REDUCING EXCESS INVENTORY IN A HIGH-MIX LOW-VOLUME MANUFACTURING SETTING

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Introduction

Providing customers with a wide variety of products and services has been a characteristic of some manufacturing and service industries. Increased customisation generally leads to varied proliferation of a given part and often requires Original Equipment Manufacturers (OEMs) to hold inventory of a wide range of variants of a given part. This study investigates the case of an OEM which supplies batteries to its worldwide customers in the electronics industry.

This operating environment is characterised by high-mix, low-volume manufacturing, i.e. about 90% of its products are customised according to customer's requirement while the balance of about 10% belongs to trading and direct retail items. The customisation strategy resulted in at least 20% of the critical components in the product's bill of material to be unique to the end product. The company faces high operating cost due to excess inventory coverage and stock obsolescence. To align with the company's strategic focus of cost efficiency, it is essential for the company to reduce the excess inventory cost.

The manufacturing activities of this OEM such as production, R&D and quality activities are carried out at its assembly plants on Batam Island, Indonesia, located 20 km off Singapore's south coast. The planning, customer service, sales and marketing functions are centralised at its regional office in Singapore. The company uses the SAP R/3 system to integrate the systems in Batam and Singapore to facilitate information flow between the plants. Real-time information overcomes the distance barrier in information and allows the planners to have timely information for material planning and master scheduling.

This paper examines the issues of excess inventory and stock obsolescence at this high-mix low-volume OEM using Lean Six Sigma's DMAIC (Define-Measure-Analyse-Improve-Control) approach. The objectives of this paper are three-fold. First, we seek to examine the item category with the highest impact to overall inventory. Second, we identify the main causes of excess stock. Finally, we determine the possible improvement solutions to reduce excess stock. The following research questions (RQs) were developed to guide the study to achieve the three objectives.

RQ1: What are the items with highest impact to overall inventory?
RQ2: What are the root causes of excess inventory?
RQ3: How can the company reduce the current levels of excess inventory?

Figure 1 shows the scope of study that was focused on the material planning and procurement activities within the company's order-to-cash cycle. The activities of both phases were taken into account in the root cause analysis of RQ2 as they were activities considered to have the most impact on the inventory levels.

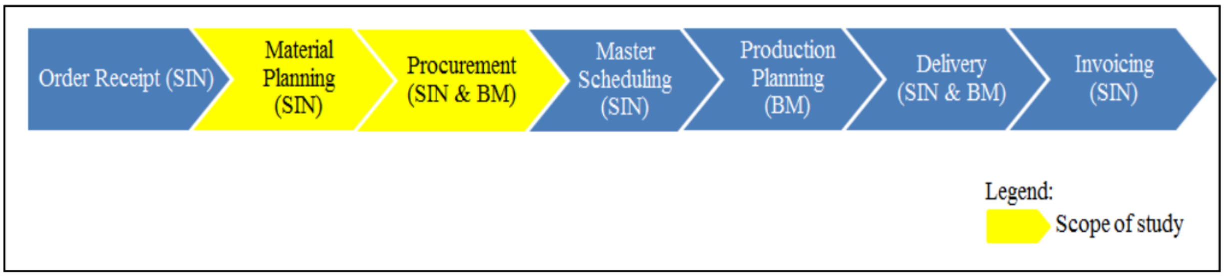

Figure 1: Scope of study in relation to the OEM's order-to-cash cycle

Literature Review

The review of existing literature relevant to the study were broadly summarised into two groups: techniques for identifying item categories with the greatest impact to overall inventory and Lean Six Sigma tools for determining the main causes and viable solutions to address the issues of excess inventory and stock obsolescence.

Market competition has forced many companies to focus on eliminating waste in the form of time, effort, defective units, and inventory in manufacturing-distribution systems (Larson and Lusch, 1990; Schonberger and Ansari, 1984). Ted Farris reported that 66% of the cash-to-cash improvements since 1986 in the majority of industry segments have come from reductions in days of inventory (Trunick, 2005). Farris noted that improvements to operations resulted in a reduction in the amount of inventory held within the company, leading to reduction in incidents of stock obsolescence.

Pattinson (1974) controlled excess and obsolete inventories by developing a suspect inventory list. He processed the suspect inventory list by shortlisting the high cost items which contributed 50% or more to the inventory value. As our aim was to achieve the greatest reduction of inventory value and stock obsolescence, this category management approach was most suited with our objectives and was considered useful in generating improvement solutions for multiple items with similar characteristics. Pattinson highlighted that the analysis of usage volume should ideally be based on future demand in the next 12 months. Since this information is not readily available, companies often use sales figure from the past 12 months as a proxy of the projected usage. We used Pattinson's approach to address RQ1. We focused on identifying the groups of items with the largest impact on the inventory value based on two variables: level of excess stock and stock value.

Many companies have developed and implemented Lean Six Sigma approaches in their pursuit for continuous improvement. Kumar and Sosnoski (2009) provided detailed discussion of the five Lean Six Sigma phases: Define, Measure, Analyse, Improve and Control (or DMAIC). Our study looked at the application of the concepts and tools under the 'Analyse' and 'Improve' phases, namely the cause-and-effect diagram, and the interrelationship digraph.

Doggett (2004) pointed out that the cause-and-effect diagram was easy to use and allowed flexibility in identifying problem-solving solutions through brainstorming. He also highlighted the interrelationship digraph as a structured tool for problem solving since it can show relationships of multi-variables which contributes to the problem. Crandall and Crandall (2003) supported the use of the cause-and-effect diagram to identify the main causes of excess inventories.

Notable cases on how companies have applied the Lean Six Sigma framework in their pursuit of continuous improvement and customer value enhancement are Fujitsu and Xerox. Fujitsu (2007) used visual management tools and kaizen as key elements of its lean programme. Xerox (Fornari and Maszle, 2004) considered enhancing customer value as the central focus when aligned its goals for its lean six sigma projects.

Methodology

We adopted the case study method (Yin, 2003) to conduct an empirical study of the inventory issues faced by this OEM that produces batteries for the consumer electronics industry. As most items are unique to the end product, the company finds it difficult to use the components for production of other battery models, resulting in stock obsolescence and high operating cost due to excess inventories. There is an urgent need for the company to reduce excess inventory and improve its cost efficiency.

Quantitative and qualitative data for this study were extracted from the case company through a mix of random and systematic sampling. They included:

- Stock coverage (or stock turnover in days) report is generated by the company's SAP system; this indicator is used to measure the level of excess stock
- Stock value percentage (the value of each stock item against the overall inventory) is generated by the company's SAP system
- Monthly rolling forecast of selected items from customers
- Ideas from brainstorming sessions with the company's Material Requirements Planning (MRP) controllers or planners
- Management's performance expectations and targets

Results and Discussion

The findings were grouped into three sections in response to the three research questions.

Items with highest impact to overall inventory

The item category with the most impact to the inventory was determined by using the multi-variate weightage method. The importance of each item category was weighted with a score based on two decision variables: stock value percentage and stock coverage. For each item, a score ranging from 0 (least important) to 10 (most important) was assigned to each item based on the company's perspective of its relative importance to stock value and stock coverage. The scores for stock value and stock coverage were then combined to obtain the total weighted score.

This allowed us to segregate the item categories into three levels of importance (high, medium and minimal) while taking into account the impact of the two variables. From the analysis, the category with the highest impact was the LIC cell category which had 8,307 days of stock coverage and contributed to 60% of the overall inventory value.

Root causes of excess inventory

Following a brainstorming session with the OEM's planners which enabled useful ideas to be generated, we applied the cause-and-effect diagram to identify the possible causes of excess stock for the LIC category. Figure 2 illustrates the 19 causal factors grouped into the six major categories: material, demand forecast, man, measurement, procedure and environment.

We then applied the interrelationship digraph to establish the relationship between the causal factors and determine the most likely root cause of the problem. Figure 3 depicts the relationship of these causal factors. High buffer stock, high risk of obsolescence, high purchase quantity and inconsistency of measurement methods were the most likely outcomes which led to the problem of excess inventory for LIC cell category.

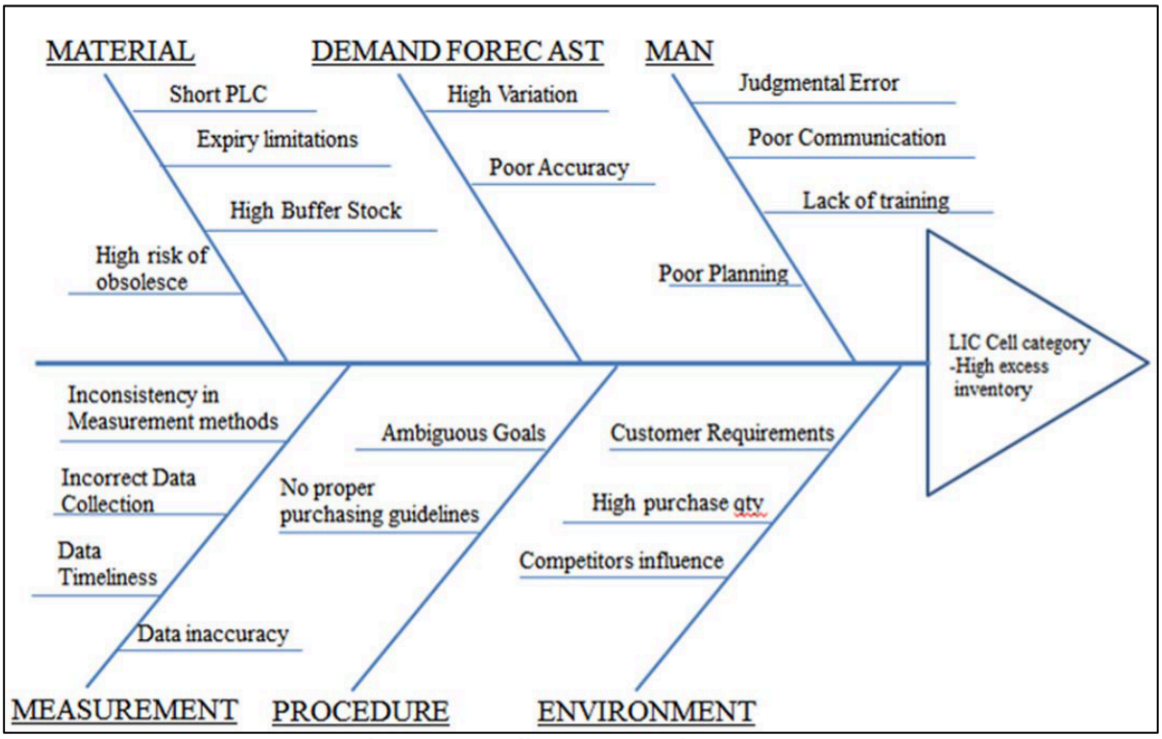

Figure 2: Cause-and-effect diagram for excess inventory

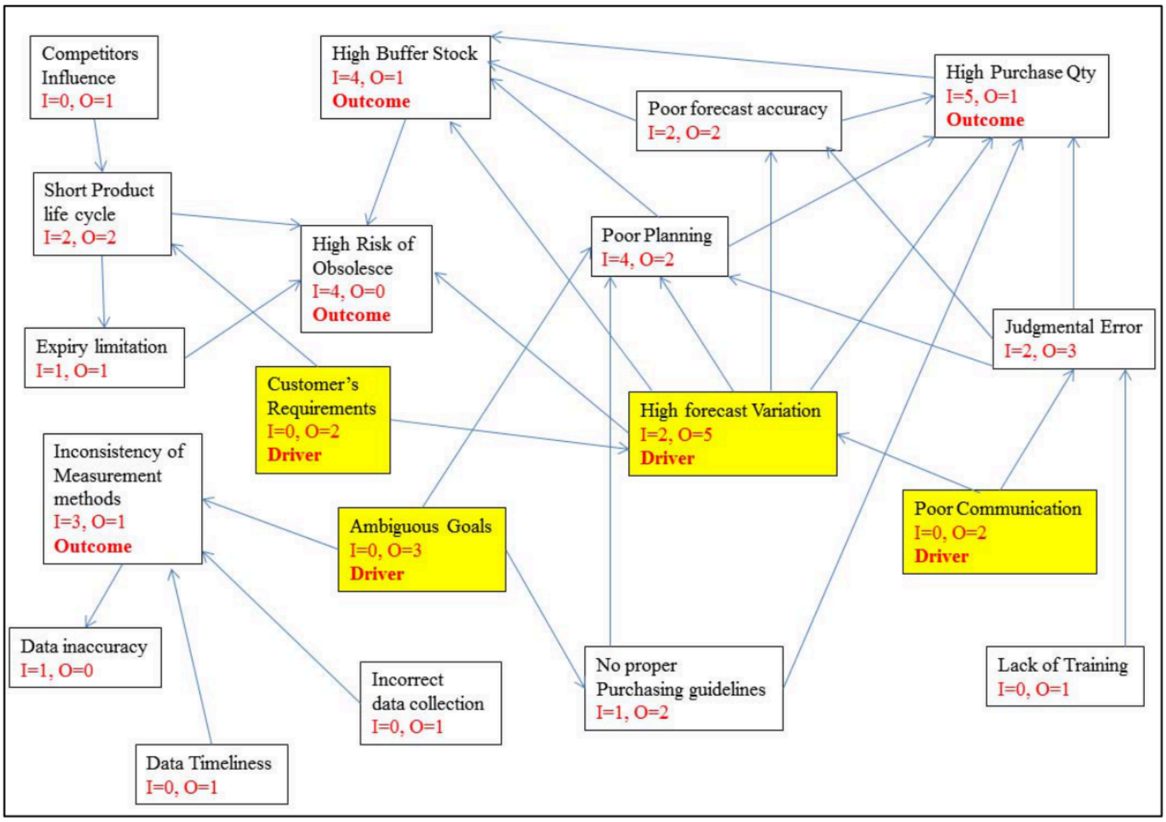

Figure 3: Interrelationship digraph of causal factors

The drivers (root causes) for these outcomes were identified as volatile customer's requirement, high forecast variation, ambiguous goals and poor communication.

- *Root cause #1 Customer's requirements*: Increasing speed of innovation and shortened product life cycles have contributed to high demand volatility in the electronics sector. OEMs have to fit the changing market by customising to volatile customer demand. However, such flexibility comes at a cost to the OEM as this often resulted in high forecast variation and liabilities such as stock obsolescence and excess inventory.

- *Root cause #2 High forecast variation*: Over a six-month period, we found that there were variations of about 5% to 106% for each forecast version done by the product manager. This meant that the forecast for the same period varied across every forecast version. As material planning and purchases for LIC cells are dependent on forecast figures, large variations of forecast resulted in excess or shortage of materials.

- *Root cause #3 Ambiguous goals*: The management sets goals and KPIs for each functional department. However, there were situations when objectives and goals were not aligned. For instance, the planners were not clear whether they should cater to additional stock for order fulfilment or reduce inventory level. Therefore, ambiguous goals led to inconsistency of measurement methods, poor planning and no proper purchasing guidelines.

- *Root cause #4 Poor communication*: Two types of communication were identified in our observations: internal and external communication. Poor internal communication occurred when information did not flow across functional departments in a timely manner. Poor external communication occurred when sales personnel did not communicate frequently to obtain latest updates from customers. Both led to poor judgment in decision making and contributed to high forecast variations.

Possible solutions to reduce excess inventory

After the root causes were identified, another brainstorming session was conducted with the OEM's planners to gather ideas on possible solutions to reduce excess inventory. Table 1 summarises the improvement ideas that were generated.

Root Causes	Description	Possible Improvement solutions
1. Customer's Requirements	- Frequent changes in customer's requirements. - Root cause for short product life cycle and high forecast variation.	#1. Establish close communications with customer through bi-weekly meetings #2. Adopt long term liability contracts with customer
2. High Forecast Variation	- Variation between 5% - 106% for each forecast version - Root cause for high buffer stock, high purchase quantity, poor forecast accuracy, high risk of obsolesce and poor planning.	#3. Establish matrix for demand planning #4. Establish weekly sales and operations meeting #5. Adopt forecasting system #6. Adopt Collaborative planning, forecasting and replenishment (CPFR)
3. Ambiguous Goals	- Unclear management objectives and goals. For example, what to measure and what is the priority? - Root cause for inconsistency of measurement methods, poor planning, no proper purchasing guidelines	#7. Top management to review and re-establish corporate goals and guidelines #8. Establish bottom up feedback system #9. Adopt Visual Management
4. Poor Communication	- Poor internal and external communication. - Root cause for judgmental error and high forecast variation	#10. Internal communication: Top management to re-establish and control information flow between functional departments - External communication: Same as idea #1

Table 1: Summary of root causes and possible solutions

Figure 4 shows the impact/effort matrix to assist in prioritising the improvement solutions that could mitigate the excess inventory problem at this OEM. Solutions within quadrant 1 were the 'quick wins' which yield the highest impact with the least amount of effort. The remaining solutions within quadrant 2 were 'major projects' which required further study.

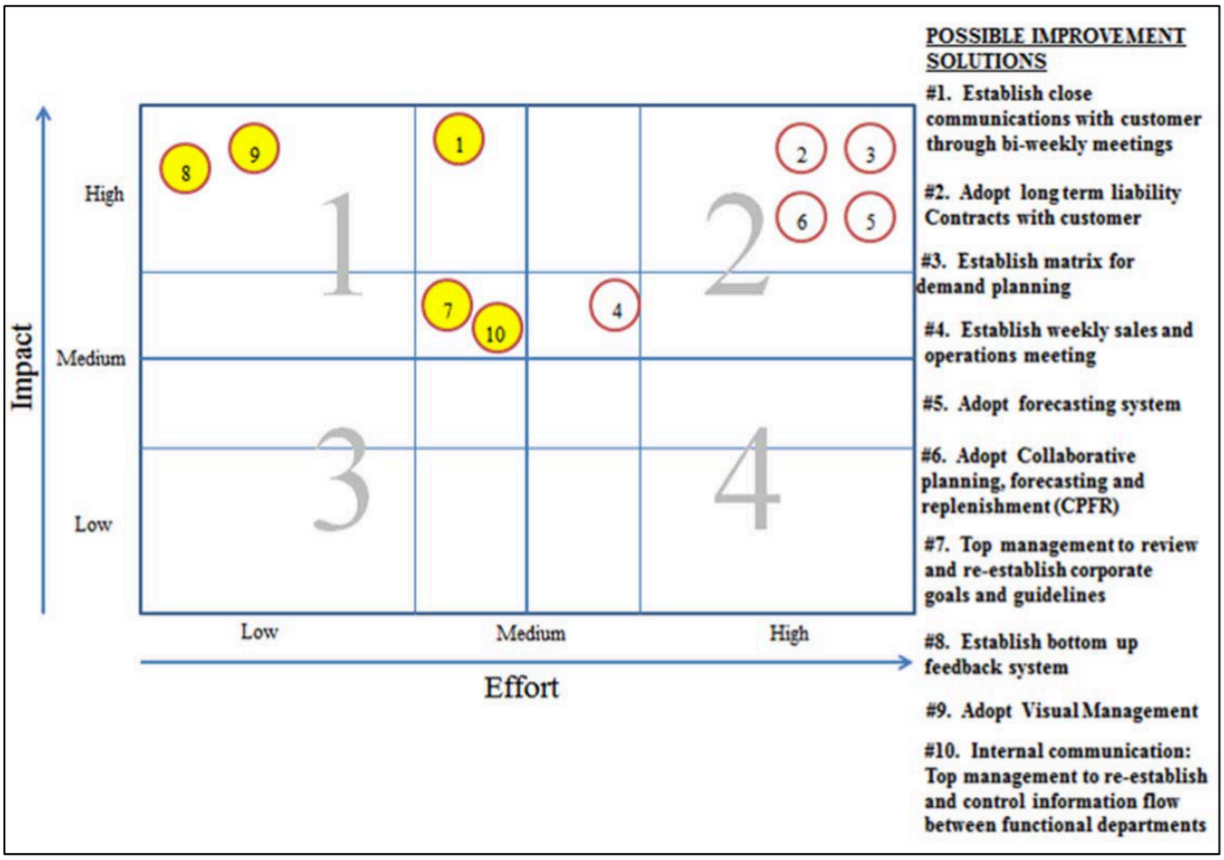

Figure 4: Impact/effort matrix for possible solutions

The following solutions were considered Priority 1 High Impact-Low Effort:

- *Solution #8 Establish bottom-up feedback system*: This solution is the easiest to implement and yields the highest impact. Establishing a bottom-up feedback system allows employees to request for information regarding the company's goals and to seek clarity on potential issues quickly, e.g. when the planner is not sure if keeping additional stock for order fulfilment or lean inventory is more important. The company's web-based intranet can serve as a platform for employees to submit their feedback to the management for review.

- *Solution #9 Adopt visual management*: Visual tools "provide quick and effective controls as it is easy to understand by employees" (Myerson, 2012) as demonstrated by the success of Fujitsu's lean project. Management can use visual management tools to develop control charts and encourage prompt action from employees. For example, order fulfilment, forecast and inventory level charts can be updated on a daily or weekly basis and displayed at a visible place for all employees. This allows all employees to be very clear of the management goals and whether they are performing in accordance to the management's objectives.

The following solution was considered Priority 2 High Impact-Medium Effort:

- *Solution #1 Establish close communications with customers through bi-weekly meetings*: This solution aims to keep the company abreast of customers' requirements and plans that affect the company's product lifecycle and demand forecast. It requires minimal to medium effort to gather cooperation from customers and sales personnel for bi-weekly meetings. The OEM can gather the voice of the customer (VOC) and understand customers' requirements in order to take timely actions. VOC was the basis to align Fujitsu's lean objectives to customer's needs. VOC can also allow the OEM to ensure customers' interests are not affected while the company attempts to reduce excess inventory.

The following solutions were considered Priority 3 Medium Impact-Medium Effort:

- *Solution #7 Top Management to review and re-establish corporate goals and guidelines*: Setting clear directions and aligning strategies with corporate goals can enable the company to keep up with the competition as well as eliminate and improve non-value added processes. Such a performance excellence process backed by strong management support contributed to the success of Xerox's lean six sigma projects. For instance, the OEM can identify the key customers for order fulfilment so that the planner can cater for additional stock to ensure no stockout situations for these customers.

- *Solution #10 Internal communication - Top management to re-establish and control information flow between functional departments*: Poor internal communication exists when information does not flow timely across the different functional departments. This can be due to a silo mentality where functional departments are either unwilling to share information with other departments or they forget to circulate the information. Top management can establish monthly meetings with the mid-management team to drive the importance of information sharing and resolve possible conflicts between departments. Improved communications can reduce the impact of forecast variations as actions can be taken in advance.

Conclusions and Recommendations

The purpose of this study was to underscore how a leading Original Equipment Manufacturer (OEM) of batteries can make use of Lean Six Sigma's DMAIC (Define-Measure-Analyse-Improve-Control) approach to address issues related to excess inventory and stock obsolescence. The case study focused on the 'Analyse' and 'Improve' phases of the DMAIC approach. Quantitative and qualitative data were extracted from the OEM for analysis.

We identified the item category with the highest impact to overall inventory through a scoring system based on two weighted decision variables - level of excess stock and stock value. The result from the evaluation of the total score revealed LIC cell category as the one with the highest impact on inventory with a stock coverage of 8,307 days and contributed to 60% of overall inventory value. Drawing from this finding, we focused on reducing excess inventory of the LIC cell category so as to achieve greater result on the overall inventory value.

An analysis of root causes was performed specifically for the LIC cell category. The cause-and-effect diagram identified 19 causal factors grouped into six categories. These factors were further analysed by establishing the interrelationship diagraph between the factors. By doing so, we identified four root causes of excess stock situation of LIC cell category: (i) customer's requirements, (ii) high forecast variation, (iii) ambiguous goals, and (iv) poor communication.

We recommended strategies to establish an improved inventory management and control system for the long run. The impact/effort matrix was used to determine the best improvement solutions to prioritise for implementation. The matrix identified five 'quick-win' solutions: (i) establish bottom-up feedback system, (ii) adopt visual management, (iii) establish close communications with customers through bi-weekly meetings, (iv) top management to review and re-establish corporate goals and guidelines, and (v) top management to re-establish and control information flow between functional departments.

Overall, the findings from the study can serve as a guide on the techniques that can be applied to a high-mix low-volume manufacturing setting to reduce excess stocks and improve operating cost in the long run.

References

- Crandall, R.E. and Crandall, W.R. (2003), "Managing excess inventories: a life-cycle approach", *Academy of Management Executive*, Vol. 17 Iss. 3, pp. 99.
- Doggett, A.M. (2004), "A statistical comparison of three root cause analysis tools", *Journal of Industrial Technology*, Vol. 20 No. 2, pp. 2-9.
- Fornari, A. and Maszle, G. (2004), "Lean six sigma leads Xerox", *ASQ Six Sigma Forum Magazine*, pp. 11-16.

- Fujitsu Services Limited (2007), "Case Study Fujitsu: Lean supply chain reduces 'fat' by 13%", available at http://www.fujitsu.com/sk/Images/fujitsu-lean-supply-chain.pdf (accessed 2 February 2014).
- Kumar, S. and Sosnoski, M. (2009), "Using DMAIC Six Sigma to systematically improve shopfloor, production quality and costs", *International Journal of Productivity and Performance Management*, Vol. 58, Iss. 3, pp. 254-273.
- Myerson, P. (2012), *Lean supply chain and logistics management*, McGraw-Hill, New York.
- Larson, P.D. and Lusch, R.F. (1990), "Quick response retail technology: integration and performance measurement", *International Review of Retail, Distribution and Consumer Research*, Vol. 1 No. 1, pp. 17-35.
- Pattinson, W.R. (1974), "Excess and obsolete inventory", Management Accounting, Vol. 55, No. 12, pp. 35-38 (accessed 10 April 2014 from ABI/INFORM Complete Database, ISSN: 00251690).
- Schonberger, R.J. and Ansari, A. (1984), "Just-in-time purchasing can improve quality", *Journal of Purchasing and Materials Management*, Vol. 20, pp. 1-7.
- Trunick, P.A. (2005), "Time is inventory", *Logistics Today*, Vol. 46 No. 4, pp. 26-27.
- Yin, R.K. (2003), *Case Study Research Design and Method*, 3rd Edition, London: Sage