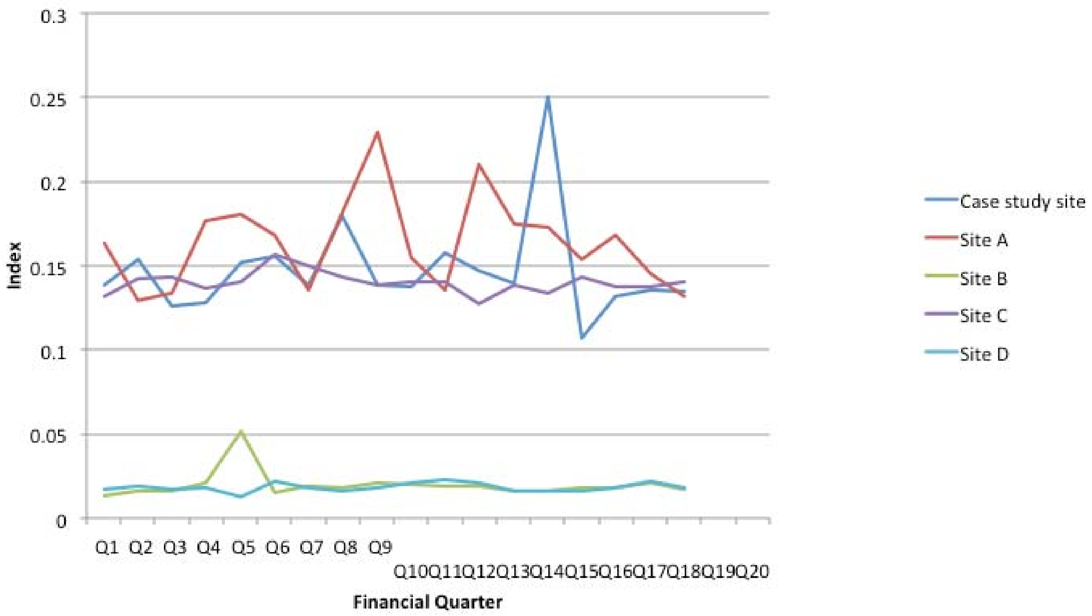

Figure 4: Quarterly finished goods metal inventory indices for all 5 sites

By looking at the finished goods indices separately, Figure 4 shows superior performance by Site B and D. Although the finished good inventory performance of the Case study site is very similar to that of C, both sites outperform Site A by a small margin. The peak shown by the Case study site in Q14 (Q2 2013) is an outlying data point and will be neglected. This peak is a result of a very low production figure against finished goods that had been imported to satisfy customer orders following a fire in the steel shop, halting steel production for two months. The main driver of the superior performance by Site B and Site D is due to the use of merchant warehouses as discussed previously.

Work in progress inventory index

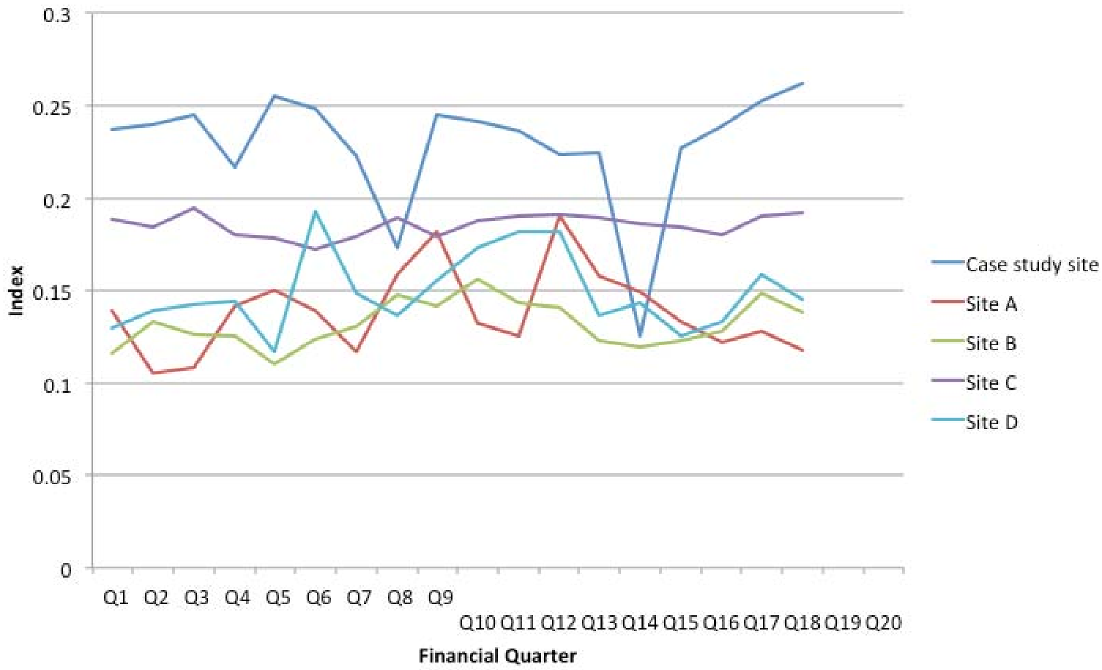

Figure 5: Quarterly work in progress metal inventory indices for all 5 sites

The work in progress indices shown in Figure 5 tell a completely different story. Disregarding the dip in Q14 caused by the fire, the Case study site appears to be the worst performer under the work in progress category. It is the only site that has an index that is consistently above 0.2. However, Site B and Site D, the top performers in gross and finished goods products are not the stars that one would expect in this category. In fact, Site D is marginally outperformed by Site A, but there is little to differentiate between Site A, B and D in this index. Site A and B have a 5 year mean of 0.135, Site D a 5 year mean of 0.14 and the Case study site, a 5 year mean of 0.22. This analysis suggests that the superior gross inventory performance of Site B and D is mainly buoyed by their strong performance in finished goods inventories. This inference will allow lessons to be drawn from each site in the areas were they present the best performance.

ANALYSIS AND DISCUSSION OF RESULTS

Inventory drivers

In this section, the different inventory drivers and how they have impacted the inventories levels seen at each site are discussed. These will be used to explain the apparent superior performance shown by some sites and ways of transferring these to the low performance sites will be explored. In an effort to separate myth from truth, the following factors, which emerged as the main suspects in the interview findings will now be analysed for statistical correlation to the gross inventory index. These are plant reliability, plant age, number of product produced at each site and rated plant capacity.

Reliability and inventory strategy

One of the factors that has a direct bearing on the levels of inventory a site will carry is the inventory strategy. Although it is group policy to maintain a minimum amount of inventory, individual sites have the flexibility of determining their own inventory levels in a way that best serves their markets. The result is that some sites will show higher levels of inventory than other sites. One of the main factors sites consider when developing an inventory strategy is the reliability of the plants. Reliability is a function of the age of a plant and quality of maintenance. Generally, the less reliable a plant is the higher the levels of inventory it will carry.

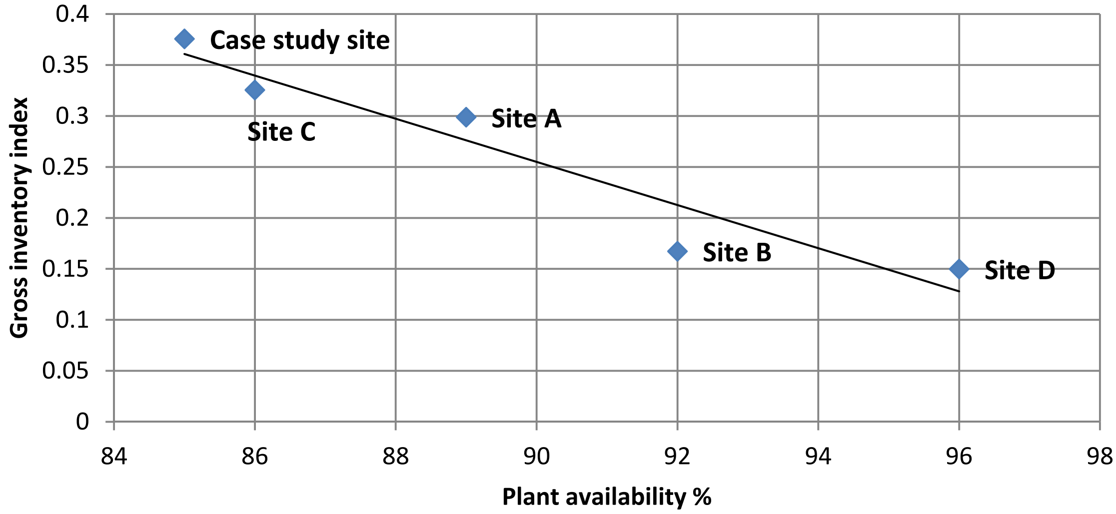

Figure 6: Correlation of average inventory index to plant availability for all 5 sites

Figure 6 shows a very strong negative correlation of -0.95 between the average inventory levels and plant availability. Plant availability is a measure of the reliability of a plant. The higher the availability of a plant, the more reliable the plant is. To buffer against breakdowns, a site will typically build a buffer of material at various stages of production to ensure that a break down will not stop the entire process chain and disrupt sales. Typically, one will see a buildup of inventory in front of the plants that break down often.

Plant age and inventory performance

One of the themes that surfaced in the interviews is that the older plants are generally less reliable and can be reasonably expected to keep higher levels of inventory. Figure 7 shows a positive correlation between inventory levels and plant age. Although not very strong, there is a positive correlation of 0.65 between the average inventory over 5 years and the age of the plant. This to some extent supports the assertion that the older plants are less reliable and thus build bigger volumes of safety stock to protect their sales from manufacturing delays that could result from plant breakdown. It should be noted that the Case study site is the oldest plant among these benchmark plants.

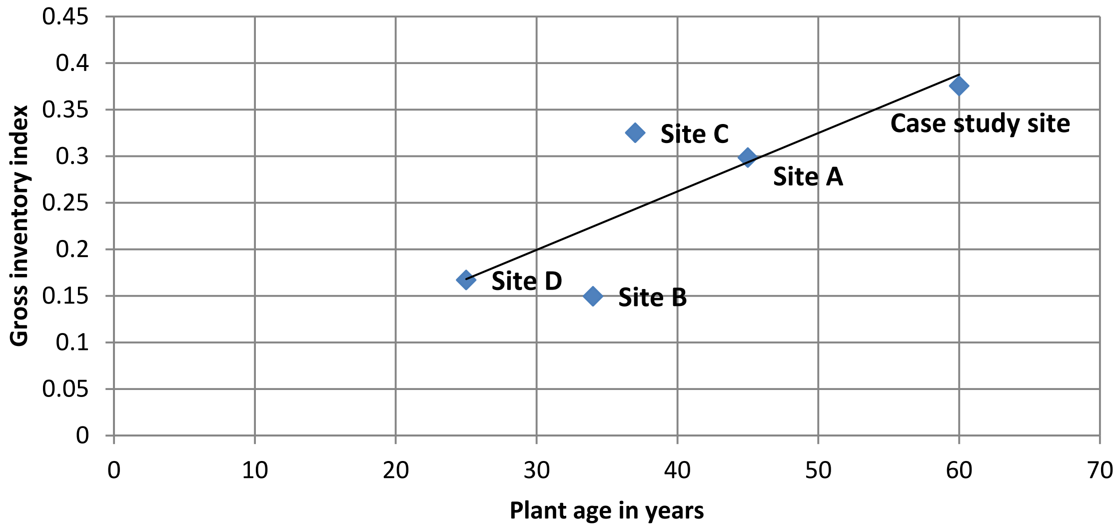

Figure 7: Correlation of inventory index to plant age for all 5 sites

Range of products

Both the product line and production processes exploited at a site have a direct bearing on the level of inventory carried by a site. Generally speaking, the greater the product range offered by a site, the higher the expected inventory levels. This is because each unique product contributes a distinct amount of inventory to the inventory register. This theme emerged in interviews with the supply chain manager at the Case study site. It was believed that the fact that the facility offers a broad range of products could be partly used to explain the inferior inventory performance.

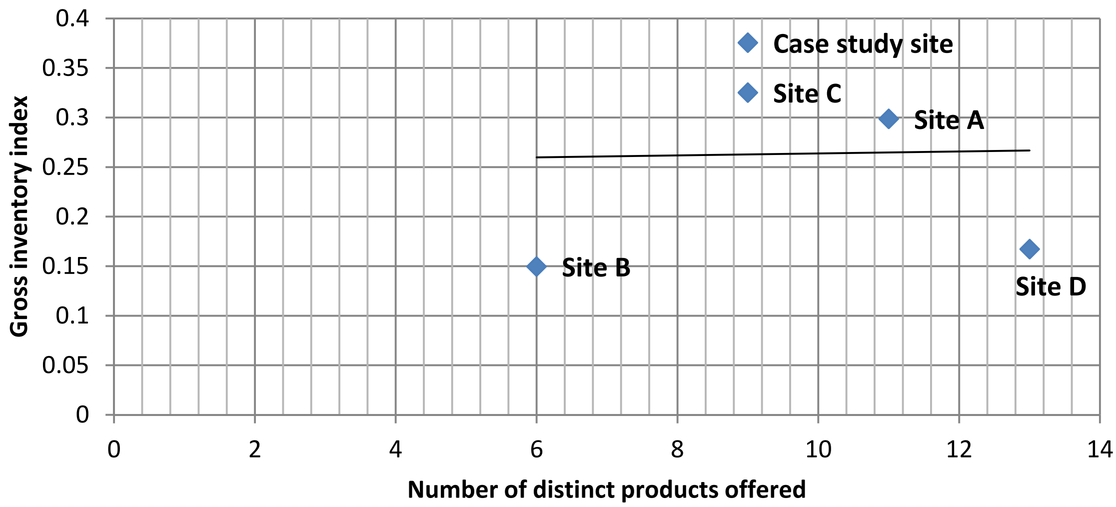

Figure 8: Correlation of average inventory index to number of products offered

However, upon further analysis, Figure 8 shows no notable correlation between the number of products offered at each site and the inventory index of that site. This analysis therefore dismisses the notion that the Case study site's poor performance relative to the benchmark partners can be attributed to the broad range of products.

Plant capacity

The relative size of a plant, in terms of production capacity has been suggested to have a bearing on the level of inventory carried by the plant. This is to be expected as bigger plants normally have a greater volume of work in progress inventory. However the concept inventory index negates this fact by also taking the total production of the plant into the denominator of the index. Figure 9 confirmed that there is no notable correlation between the size of the plant and its inventory performance among the benchmark partners.

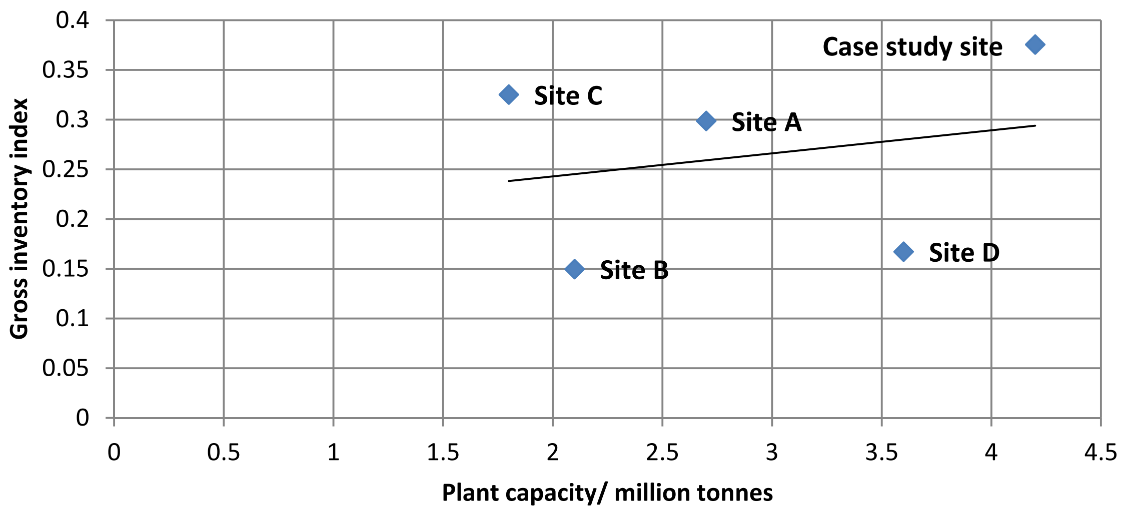

Figure 9: Correlation of average inventory index to rated plant capacity

In the steel manufacturing environment, there are certain operational rules that are unique to each process. For instance, the steel shop requires that a certain minimum tonnage of each grade be cast at one go, for quality and stability of the process. Since the minimum tonnage of the rolling mills is much lower than that required at steel making, the excess slabs add on to the inventory of the site. Several other inconsistencies in the rules of different processes result in a similar outcome, ultimately adding to the site inventory. All these inconsistencies exist in all plants being considered herein, their impact on the inventory ultimately depends on what the plant then does with this excess inventory.

CONCLUSIONS AND RECOMMENDATIONS

While the Facility site's finished goods inventory performance lagged behind the top benchmark performers by a significant margin, its work in progress lagged behind the top performers by a smaller margin. The major differences in the finished goods inventory performance was found to be a result of the different distribution channels employed by different sites. These fundamental differences in the inventory recognition policies make a direct comparison of these indicators unreasonable.

Plant reliability and age were quantitatively confirmed to be real inventory drivers while the range of products and plant capacity were shown to have no significant correlation to the inventory performance amongst the benchmark sites. A very strong negative correlation has been shown to exist between the plant reliability and the gross inventory index. Although establishing correlation does not imply causality, it is reasonable here to infer that the low reliability is leading to a build-up of inventory.

The structured and analytical approach which was used to understand the inventory levels at the Facility site provided insight into the key drivers of high inventory levels. Making use of the benchmarked sites, enabled a comparison to test different theories underlying inventory management. Although management at sites have a wealth of knowledge on their plants and their operation, it is interesting what a strong impact perceptions can have on how a plant is run. The benefit of this approach is that it provides facts which enable a more rigorous problem solving approach enabling the Facility to prioritise and tackle key issues.

Based on the findings from this approach, the Facility site needs to understand the impact of plant availability on their inventory levels. Although inventory levels can be used to buffer against variation within processes, they also hide inefficiencies and result in high costs of operation. The Facility needs to improve the reliability of their plant. Although the age of the plant may be used to explain the poor reliability, proper maintenance schedules and a reliability program may be used to mitigate this.

The results of this study should also be communicated to all managers at the Facility. By educating managers that the factors resulting in poor inventory performance are largely within their control, it is hoped that personnel will be motivated to try and tackle key issues affecting inventory levels.

This paper shows that a proper understanding of the operation and management of technology plays a key role in the operations and ultimately profitability of the Facility.

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