A CROSS PLANT COMPARISON OF AN ERP/MRP SYSTEM

by

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EXECUTIVE SUMMARY

In July 2007 Kemira Chemicals implemented a new ERP/MRP system in its North American Operations. The focus of this project is to compare inventory management practices at two Kemira plants both of which have long supply chains but elected to utilize the MRP system in different ways. The Prince George plant manages raw material inventories internally and the Bushy Park plant which is managed externally through the use of brokers.

Due to the fact that forecasting is not customer order driven we can see considerable evidence of the "bullwhip" effect Lee et al, (1997). The four common bullwhipping behaviours: poor forecasting methods, order batching, price variations and the rationing game have all been observed in both supply chains throughout the research period. Lee et al, (1997). Wherever possible visibility and control within the supply chain should be improved to mitigate risk. Christopher et al, (2004).

The following recommendations should be implemented immediately. Bushy Park should fully employ all its purchasing activities in the ERP/MRP system. Communication should be improved between Kemira and its brokers to improve transparency of raw material inventory as it moves through the supply chain. A better methodology/discipline of forecasting should be executed immediately including a formal review process in cases where additional inventory is being ordered to take advantage of a price promotion.

INTRODUCTION

This paper is concerned with managing inventories in a chemicals processing industry. Such industries have large fixed cost and thus are operated continuously with high volumes of throughput. With typical high volumes it is vital that firms closely monitor and manage the costs of their inventories. The firm under examination here implemented an ERP system in the belief that it would provide better inventory control. In this paper we explore the case of two sites of the firm in which it was clear that the sites were utilizing the ERP systems differently giving rise to markedly different results. This paper is to compare the ERP installation at these two sites in order to extract best features and to make recommendations on how to best manage inventories in such environments.

The company under study is Kemira Chemicals (Kemira), a 2.8 billion EUR global chemical company. Kemira's revenues are derived from customers in the pulp and paper, municipal/industrial and oil and gas sectors. Kemira has over 140 sites operating in 40 different countries with 9400 employees. Revenues in North America account for twenty-three percent of Kemira's total revenues.

In 2007 Kemira implemented a new ERP system consecutively in all locations around the globe. There were considerable costs associated with the implementation. As of the annual report ending 2008 Kemira has invested 42 million Euros in this implementation. Prior to implementing the ERP system each plant's purchasing department managed purchasing and inventory functions independently. One of the objectives of the new ERP system was to provide standardization to the planning process. Within the ERP system

Kemira adopted Material Requirements Planning (MRP) in order to better manage inventories at their diverse sites.

"MRP is designed specifically to deal with dependent demand, acknowledging that demand for lower level items can be calculated based on upper demand level and do not have to be forecasted. Thus MRP presents a projection of future orders." Olhager et al, (2006). For the purposes of this study lower level items include raw materials and upper demand level items include finished products which are sold directly to Kemira's customers.

Kemira operates many different types of production facilities in North America including production/manufacturing facilities, stocking warehouses, terminals/transloading facilities and third party tolling operations. There are twenty-one production and manufacturing facilities in North America, in these production plants the assets are owned and staffed by Kemira.

Within Kemira's production plants the majority of raw materials are sourced domestically. Raw materials are readily available and are stocked from a vendor in close proximity to the production plant which allows for short lead times. There are however two important exceptions to this. The Prince George, British Columbia plant obtains 97% of its raw materials from China and the Goose Creek, South Carolina (Bushy Park) plant obtains 74% from Chinese or Indian sources. These two plants are faced with unique challenges in managing its supply chain unlike the other production plants in North America. It is these two plants that is the focus of this project.

The purpose of this research paper is a cross plant comparison of an ERP/MRP system; specifically a comparison of the purchasing function of the Prince George plant and the

Bushy Park plant installations to evaluate how the MRP system has performed. From January 1, 2009 to October 31, 2009 Kemira's North American plants spent $193.5 million USD on raw materials. Bushy Park ranked 6th overall with a spend of $9.07 million and Prince George ranked 26th with $1.955 million for this same period. Both plants received the same formalized training during the ERP/MRP implementation and have attempted to manage its inventory as effectively as possible.

Given the global nature of Kemira's business and the capital investment in the ERP/MRP system it is naturally vitally important that the MRP system is utilized as efficiently and effectively as possible in managing both raw material and finished product inventories.

This project is to compare these two applications of the ERP/MRP system. Given that both plants implemented the basic system at the same time but elected to utilize it in a different manner, it provides an ideal opportunity to judge the impact of such a contrasting approach to managing inventories and evaluate if one approach is superior to the other from the perspective of Kemira. A variety of measures will be utilized to judge the effectiveness of the two systems. These include, among others, average month end inventory levels, frequency of stock outs, reduction in working capital needs, economics (purchase price and FOB landed cost) as well as raw material cost stability (from the view of Kemira).

In the environments of interest in this research paper, we have lead times of four to eight weeks. We also have situations in which no sales forecasts are available. In such circumstances, managing a supply chain can prove to be a complex task.

The remainder of this paper is organized as follows. In the next section we provide a literature review relevant to the issue of managing global supply chains such as that

experienced by this firm. Chapter Two will provide a more detailed description of the implementation of the ERP/MRP systems at the two plants in question. Chapter Three will provide empirical comparisons of the two implementations with a view to extracting the important differences and lessons to be learned on how best to manage such inventories. Such comparisons will permit us to draw conclusions regarding the causes of observed results. In particular, although not exclusively, we can see considerable evidence of the "bullwhip" effect Lee et al, (1997) well documented in the literature and known to be prevalent in global supply chain environments.

Finally, in Chapter Four, we will provide recommendations on how to improve the processes within the two plants and suggest a series of best practices to be shared with the rest of the organization including ways to counter-attack and mitigate the "bullwhip" effect Lee et al, (1997). We also suggest areas of further improvement in the MRP system being used.

CHAPTER ONE

Literature Review

In conducting a relevant literature review, it is quite apparent that examples used by the various authors are drawn mainly from automotive and other manufacturing environments. As such, examples of operating supply chains within continuous processing facilities such as the chemical industry are not presented. However, many of the principles remain the same. Notwithstanding, in order to focus on our issues, we will relate the literature to our examples in order to demonstrate the generality of these principles.

1.1 Bullwhipping

"Bullwhipping" Lee et al, (1997) is a well recognized and highly problematic issue in managing complex global supply chains and can lead to excessive inventory, lost revenues and missed production schedules. Bullwhipping is usually seen when a forecast is not customer order driven. Hardly ever do forecasts remain unchanged and the longer the lead times are in a supply chain or more levels/parties involved in a supply chain the greater the risk for there to be imbalances between supply and demand.

"Supply chains can be seen as systems, with complex interactions between different parts of the chain." Dejonckheere et al, (2003). Supply chain members in this research project include raw material manufacturers, raw material suppliers, logistic agents for ocean cargo, domestic transportation vendors, third party warehouses; Kemira's manufacturing facilities and Kemira's customers.

Two forecasting models are currently being used by Kemira to manage customer demand in its supply chain. The first method is through Kemira's sales representatives communicating projected customer usages and reporting this information to a Kemira

production planner. The second, and the most widely used method, is through reviewing previous demand history. "Forecasting is a predictive process which by its very nature carries an element of uncertainty" Mason-Jones et al, (2000).

Historically bullwhipping was viewed as a fact of life and a necessary evil in a supply chain. Early pioneers of this research include Forrester (1958), Sterman (1989) and Lee et al, (1997) initially identified this phenomenon, arguing that the bullwhip effect and its effects were serious issues needing to be addressed in supply chains. According to Dejonckheere et al, (2003) "the bullwhipping phenomenon is unavoidable when forecasting is necessary; it is the price to pay to forecast unstable demand and to detect trends." Levy (1995) states "the situation is worsened, not bettered when international outsourcing is adopted. An international supply chain can generate substantial and unexpected costs when shipping and lead times are long. These costs take the form of expedited shipping, high inventories and lower demand fulfillment." "These longer lead times tend to just aggravate the information distortion." Lee et al, (2004)

The cruxes of the effects of bullwhipping are as Andraski (1994) put it "problems in supply chains are 80% people centre and 20% technology centered." Supply chain members make decisions based on the best information available at the time. It is the behaviour and response when there are shortages/stock outs/spikes in demand that supply chain members take action on which aggravate the bullwhip. "Bullwhip is a consequence of such a long and protracted chain, with every "player" double guessing what is really required….double guessing between the various participants simply makes things worse." Disney et al, (2006). That is why "it is called the bullwhip effect because a little flick of the whip at the wrist will produce a big arc at the end of the whip." Leach (2008). Bean (2009) reiterates "decisions

made by groups along the supply chain actually worsen shortages and overstocks." This results in "orders to the supplier tending to have larger variances than the sales to the buyer" Lee et al, (2004) resulting in an inventory supply and demand imbalance. Lee et al, (2004) asserts that supply chain members need to be "rational and optimizing."

There are four common behaviours whereby the bullwhipping phenomenon reveals itself:

1. **Poor Forecasting Methods**

   Poor demand forecasting is a consequence of a forecast not being driven by a customer order. Due to the fact that forecasts are rarely accurate, there is either a scramble to obtain raw materials to meet customer demands or working capital being tied up in slower moving raw material stock. To mitigate this effect "demand forecasts must be updated based on observed demand." Lee et al, (2004).

2. **Order Batching**

   "Many manufacturers place purchase orders with suppliers when they run their MRP systems. MRP systems are often run monthly, resulting in monthly ordering with suppliers. The supplier faces a highly erratic stream of orders. There is a spike in demand at one time during the month, followed by no demands for the rest of the month." Lee et al, (1997). Supply chain members need to be observers to distinguish and analyze when there truly is a demand spike that needs to be responded to with procurement of additional inventories.

3. **Price Variations**

   When purchase prices are not stable, there is a tendency for buyers to purchase more inventories when there is a price promotion. "The result is that customers buy in quantities that do not reflect their immediate needs, they buy in bigger quantities and stock up for the future." Lee et al, (1997). Ideally manufacturers should not participate in price promotions as price promotions aggravate the bullwhip effect.

4. **The Rationing Game**

   The rationing game is usually prevalent in retail industries. The rationing game is observed when product demand exceeds supply. "When this happens a manufacturer often rations its product to retailers. To try and secure more inventories the retailer will issue an order which exceeds the quantity the retailer would normally order if the supply of the product was unlimited." Lee et al, (2004). When this occurs the manufacturer is not able to determine what the retailers demand actually is causing the manufacturer to ration its inventory of the product even more.

Given the nature that forecasts are not customer order driven in the Prince George and Bushy Park plant many of these behaviours are believed to be present at various times throughout the research project period. These bullwhipping effects will be discussed in more detail in Chapter 4.

1.2 Countering the Bullwhip Effect

Countering the effects of bullwhipping and gaining control of a supply chain is accomplished through a variety of means. "Supply chain management requires co-operation

and co-ordination." Svensson (2005). "The best way to reduce uncertainty within the order information pipeline is to ensure everyone in the supply chain gets the most up-to-date and useful information." Mason-Jones et al, (2000). "Only through informational sharing and tight coordination can one regain control of supply chain efficiency." Lee et al, (2002). "A robust supply chain requires frequent data exchanges amount inner-company processes and outside suppliers processes." Umeda et al, (2006).

There should be a coordinated and transparent process of forecasting, ideally throughout the supply chain. Such coordination is designated to one person to ensure a coherent and properly functioning forecasting plan is in place. Improved communication and information sharing between supply chain members must be continually developed. Lead times should be updated and reflective of changing market conditions and shortened wherever possible.

1.3 Risk Spiral

Both Prince George and Bushy Park are also exposed to a great amount of risk in each of their respective supply chains. Christopher et al, (2004) have presented a useful framework for viewing a "Risk Spiral." The "Risk Spiral" depicted in Figure 1 is evidenced naturally by the fact that there is a long pipeline. When this long pipeline is combined with lack of visibility of where inventory is in the pipeline the supply chain is exposed to even more risk. If there is a lack of confidence in customer demand there could be too much or too little raw material ordered resulting in stock outs or over stocks. The result is that customer demand is not met on time and in full or there are increased raw material costs by expediting raw materials. According to Christopher et al, (2004) the way to break the risk

spiral is to address two basic elements visibility and control to improve confidence in the supply chain.

We suggest that both Prince George and Bushy Park will benefit from having increased visibility, transparency and communication as raw material moves throughout the supply chain by reducing the risks associated with managing the raw material inventories. When information is shared it reduces uncertainty and improves confidence in the supply chain. As visibility and confidence is attained it could also result in reducing safety stock and build-up of inventory buffers.

One way to break the risk spiral is to build-up buffers and safety stock. "Safety stock is a function of cycle service level, the demand uncertainty, the replenishment lead time and the lead time uncertainty." Chopra et al, (2004).

Figure 1 Risk Spiral (Christopher, M & Lee, H. 2004)
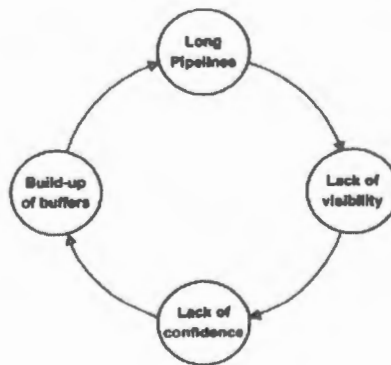
Another area that supply chains can be exposed to risk is when raw materials are sourced by a single supplier. Within long pipelines there is the possibility that there could be raw material manufacturing delays, shipping delays or even labor strikes at the port of disembarkation. If a manufacturing plant relies heavily on only one supplier the plant is exposed to great risk if something is delayed or if something catastrophic occurs that the supplier is not able to fulfill its customer orders. Although purchase order commitments and

confirmation may have been made, there is no real confidence or assurance in the actual delivery date until the raw material is at the port and ready to be ocean shipped. To mitigate this risk multiple suppliers should be engaged at all times so that if one supplier is delayed or unable to supply raw material, raw material is still in the supply chain from the other source.

By executing the countering effects that the bullwhip can have on a supply chain and increasing visibility and control to reduce the risk spiral Prince George and Bushy Park can improve confidence in each respective supply chain.

CHAPTER TWO

2.1 Overview of the Prince George Plant

The Prince George Plant obtains 97% of its raw material requirements from various sources in China. Raw material purchase orders are placed directly to the Chinese manufacturer or agent and the product which is shipped in forty foot containers from various ports in China directly to the Prince George plant. Containers are unloaded and inventory is stored on site in Kemira's production plant. For simplicity in this paper, we will refer to this raw material product simply as PG-Raw throughout.

The Prince George plant manufactures one product which, again for the purpose of simplicity we will refer to as PG-Final hereafter. This product is sold in bulk and in intermediate bulk containers called totes. Kemira monitors its customer's inventory through an e-mail which reports the daily level in the storage tank. Monitoring of the customer inventory levels through historical customer usages is the only mechanism Kemira has available to determine customer demand. Kemira analyses historical customer usages to determine the PG-Final production schedule and procure appropriate inventory of raw materials.

The Chinese suppliers of PG-Raw insist on three weeks lead time to prepare and bring raw material to a predetermined Port of China when a new purchase order is placed. Transit times are currently sixteen days resulting in a 37 day total replenishment lead time. Kemira instructs its vendors on which vessel to ship the container and there is now visibility of the estimated time of arrival of the container since it has begun receiving containers through the Port of Prince Rupert. A reduction in ten days transit time and reduced

transportation costs have also been realized. In addition, Kemira now has complete visibility throughout all of the stages in the entire supply chain. Previously there had been no visibility from the time the purchase order was placed with the Chinese vendor until the container was delivered to Prince George. Under the new model of shipping through the Port of Prince Rupert there is information now available which enables Kemira to respond quickly to demand fluctuations or raw material delays which should result in better inventory management decisions.

Several factors influence the procurement practices of PG-Raw. History has repeatedly revealed that the price of PG-Raw is always the highest around Chinese New Year. This season is plagued with severe constraints in raw material availability due to planned plant shutdowns and limitations in ocean cargo shipping space. In order to mitigate these conditions Prince George orders raw material inventory in advance and avoids placing new raw material orders during the first quarter of each year.

Customer's requirements for PG-Final can be directly linked to global market demands for pulp. If global market conditions are poor customers can eliminate this product entirely or significantly reduce the application rates that PG-Final is applied at.

To summarize, the Prince George plant operates with no sales forecast other than data obtained from monitoring customer daily usage rates. Raw material inventory is managed internally and procured directly from China. The Prince George plant manufactures PG-Final, monitors the customer inventory and delivers PG-Final directly to its customers. All of this is managed internally and Kemira has moderate visibility of the total supply chain.

2.2 Overview of the Bushy Park Plant

The Bushy Park plant is a colorants plant manufacturing dyes and pigments for a variety of customers. These dyes include seasonally colored holiday napkins or the red colored logo you see on a Wendy's restaurant napkin.

The Bushy Park plant operates with a six month sales forecast. This forecast is initiated by an internal sales force coordinated through the Colorants Product Manager. The six month forecast becomes the basis for the forecasted demand at the specific customer/item level. From this sales forecast Kemira can plan its monthly production schedule and determine its future raw material requirements.

For several decades Bushy Park has chosen to work with brokers to manage its inventories from China and India. Today it is the only Kemira plant to manage raw material inventories jointly through external vendors. Specifically two brokers manage 56% of the $9 million raw material spends at the plant. The first reason brokers were chosen in Bushy Park were because the sales forecast typically had not been reliable. The brokers mitigated risk of sales forecast inaccuracies by warehousing an additional two months of raw material inventory for Kemira. As well, this acted as a safety stock buffer due to long lead times of six to eight weeks. If the forecast changed or demand increased, raw material was readily available to be delivered to Bushy Park "just in time" (JIT) Sugimore et al, (1977) so Kemira could produce finished product and meet its customer demand.

The second reason brokers were chosen were because the plant had to meet stringent operational targets to maintain the lowest level of raw material inventory and to reduce working capital needs. Brokers solved this dilemma by providing consignment. Raw

material was allocated and available to Bushy Park in close proximity to the plant. However the raw material did not have to be paid for until it was physically delivered.

Operational ease is the third reason that brokers were chosen in Bushy Park. The plant could operate with more production capacity and less raw material storage capacity. The plant could shift the burden and risk to the broker as it was the broker's responsibility to keep raw material in the supply chain to meet Kemira's customer demands which were unpredictable.

Kemira meets regularly with each broker and openly communicates its upcoming raw materials forecast needs. When Bushy Park is ready to use a raw material in production, a purchase order is issued and the inventory is delivered. Such deliveries are a JIT strategy Sugimore et al, (1977) since the broker (the vendor to Kemira) can deliver almost instantaneously to the Kemira plant.

Customer orders once received at the Bushy Park plant dictate changes to the plant production schedule. The plant produces a variety of finished products which have long cycle times and require tank washouts upon completion of a batch. The plant sells finished product is a variety of packages including tank trucks, intermediate bulk containers and drums.

In summary, Bushy Park has chosen to manage their inventory requirements through a broker. These two brokers procure raw material, manage and warehouse Kemira's raw material. Raw material is delivered JIT Sugimore et al, (1977). Forecast swings or errors are mitigated and the risk is shifted to the broker who carries the plant's raw material inventory burden.

CHAPTER THREE

Cross Plant Comparison

Prince George had chosen to manage all of its raw material requirements internally whereas Bushy Park is managed externally through brokers. The purpose of this research project is to determine if one method is superior and/or to establish best practices to share with the rest of the organization. At the heart of managing a supply chain is the handling of inventories; that is, the MRP system. In Prince George the MRP system is internally managed as part of the larger ERP system. In Bushy Park, MRP involves the use of brokers. Hamilton et al, (1981) lists seven objectives of an MRP system. However his categorization of objectives extends well beyond straightforward inventory management (into higher level corporate objectives) which is the focus of this paper. Hence, from his list we have synthesized two MRP objectives against which to evaluate the issues here in this paper. The following are the two MRP objectives:

1. Minimize Inventory Levels
2. Improve product availability and enhance inventory control. Hamilton et al, (1981).

If an MRP system does have these inventory objectives, we should be able to evaluate and judge the effectiveness of the Prince George and the Bushy Park plants on the following criteria since the onset of the ERP/MRP implementation:

- Is there evidence of improved inventories and working capital requirements post-ERP implementation?
- Is there visibility in the raw material supply chain?
- How stable have raw material prices been?

- Have increasing raw materials costs been passed along to Kemira's customers?

- Identifying differences in costs structures between internally and externally managed inventories?

- Have the plants been able to meet customer demands?

- Has our use of the MRP system resulted in less frequent stock outs in one location over the other? (We must remember that this is a cross-plant comparison, not a pre-post comparison. Hence we cannot address the issue of whether either plant has lower stock outs as a result of the implementation of the MRP system compared to the pre-MRP phase).

- Can the plants quickly respond to changing customer demands?

The period of data analysis will begin in July 1, 2007 when both plants began using the ERP system until December 31, 2009 for a total of 30 data points. For Prince George the main raw material PG-Raw will be analyzed as well as the sales demand for the finished product PG-Final. Two raw materials used in Bushy Park will be analyzed. For reference we will refer to the raw materials at Bushy Park as BP-Raw1 and BP-Raw2; which are critical components in two finished products, hereafter referred to as BP-Final1&2 and BP-Final3. (BP-Final1&2 is the same finished product however sold in two different packages. Hence we can treat them as one product for the purposes of this paper).

3.1 Evidence of improved inventories and working capital requirements post ERP implementation.

Prince George has experienced significant variability in raw material inventories over the thirty month period as shown in Figure 2. During the time that Prince George was able to

use vendor consignment (July 2007 to August 2008) the raw material inventories and working capital requirements were under strict control. Vendor consignment is a form of a broker as it permits risk mitigation. Although Kemira's working capital requirements are lower under vendor consignment, the brokers increase their raw material costs to cover costs such as financing charges which ultimately results in a higher raw material cost from the broker. As soon as vendor consignment terms were not available, inventory and working capital requirements increased substantially in Prince George (Figure 2, January 2009).

In October 2008 Kemira's largest customer announced that it would stop usage of PG-Final. No formal contract language was in place to deal with the customer discontinuing usage of PG-Final unexpectedly. The customer stopped using PG-Final on the basis of difficult economic times due to a saturation in the global pulp market and needing to eliminate costs wherever possible until market pulp prices improved. In October 2008 when the customer announced discontinuing the use of PG-Final there was no opportunity to stop or postpone the flow of PG-Raw in the supply chain as it had already shipped from China. Some financial burden was postponed under a vendor consignment agreement, but nonetheless in February 2009 PG-Raw inventories soared to $1,654,068 USD. Kemira Prince George carried PG-Raw inventory for this customer from October 2008 until July 2009 when the customer demand returned.

Figure 2 – PG-Raw Inventory Value at Month End USD
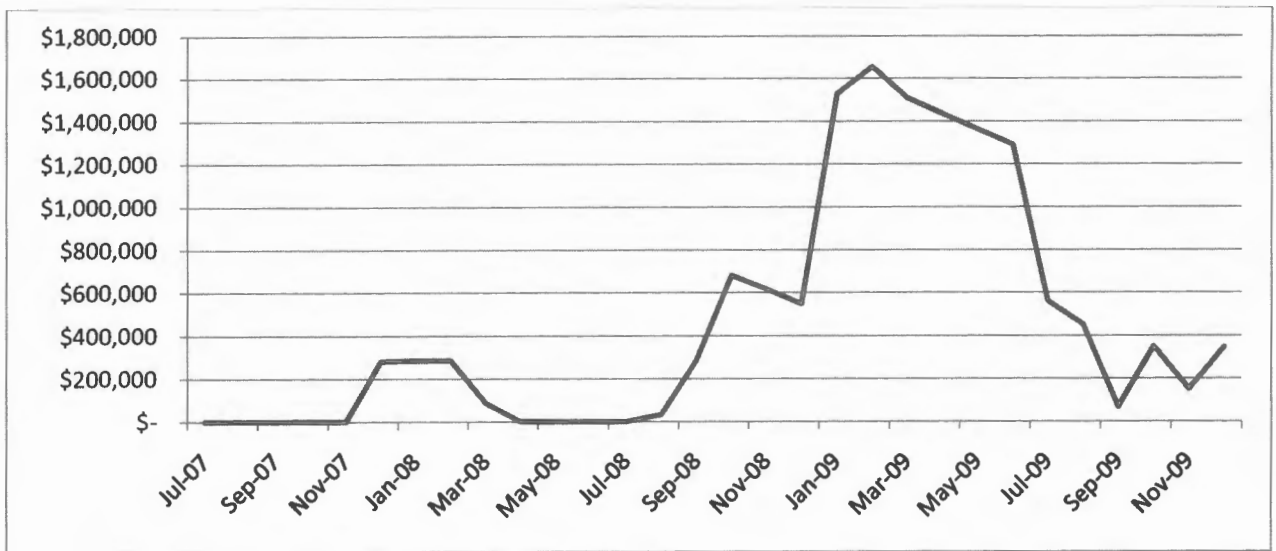
Overall, Bushy Park managed its BP-Raw1 and BP-Raw2 working capital

requirements well however the effects of "bullwhipping" Lee et al, (1997) struck both raw

material supply chains during the data research period. In June 2009 inventory of BP-Raw1

spiked to $767,294 USD as depicted in Figure 3 and in December 2008 inventory of BP-

Raw2 reached $379,689 USD as portrayed in Figure 4. More detailed analysis of the effects

of "bullwhipping" Lee et al, (1997) will be described in Section 3.7.

In comparison to Figure 2, we can see that Bushy Park (Figure 3 & 4) has maintained

much more stable monthly inventory management. While inventory value at Bushy Park has

increased over the research data period, the variability is quite small. This provides some

evidence of the difference in inventory management approaches at the two plants with the

use of brokers in Bushy Park yielding much more stable inventory flows than that seen in the

self-managed Prince George plant. The Bushy Park brokers can warehouse Kemira's raw

material inventories until the time that the raw material needs to be used in production a JIT

strategy. Sugimore et al, (1977).

Figure 3 – BP-Raw1 Inventory Value at Month End USD
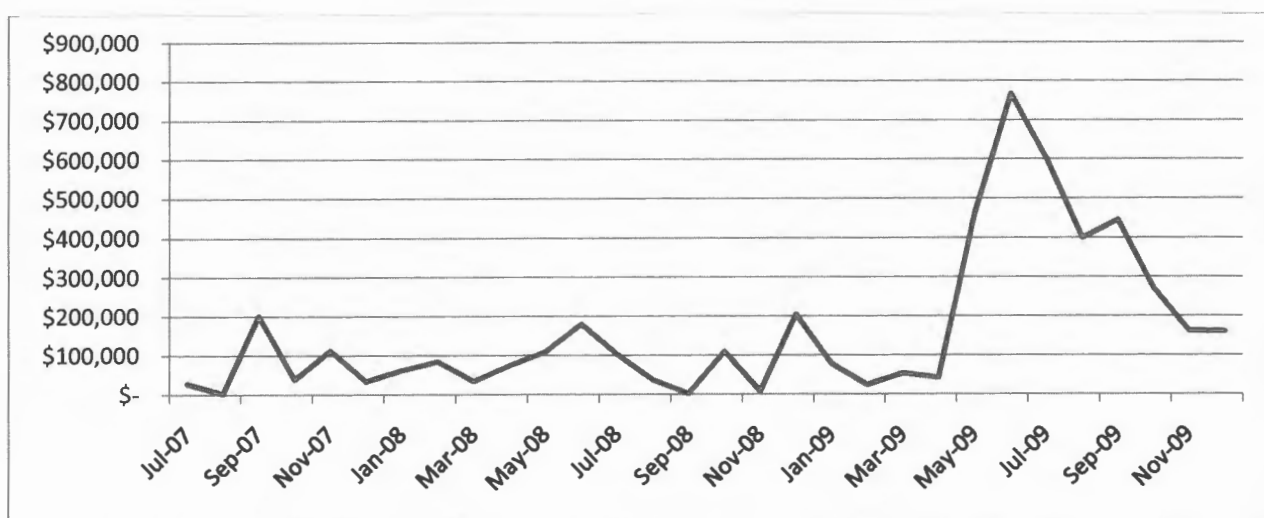
Figure 4 – BP-Raw2 Inventory Value at Month End USD
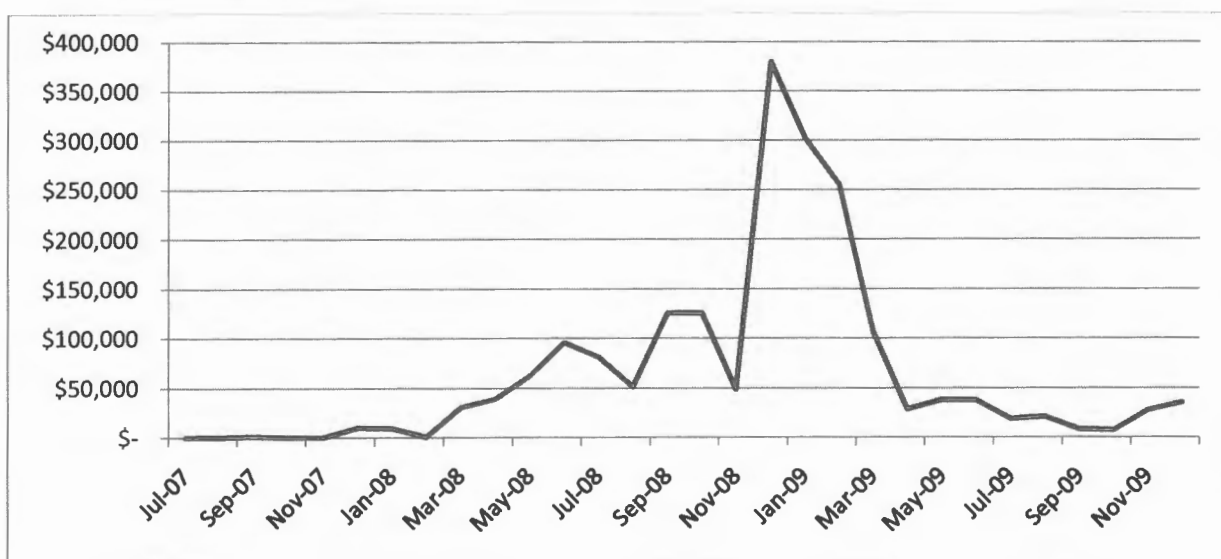
Through the use of brokers Bushy Park has been able to minimize working capital requirements for the plant. The average month end inventory value in Prince George was $460,137 USD versus $162,641 USD of BP-Raw1 and $64,820 USD for BP-Raw2. Kemira's weighted average cost of capital (WACC) is 7% so annual interest charges for carrying inventory are approximately $32,209.59 USD in Prince George versus $11,384.89

USD in Bushy Park for BP-Raw1 and $4,537.39 USD for BP-Raw2. Bushy Park's inventories and working capital would be significantly more if they did not have these external brokers. It is worth noting as well that in Bushy Park there is currently not enough warehouse space at the plant to store all of the raw material requirements. Hence Kemira would need to secure public storage and would incur additional transportation charges. The brokers currently provide this service but ultimately at a cost to Kemira.

Internally managed inventory in Prince George and externally managed inventory in Bushy Park is the difference between these two plants as each plant has adopted different inventory management strategies.

3.2   Visibility in the raw material supply chain.

By actively managing its inventories within the ERP system, Prince George has high visibility of inventory stocks and flows in the supply chain. Specific container shipment dates, container number and vessel arrival information are known. Currently in Bushy Park there is no such visibility or communication of the inventory status while in the supply chain. Inventory is updated via a monthly meeting with the broker who provides inventory updates.

All raw materials are warehoused in the Prince George plant so inventory counts and/or discrepancies could be reconciled quickly. In Bushy Park the inventory is not physically on site at the plant so a vendor must be contacted, who in turn needs to obtain this information from its contracted warehouse in order to confirm raw material availability and quantities.

All purchase orders are entered into the MRP system in Prince George at the time the order is placed so there is visibility in the ERP/MRP system. In Bushy Park purchase orders

are not entered into the ERP/MRP system until there is an immediate production requirement in the plant. An excel spreadsheet is shared between Kemira and the broker to keep track of all of the raw material inventories and is updated continuously. This excel spreadsheet must be checked to verify actual available inventories from the brokers.

In Prince George Kemira has control of the supply chain in that the raw material inventory is managed internally. Prince George is directly responsible and accountable for the procurement of raw materials. This responsibility is not shared with the vendor. In Bushy Park control is shared and the plant shares risk and responsibility with the broker. Ultimately Bushy Park is accountable for procurement of raw material however the broker is evaluated by Bushy Park on the basis of having inventory on hand in their warehouse for Kemira when demand dictates a requirement. One of the strengths of the Bushy Park supply chain is the trust and mutual confidence the plant has with the brokers. However, obviously there is a financial incentive for the broker. Both brokers are private companies and the financial health of these companies is not publicly available.

3.3   Stability of raw material prices.

One similar critical shock experienced by both Prince George and Bushy Park was the impact of the Beijing Olympics (August 2008) on the supply chain. It would be unreasonable to expect either of these two plants to have predicted the shock. However the robustness of the system in place to handle such unique risks (shocks) is certainly a vital component on an MRP system. No one could have predicted what would happen to raw material pricing and availability pre and post Olympics (Beijing 2008), but both Prince

George and Bushy Park responded as best they could to the signals and constraints evidenced in the market place based on the best information available each plant had at the time. Of the three raw materials PG-Raw pricing remained the most stable throughout the research period. BP-Raw1 has been hit the hardest with raw material price increases and nineteen months later has still not recovered to pre-Olympic (Beijing 2008) pricing. BP-Raw2 pricing escalated as a result of the bullwhipping rationing game and will be described in more detail in section 3.7. Lee et al, (1997). It took ten months for raw material costs to return to pre-Olympic pricing.

A significant purchasing mistake was made in August 2008 in Prince George. Kemira's sales department was demanding raw material price relief which purchasing achieved however the sales department should have been communicating with the customer to understand the customer needs and future demands. A purchase order for eight containers of PG-Raw was placed to take advantage of a price promotion. The price promotion represented a savings of $94,000 or raw material priced at 13% below market pricing however, the raw material inventories of PG-Raw were adequate at the time. In reality, it would have been very hard to predict that the PG-Final customers would stop usage of PG-Final. A purchasing decision was made to take advantage of a $94,000 savings yet $10,000 were spent in warehousing and transportation costs, $630,000 was tied up in net working capital and the inventory carried for more than six months and an estimated $22,050 in interest charges were paid (WACC 7%). This illustrates the type of poor management that can occur when decisions are handled myopically and is another instance of the effects that "bullwhipping" Lee et al, (1997) can have on a supply chain. Kemira modified its order pattern to take advantage of a price discount when, as it turned out, Kemira didn't really need

the raw materials. Better visibility of demand expectations by Prince George customers and system-wide communication of expectations might well have avoided this. Equally, the new contractual arrangements between Prince George and its customer, referred to above, would have mitigated much of these costs if communications were not fully transparent.

The average purchase price for PG-Raw was $3.48/Kg. The average price of BP-Raw1 was $12.61/Kg and for BP-Raw2 was $3.39. As you can see the price of BP-Raw1 is three times the price as PG-Raw and BP-Raw2. Both PG-Raw and BP-Raw2 have returned to pre-Olympic (2008 Beijing) pricing however BP-Raw1 has still not seen any relief.

Figure 5 - Raw Material Costs July 2007 – December 2009 US/KG
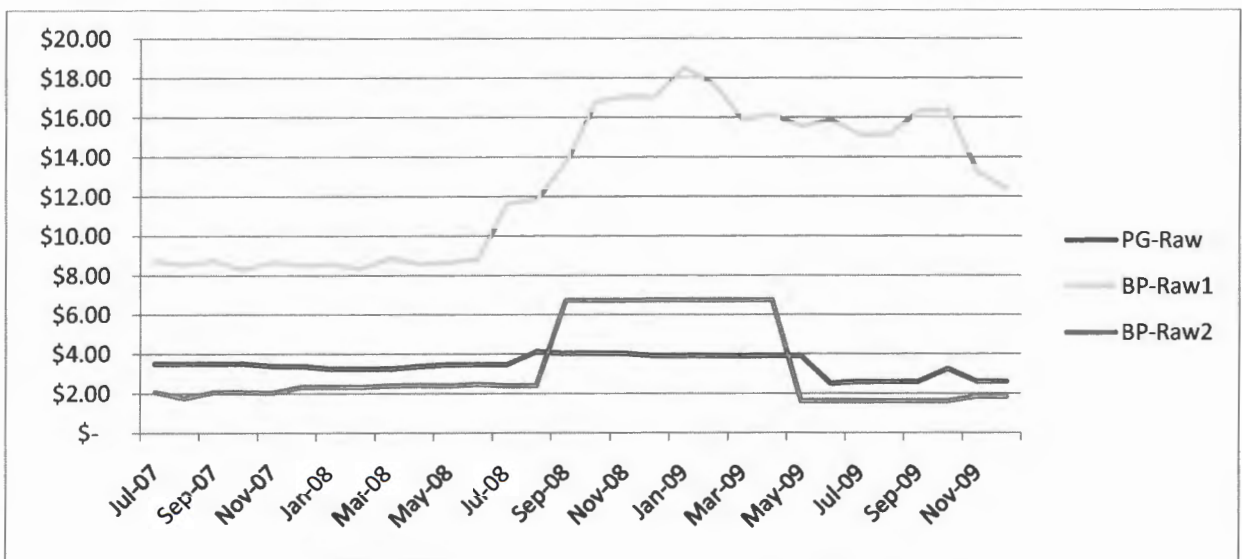
3.4 Passing along raw material costs to customers.

Figure 6 depicts the finished product gross margins from December 2007 to December 2009. (One should note that the gross margin data in all three finished products

from July 2007 to November 2007 is suspect due to issues involved in implementing the ERP system. Thus this information has not been included).

Both BP-Raw1 based products BP-Final1&2 are the only finished products that avoided a negative profit margin. On the other hand Bushy Park was not able to fulfill all of the customer demand for BP-Final1&2 and had to declare force majeure and lost customers as a result.

BP-Final 3 was sold under negative profit margins conditions for almost ten months until the BP-Raw2 pricing returned to pre-Olympic (Beijing 2008) pricing. The increased BP-Raw2 raw material costs were absorbed and were not able to be passed along to its customers.

PG-Final experienced a negative profit margin from July-August 2009. Market prices of PG-Raw had fallen to a ten year low and Prince George's inventory was 60% higher than the market price.

Similarly all three finished products experienced lower gross margins when higher priced raw materials were procured during the 2008 Beijing Olympics.

PG-Final is far more sensitive to price variability in PG-Raw than the raw material BP-Raw1 and BP-Raw2 which are used in BP-Final1&2 and BP-Final3 respectively.

Figure 6 – Finished Product Gross Margins December 2007 – December 2009
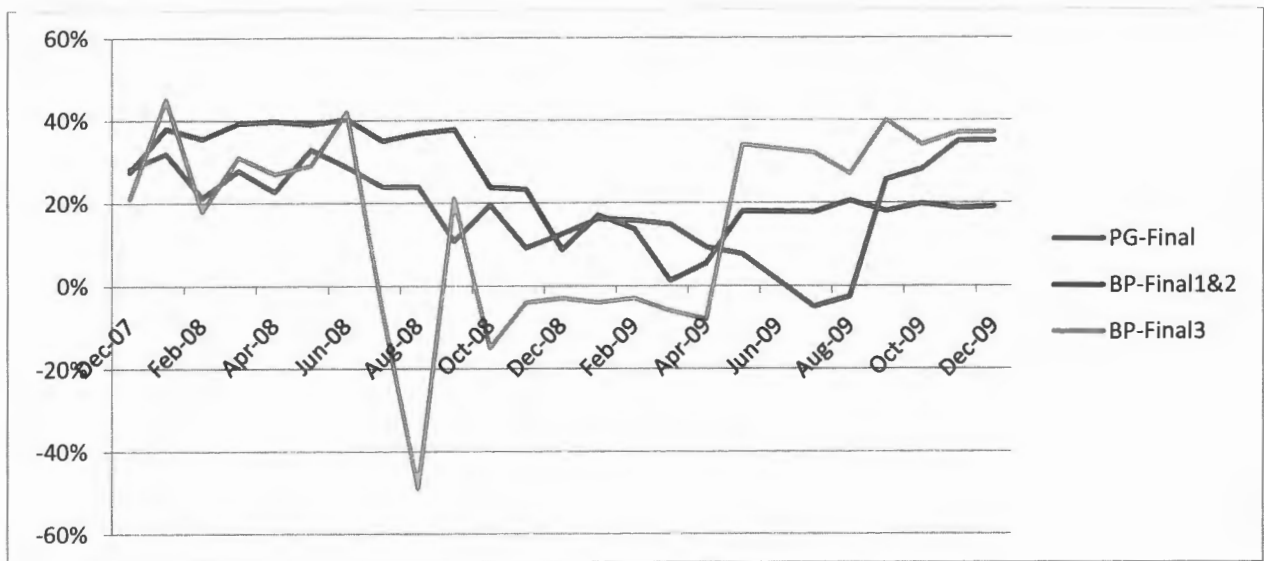
3.5 Identifying differences in costs structures between internally and externally managed inventories?

Procurement of PG-Raw, BP-Raw1 and BP-Raw2 would all have some currency

fluctuations from the Chinese RMB and Indian rupee. These exchange fluctuations are not

included in the cost structures analysis for the purposes of this research project as their

effects are small and relatively insignificant.

The cost of PG-Raw is determined by the FOB China price of the raw material, ocean

shipping charges and local trucking charges from the Port of Prince Rupert to Prince George.

Transportation charges represent 5.3% of the total PG-Raw total landed cost to Prince

George.

There are several additional charges that are added to the raw material costs of BP-

Raw1 and BP-Raw2 as a broker is used to manage Bushy Park's inventory. These additional

charges include warehousing costs, palletizing, shrink wrapping, and strapping, local

transportation and storage fees herein referred to as broker handling fees. These broker handling fees represent 14% of the total landed raw material cost to the Bushy Park plant from the broker or approximately $700,000 per year[1]. Not included in the analysis are the finance charges that the broker would factor into the cost of the raw material. One suspects that the broker has some ambiguity and/or uncertainly when and in what quantity they will actually make a delivery to Bushy Park. Such ambiguity would increase the broker risk and, as we discuss below, we would expect the broker to militate such risk by increasing the delivered raw material cost to Bushy Park.

3.6 Comparing customer demands at the Prince George and Bushy Park plants.

The central value of an MRP system is its ability to aid in meeting customer demands. As we will show in our data analysis of plant performance, Prince George has been able to meet all of its sales demand. Although the raw material PG-Raw may have been scarce or in short supply at times, the customer demands for PG-Final have always been met. The plant reports a 100% order fill rate and on time shipments 99.9% of the time.

Bushy Park on the other hand has had some difficulties with the supply of BP-Raw1 which will be discussed further in section 3.7. The raw material BP-Raw1 was in very short supply and Kemira was not able to meet its customer demands for BP-Final1&2. Customers were placed on reduced allocation and in several cases Kemira declared force majeure[2]. Kemira lost several customers as a result of the incidence.

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[1] The 14% was a value supplied by the broker
[2] Force majeure is defined "unforeseeable circumstances that present someone from fulfilling a contract." (Force Majeure Reference)

3.7   Frequency of Stock Outs.

Prince George has managed the raw material inventory of PG-Raw historically

through vendor consignment. Under the terms of vendor consignment PG-Raw was procured

and delivered to Prince George. PG-Raw was not paid for until it was actually consumed in

production. A month end physical inventory count was conducted, inventories were

reconciled and the quantities reported to the vendor. An invoice would be supplied by the

vendor and prompt payment made. PG-Raw could be kept on site under vendor consignment

terms for six months. After six months Kemira would be invoiced for all remaining

quantities on hand. Unlike typical consignment agreements, PG-Raw could not be returned.

Kemira was committed to all quantities procured.

Figure 7 below depicts the month end inventory balance for PG-Raw. The black

represents the inventory on hand which Kemira has a financial commitment. The grey line is

consignment inventory of PG-Raw that is on-hand in Prince George but not paid for. Kemira

Prince George was able to postpone some of the financial impact to the extent that it had a

six month grace period before the payment for inventories was required. Unfortunately a

change in suppliers in the fourth quarter of 2008 resulted in the vendors not being able to

continue vendor consignment terms. The switch in inventory management practices in the

middle of the data period is evidenced in Figure 7 when the consignment stock of PG-raw

was completely eliminated in January 2008. This also co-insides and explains in Figure 2

why the working capital requirements substantially increased of PG-Raw in January 2008.

A stock out occurred in October 2007 of PG-Raw due to customer demand increasing

at the Prince George Plant.   No customers experienced disruptions of PG-Final but in

response to this outage, extra inventory of PG-Raw was ordered to fill the supply chain

pipeline and PG-Raw inventory spiked to 450,000 Kgs in January 2008. By the time the extra inventory arrived, customer's demands had significantly shifted. This behaviour and distortion in information is a classic example of "bullwhipping" Lee et al, (1997) and its effects it can have on inventory management practices. Supply chain members responded to the increase demand in October 2007 by ordering additional PG-Raw, however the demand was just a spike and within one month the supply chain returned to normal. There was no way to stop the additional inventory procured and by January 2008 the Prince George plant had significant overstock of PG-Raw.

A second stock out of PG-Raw almost occurred in September 2009. Kemira's customer demand of PG-Final was increasing and Kemira could not replenish its supply chain quickly enough. This stock out was prompted by extremely low levels of raw material inventory being available from China as well as difficulties in obtaining ocean shipping space. The PG-Raw manufacturing plants in China were running at significantly lower production capacity due to overall decreased global demand of PG-Raw so they needed longer than normal lead time to manufacture and prepare raw material for export. One plant for example was running at 90% lower production rates than the same time the previous year.

Another problem attributed to the effects of bull whipping was that historically when PG-Raw was purchased it was ordered in batches of containers, a single purchase order could contain two to six containers shipped all at the same time. This created surging flows from order batching resulting in raw material inventory spikes. To ease these spikes the Prince George Plant started placing purchase orders based on only one or two containers and spacing the purchasing orders so that deliveries were spread out over the course of a calendar month. This strategy is referred to as "order smoothing." Dejonckheere et al, (2002).

Figure 7 - Month End Inventory (Kgs) PG-Raw July 2007 – December 2009
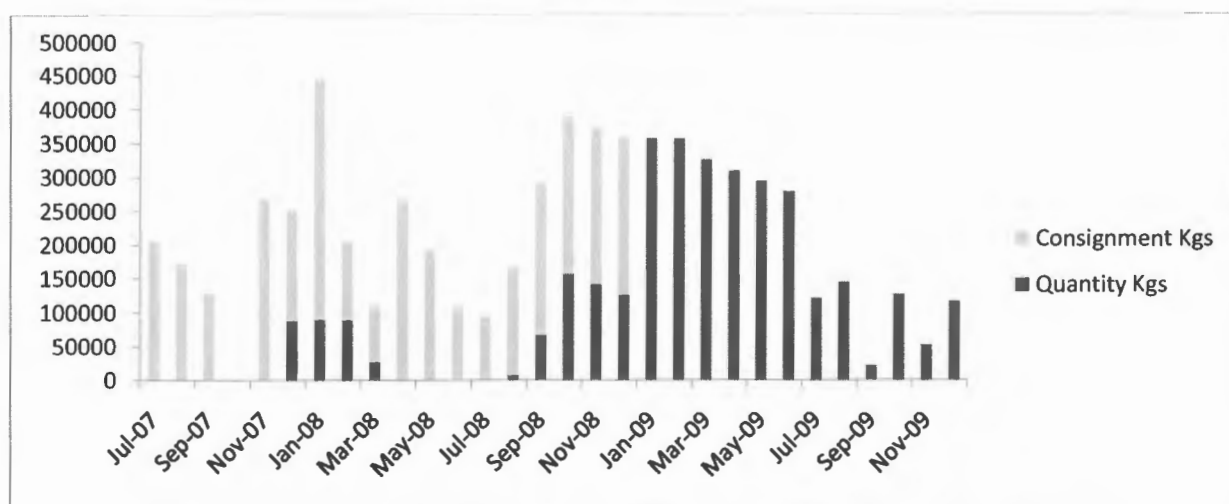
The presumption is that Bushy Park should not have as many swings in inventory as the brokers are supposed to be carrying Bushy Park's monthly inventories. Bushy Park has overall maintained lower levels of inventory up to a maximum of 50,000 Kgs. Figure 8 depicts the shortages of BP-Raw1 in which raw material scarcity wreaked havoc on the supply chain from January to April 2009.

The events that lead up to the shortages in January 2009 however could have been avoided if Bushy Park had been fully aware of the situation of the Chinese source of BP-Raw1. It seems a communication gap between Bushy Park, brokers and the Chinese supplier created an avoidable but disastrous situation for Bushy Park. In July 2008 one month prior to the Beijing Olympics the chemical factory had to shut down the production of BP-Raw1 as the chemical factory operated within the 1000 kilometer radius of Beijing. No hazardous chemicals could be produced or transported within this 1000 kilometer radius in anticipation of the August 2008 Beijing Olympics. The chemical factory was unable to receive raw materials and therefore had to shut down the production line of BP-Raw1. The area in Shanghai that the chemical factory operated had also developed into a densely populated

residential area. The local Chinese government no longer wanted a chemical factory that produced hazardous chemicals operating in the area. The local government ultimately exerted its power and successfully cut off the water supply to this factory. The factory was rendered helpless and was forced to relocate its operations in China to other areas designed for industrial/chemical production. This chemical factory represented 56% of the raw material supply of BP-Raw1 into Bushy Park. The production supply of BP-Raw1 was eliminated in July 2008, however Bushy Park did not see shortages of BP-Raw1 until January 2009, six months after the Chinese factory of BP-Raw1 was shut down. Had Bushy Park been totally informed of the situation in China and the troubles within the chemical factory, Bushy Park could have responded sooner and mitigated its risk. At the time of this writing this Chinese source of BP-Raw1 has resumed production in its new operations in another province in China however they will not be able to supply Kemira's requirements for BP-Raw1 until at least the fourth quarter of 2010.

It was not until March 2009 (9 months after the Chinese Source of BP-Raw1 stopped production) that the Bushy Park Plant Manager persuaded a German source of BP-Raw1 to begin production specifically to meet Kemira's needs for this raw material. Shipments were delivered to Bushy Park beginning in May 2009 and continued until June 2009. This vendor typically has chosen to operate its production equipment with other more profitable product lines rather than with BP-Raw1.

The force majeure in the product's BP-Final1&2 were a direct result of the Chinese source of BP-Raw1 not being able to fulfill Kemira's purchase orders. This exposed the plant to unnecessary risk. The plant did learn from this experience, in 2009 the plant purchased from three sources 27%, 34% and 39% respectively. The sourcing strategy now

includes the inclusion of several sources for this product at all times to mitigate risk and the risk spiral. Christopher et al, (2004). This situation illustrates why visibility and open communication with suppliers is so important in these long supply chains. The Chinese source of BP-Raw1 was able to continue to supply Bushy Park its short term requirements of BP-Raw1, however it did not communicate that it was not able to produce more inventory. This is why the effects in Kemira's supply chain did not reveal BP-Raw1 shortages until January 2009 (six months later). If Kemira had understood the situation with the Chinese source of BP-Raw1 in July/August 2008, the German source of BP-Raw1 could have been contacted in the fourth quarter of 2008 which potentially could have eliminated the shortages that Bushy Park faced with from having to declare force majeure of BP-Final1&2.

**Figure 8 - Month End Inventory (Kgs) BP-Raw1 July 2007 – December 2009**
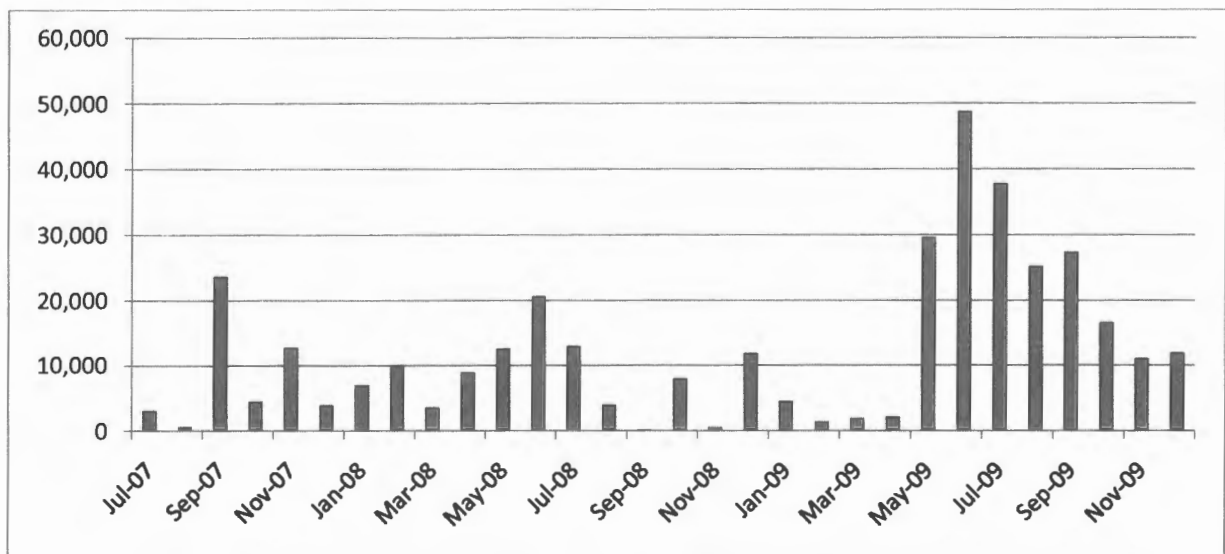
Bushy Park successfully managed its BP-Raw2 requirements with its brokers in 2007 and in the first quarter of 2008. Too much BP-Raw2 inventory was ordered in the fourth quarter of 2008 and inventories spiked in June 2008 and again in December 2008 as shown in Figure 9. Pre/post the Beijing 2008 Olympics raw material prices soared as many factories

were forced to close over environmental concerns, the global economy boomed and many raw materials were in high demand. This fear of raw material shortage prompted one of Kemira's brokers who had 70% share of this business to procure and secure additional BP-Raw2. The BP-Raw2 was delivered to Bushy Park in the fourth quarter of 2008 and from January to May 2009 the plant did not need to receive further deliveries. This illustrates another example of bullwhipping; specifically the effects of raw material rationing and gaming. Lee et al, (1997). The fear in the market place that the raw material may not be available in the future prompted this broker to secure higher priced inventory to mitigate expected concerns of not being able to obtain it in the future. The fact that Kemira and its broker responded to this fear, is another example of how supply chain member's behaviour amplifies the bullwhip effect. Andraski (1994). Not only did the plant carry additional raw material inventories, the raw material cost at the time carried a premium because it was in short supply and the profit margins of the BP-Final3 suffered greatly until all of the higher price raw material was consumed.

Figure 9 - Month End Inventory (Kgs) BP-Raw2 July 2007 – December 2009
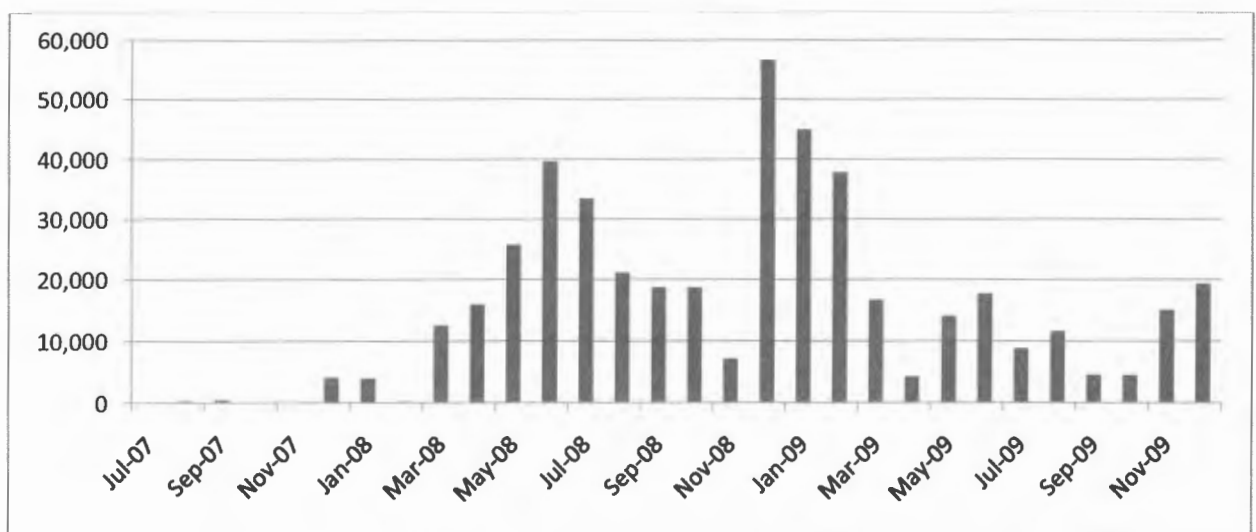
In Prince George the observance of increased demand signals resulted in supply chain members procuring additional PG-Raw which resulted in overstocks. In Bushy Park lack of information and understanding of the Chinese supplier of the BP-Raw1 situation crippled the supply chain. The effects of the rationing game Lee et al, (1997) was observed and supply chain members responded procuring additional BP-Raw2 which also resulted in overstocks. The similarities between the three raw material examples is that supply chain members behaviour ultimately affected the supply chain and resulted in some negative consequences. In contrast although Bushy Park was able to mitigate some financial risk in terms of inventory working capital because of the use of brokers (which could not be done in Prince George), it was not able to mitigate its risk of the increased raw material cost especially in the case of BP-Raw2. Eventually the higher priced BP-Raw2 was purchased and used in production in Bushy Park and finished product margins of BP-Final3 suffered.

Ultimately there was increased variability in demand in Prince George illustrating the higher risk associated with inventories of PG-Raw arriving directly into Prince George. Counterbalancing this we can see a lower average raw material carrying cost albeit there is an almost immediate impact of a financial burden. One sees decreased variability in demand indicating lower risk because of the use of brokers carrying the inventories (and the costs) but such lower variability comes with a significantly higher carrying cost.

3.8   Impacts of MRP introduction on rapid response to changing customer demands.

Kemira Prince George has had two long periods of demand interruptions of PG-Final. The first occurred in 2001 (not in the research data period) and again in 2009. Both of these demand interruptions were attributed to poor global pulp market conditions and customers

slowing down pulp production in their own operations to bring global pulp inventories back into supply and demand balance.

When Kemira's customers stopped usage of PG-Final unexpectedly in the fourth quarter 2009 on hand inventory of PG-Raw was 357,600 Kgs with no sales demand. Prince George did recover much more quickly from the 2009 sales demand interruption and within nine months new PG-Raw inventory was procured. This highlights a need that Prince George needs to have better connection to its customer demands linked through MRP. New contract terms have been negotiated with Kemira's customer to ensure that all inventory on hand or in transit of PG-Raw must be sold/consumed before the customer can stop using PG-Final. These new contract terms have reduced the risk that Kemira Prince George has previously been exposed to in the long supply chain of PG-Raw. It is not uncommon for PG-Raw inventory to be in the pipeline sixty to ninety days in advance. For the customer this means that notification of stopping usage of PG-Final today will mean the customer is still contractually obligated to use PG-Final for three to four months. This provides incentive for Kemira's customer to communicate with the Prince George plant to ensure appropriate PG-Raw inventory levels are maintained and approval obtained for inventory replenishment providing greater visibility in the supply chain upstream.

Figure 10 – PG-Final Sales July 2007 – December 2009 (Kgs)
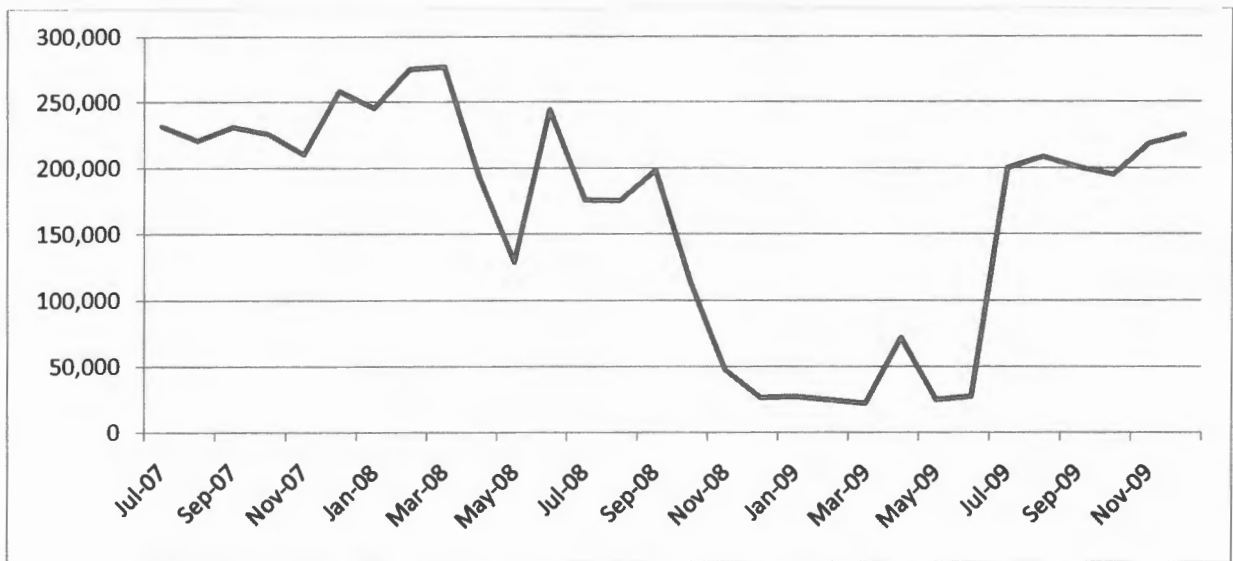
Figure 11 depicts the sales demand for the three final products of Bushy Park. Sales for BP-Final1&2 have been the most stable and the most volatile for BP-Final3. This data however does not reflect or include the lost sales and revenues due to the shortage of BP-Raw1.

Overall sales demand in Bushy Park is much more stable than in Prince George but Bushy Park's sales volumes are lower than in Prince George. Average sales volumes are 164,137 Kgs for the data period of PG-Final1 versus 60,812 Kgs for BP-Final1&2 and 63,316 Kgs for BP-Final3.

The difficulty in Prince George is the inability to deal with risk since this is a one product line manufacturing site. In Bushy Park the demand variations and risk are related to losing or gaining a new customer potentially on the basis of competitiveness in the market place based on finished product pricing or product quality.

Figure 11 – Bushy Park Finished Product Sales July 2007 – December 2009 (Kgs)
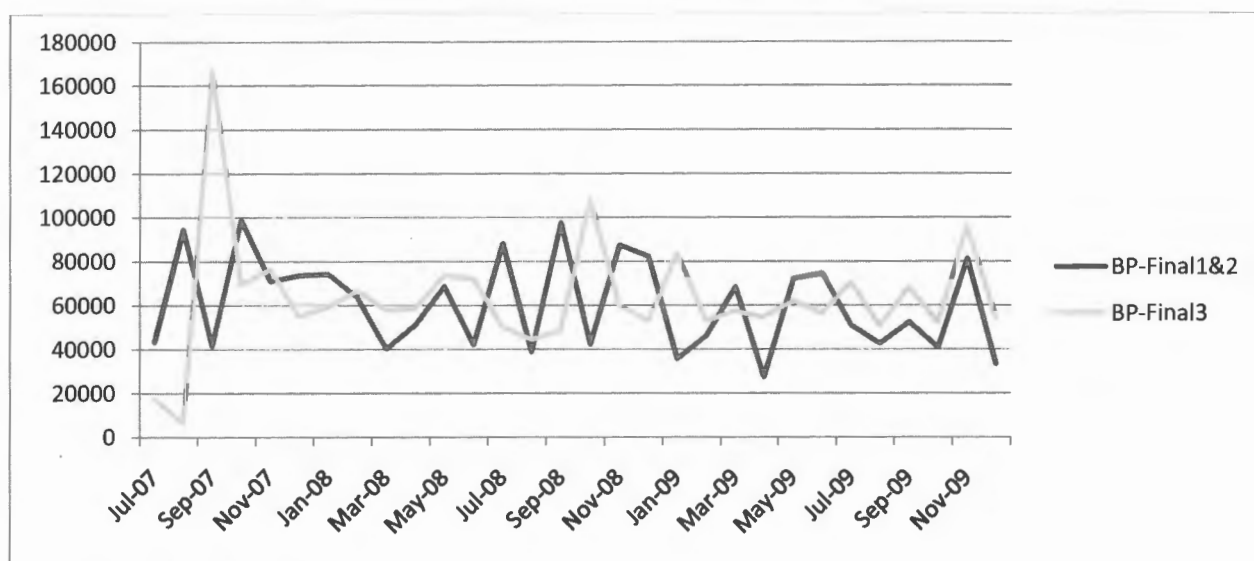
3.9 Estimating risks in dealing with raw material inventories

We expect the brokers in the case of Bushy Park to better manage the inventories compared to the self-managed system in Prince George. We expect that because brokers are being compensated for their expertise in managing these flows. Hence we expect lower risk of shortages and not the severe swings we might see without their facilitation.

There are of course risks in the delivery of physical inventories (the Kgs of material delivered) and risks associated with the financial flows associated with these inventories. In terms of financial risk there are really two concerns to the broker and to Kemira. There is the variability in prices (a pricing risk) and there is the variability in the overall value of the inventories being delivered (Kgs the inventory * price paid). In reality the broker must worry about the overall value risk since this represents the value of the inventory which the broker must deliver to their end user (Kemira).

A straightforward measure of risk whether it is physical flow (Kgs) or financial is the coefficient of variation (standard deviation/mean) or *cv* associated with these products.

In terms of physical inventories in the case of PG-Raw, using the data used to produce Figure 7 of the Kgs of inventory, we can estimate a *cv* of 1.09. In the case of PB-raw1, from Figure 8 we estimate a *cv* of 0.97 and from Figure 9 the *cv* for BP-raw2 is 0.97.

Hence we can see a lower (Kg) variability in both raw materials of Bushy Park (Figures 3 and 4) compared to Prince George (Figure 2). That is, it appears that brokers in Bushy Park are able to better manage the risks associated with inventory swings.

We see quite a different result when looking at financial risk. The variability on pricing is reversed. On price per Kg, using data from Figure 5, PG-Raw has a *cv* of 0.15 whereas BP-Raw1 the *cv* is 0.29 and BP-Raw2 is the highest with a *cv* of 0.65. That is, the pricing situation in Bushy Park is much more variable (i.e. riskier) than Prince George. Hence it would appear the brokers have a much more difficult time managing price fluctuations than physical flow variations.

As well, although arguably more importantly, if we look at the total value of inventories we see a similar pattern. Figure 2 in the case of PG-Raw provides a *cv* of 1.20. For BP-Raw1 using Figure 3 we get a *cv* of 1.17 and for BP-Raw2 from Figure 4 we get a *cv* of 1.43 These coefficients of variability reflect the month by month variability of the inventory in Bushy Park and we assume this variability reflects the risk the broker is facing since he/she must supply these raw materials when needed.

We can thus see that the broker faces a risk in agreeing to supply goods on contingency to Bushy Park. While contracted to deliver to Bushy Park both prices and financial value can vary considerably.

On a contingency basis, the broker must arrange supply from sources (at certain prices) and deliver when needed to Bushy Park (in an uncertain quantity and vague time). For this the broker charges an FOB/Kg price delivered to Bushy Park. This FOB price times the quantity delivered is Figure 3 in the case of BP-Raw1 and Figure 4 in the case of BP-Raw2. At a point in time we can treat this as $FOB_{Bushy\ Park\ Price} * inventory$. This, of course, ignores the lag effects between when inventory is purchased and when it actually flows into inventory but our purpose here is merely to describe a general model.

The broker must arrange supply. At a point in time we can say this is the *(purchase price)*(quantity acquired)*. We of course don't know the *purchase price* since this is the broker's responsibility. Furthermore, the real cost of supply to Kemira would be $(1+\alpha)*$ *(purchase price)*(quantity acquired)* since we would expect the broker to include a profit factor (α) into this price to compensate him/her for negotiating the supply contracts.

Delivery obviously requires costs of handling (packaging, shipping, warehousing etc.) for which we expect the broker to charge a markup. While we don't know what these costs are, as they are known only to the broker, we can hypothesis that they would be of the form $(1+\beta)*$[actual cost/Kg for handling] where α represents the markup (or profit margin) the broker charges for such handling activities.

At the same time the broker must be concerned with fluctuations in financial value of the goods being delivered. It is reasonable to suggest that the broker would require a risk

premium (which we will call γ) since the broker does undertake financial risk in operating on consignment. One simple measure of this is to regard this financial risk to be related to the variability of these financial flows. At any point in time this variability might be regarded as (*value of the inventory – average value of the inventory*)^2. Such values can be determined from Figure 3 for BP-Raw1 and Figure 4 for BP-Raw2. This variability is similar to the overall coefficient of variation from these figures but is evaluated for each point in time rather than overall (which *cv* does).

So we can hypothesis that the broker's view of risk at each point in time would be of the form:

FOB$_{Bushy Park Price}$*inventory = (1+β)*)*[actual cost/Kg for handling goods in inventory] + γ*(*value of the inventory – average value of the inventory*)^2 +(1+ α)*(*purchase price)*(quantity acquired*).

As noted in Section 3.5 of the paper as well as in Table 1, the broker has indicated that the costs of handling these inventories are 14% of the FOB price which implies:

0.14*FOB$_{Bushy Park Price}$*inventory =0.14*[(1+β)*[actual cost/Kg for handling goods in inventory]

So for each of BP-Raw1 and BP-Raw2 we have two equations that describe how an FOB$_{Bushy Park}$ would be arrived at. This is not to suggest that this model can be evaluated. We do not know the [actual cost/Kg for handling goods in inventory], nor the *purchase price* of materials brought into the pipeline. However, given the contingency model of a broker, we

can see that the broker's compensation is comprised of a markup (β) for handling the goods, a premium (γ) to compensate for financial risk and a profit factor (α) for arranging supply.

From the point of view of Kemira implementing an MRP system to gain visibility and better manage the flows of inventories is in effect to lower this risk premium (β). Assuming a continuance of the broker approach, likely little can be done to lower the cost since a broker's resources are needed over and above the actual handling costs to affect delivery. Furthermore, there are costs associated with arranging supply and hence one would not expect the profit premium (α) to be eliminated easily. In fact, if the system were to convert to an internally managed inventory system, it is likely that additional resources would be needed to replace α and β.

However, one would expect the MRP system, properly utilized to monitor information and coordinate better with the broker to have a big impact on reducing variability. That is, the coefficient of variation in both physical goods and in the financial value to be lowered. The lower overall inventory costs to Bushy Park are in effect, lowering this risk premium γ.

3.10 Summary of Findings and Comparisons

In Table 1 & 2 we suggest a series comparison (subjective and qualitative) of the two plants in meeting each of the MRP objectives utilized in this paper.

Table 1 – Summary of Results MRP Objective #1:

Minimize Inventory Levels

Criteria	PG-Raw	BP-Raw1	BP-Raw2
Working Capital Needs	High	Low due to use of broker	Low due to use of broker
Visibility in the Supply Chain?	Improved Visibility	Limited or Lack of Visibility due to brokerage	Limited or Lack of Visibility due to brokerage
Frequency of Stock Outs	2/30	8/30	0/30
Average Month End Inventory	110,185 Kgs	12,303 Kgs	15,262 Kgs
Month End Inventory Kgs Std Dev.	119,933	11,940	14,741
Coefficient of Variation	1.09	0.97	0.97
Average Raw Material Cost	$3.48/Kg	$12.61/Kg[*]	$3.39/Kg
Raw Material Cost Std Dev.	0.50	3.70	2.13
Coefficient of Variation	.15	.29	.65
Average Month End Inventory $	$460,137	$162,641	$64,820
Month End Inventory $ Std Dev.	551,944	189,710	93,000

Coefficient of Variation	1.20	1.17	1.43
Annual Interest Charges (7%)	$32,209.62	$11,384.89	$4537.39
Raw Material Cost Structures	5.3% (Transp.)	14% (Transp. & Broker Handling)	14% (Transp. & Broker Handling)

*BP-Raw1 has experienced a step-change increase which has yet to abate (Figure 5).

Table 2 – Summary of Results MRP Objective #2:

Improve product availability and enhance inventory control

Criteria	PG-Final	BP Final1&2	BP-Final3
Composition	60% PG-Raw and others	10% BP-Raw1 and others	7% BP-Raw2 and others
Meet Customer Demands	100%	75%	100%
Average Monthly Sales	164,137 Kgs	60,812 Kgs	63,316 Kgs
Monthly Sales Std Dev.	87,240	21,274	27,356
Respond Quickly to Changing Customer Demands?	Somewhat as there is visibility in the supply chain	Partial – some customer demands not met	Yes

Table 3 provides a summary of various effects of bullwhipping and the effects that it had on Kemira's various supply chains.

Table 3 – Summary Evidence of Bullwhipping and its Effects

Effect	PG-Raw	BP-Raw1	BP-Raw2
Poor Demand Forecasting	Figure 7	Figure 8	Figure 9
Order Batching	Figure 7	Figure 8	Figure 9
Price Variations	Figure 2	Figure 5[**]	Figure 5[***]
The Rationing Game	Figure 7	Figure 8	Figure 9

[**]Notice the step change in price of BP-Raw1 which has yet to abate

[***]BP-Raw2 price jumped up during the Beijing Olympics but has since subsided

Prince George has been able to meet all customer demands of PG-Final despite having two stock outs of PG-Raw. The plant is carrying more raw material inventory and has increased its working capital needs especially since PG-Raw is no longer supplied on consignment terms. The trade off from consignment is that there is more transparency in the raw material costs of PG-Raw and Kemira can source PG-Raw more competitively, leveraging each of the approved suppliers. When the vendor is offering a price of PG-Raw the vendor knows when the product will ship and when they will get paid. There is no ambiguity or unknown variable for the vendor to increase their offered price of PG-Raw to mitigate risk which was present under vendor consignment terms. When pricing requests are made, each vendor is offering a price under the same terms and conditions. This transparency allows Prince George to track and see true raw material costs changes.

Some recent improvements have been made to increase visibility in the supply chain of PG-Raw such as information on when a container ships from China and is expected to arrive in Canada. Within this visibility however, Kemira still has limited control in the supply chain especially in circumstances when there are shortages of PG-Raw from the manufacturer in China or limited ocean cargo space at the Port of China. With this increased visibility Prince George can somewhat respond more quickly to changing customer demands. Shipment dates of PG-Raw can be delayed if customer demand is decreasing or if one supplier is having raw material availability issues another supplier can be introduced to secure adequate raw material inventories. Surprisingly the raw material cost of PG-Raw was the most stable of the three comparison raw materials. Nonetheless increased raw material costs eroded profit margins of PG-Final which were not able to be passed along to Kemira's customers.

BP-Raw1 was plagued with the most difficulties throughout the research period. Customer demands for BP-Final1&2 were not able to be met and Kemira had to declare force majeure and lost numerous customers as result. The price of BP-Raw1 still has not returned to pre-Olympic (Beijing 2008) and was the most volatile of the three raw materials in the research study. Increased raw material costs have also not been able to be passed along to customers of BP-Final1&2 where profit margins eroded.

BP-Raw2 was able to meet customer demand and had no stock outs. Raw material pricing remained somewhat stable but the profit margins of BP-Final3 were the most volatile and negative for seven consecutive months (October 2008 – April 2009).

Despite using a broker to manage raw material inventories for BP-Raw1 and BP-Raw2 the plant increased inventory and working capital needs since implementation of the ERP/MRP system. Bushy Park has very limited or no visibility in the supply chain. The plant relies on regularly scheduled meetings with brokers for inventory status updates. Managing of raw materials inventories is being done through the use of an excel spreadsheet instead of through the ERP/MRP system.

Chapter 4

4.1   Recommendations and Best Practices

The purpose of this research project was to evaluate and compare two applications of the ERP/MRP system. The external approach in Bushy Park to managing inventory carries significantly less working capital requirements to Kemira. The trade off to this lower working capital requirement is in higher total delivered raw material costs. Carrying costs in Bushy Park represent 14% of the total raw material cost compared to 5.3% in Prince George. The external brokers mitigate risk by increasing raw material costs. Prince George carries a significantly higher requirement for net working capital however the plant has been able to leverage lower raw material costs from the Chinese suppliers which have recently resulted in higher profit margins.

Despite having two different models of managing raw material inventories both plants were affected by global events that posed problems in each respective supply chain (2008 Beijing Olympics). Both plants responded to the events based on the best available information that was available. Prince George was influenced from internal sales pressures to reduce raw materials costs and Bushy Park was influenced by fear of raw material unavailability to meet future demands.

The following recommendations can be made:

1. A better methodology of obtaining expert opinions which foster a disciplined communication between the customer, Kemira salesman, plant and raw material supplier must begin immediately. Raw material requirements should be updated based on early signals of observed customer demand. Lee et al, (2004).

2. Bushy Park needs to fully implement its purchasing activities in the MRP/ERP system. This would include entering purchase orders at the time that

requirements are confirmed to each broker. MRP would be used as a primary source for reviewing raw material requirements and will reduce the reliance of an excel spreadsheet to determine future raw material requirements. Forecasting decisions can then be made through MRP and monitored on daily or weekly basis instead of in preparation for a monthly meeting with the brokers.

3. As communication increases and more detailed shipment information is shared between the broker and Bushy Park, visibility in the supply chain will improve. Information must be shared between the vendor and the buyer as inventory moves through the various stages of the supply chain. These stages could be identified as: date available for shipment at the port or discharge, actual shipment date, shipment information and estimated arrival date at the port of entry.

4. Improve transparency in the supply chain as much as possible. Solicit information from the vendor/broker with the status of in-transit inventory. Information would include estimated ship date, actual ship date, estimated arrival date into the port of entry and estimated date that the inventory will be available to Kemira. Late shipments should be fully investigated to understand the root cause to determine if this is a single anomaly or something to take into consideration for future shipment.

5. Ensure a formal review process is completed with all interested parties (plant, sales department, customer future demands). This formal review process would ensure that all parties are aligned if additional inventory is going to be ordered to take advantage of a price promotion.

6. Review the working capital needs for the Prince George and Bushy Park Plant. These are the only two Kemira locations that rely heavily on critical raw materials from China or India which have long lead times. These plants are not the same as the rest of the Kemira production facilities who can readily source raw materials within one to two days. Consignment in Prince George began as a result of meeting blanket corporate wide reduction of net working capital. Much the same as Bushy Park whose business model with continuously changing customer demand could only survive with having raw material inventories readily available at a location in close proximity to the plant from these brokers.

7. It seems clear from this research that reliance on a single supplier bears considerable risk. Wherever possible, the firm should move to mitigate risk by introducing a secondary supplier and leveraging each supplier to obtain the lowest raw material cost possible.

The fundamental distinction between the two plants is that of the use of external brokers in Bushy Park versus internally inventory management in Prince George. We have provided some evidence to suggest that Bushy Park experiences lower variability in raw material inventories but at a higher raw material cost. The issue is whether the use of the MRP system could provide better control over the inventory swings (i.e. lower variability) and concurrently enjoy lower working capital costs in terms of inventory carrying costs. This paper suggests that this is the direction in which Kemira should move.

REFERENCES

Andraski, J.C, 1994. "Foundations for a successful continuous replenishment programme." International Journal of Logistics Management Vol 5 (1994): 1-8

Bean, Michael 2009. "Bullwhips and Beer: Why Supply Chain Management is so Difficult" http://forio.com/resources/bullwhips-and-beer/

Christopher, Martin & Lee, Hau 2004. "Mitigating Supply Chain Risk through Improved Confidence". International Journal of Physical Distribution & Logistics Management, Vol. 34. No 5, pp. 388-396.

Chopra, Sunil, Reinhardt, Gilles & Dada, Maqbool. 2004. "The Effect of Lead Time Uncertainty on Safety Stocks". Decision Sciences Vol 35 (2004)

Dejonckheere, Disney, S.M., Lambretch, M.R & Towill, D.R. 2003. "Measuring and avoiding the bullwhip effect: A control theoretic approach". European Journal of Operational Research 147 (2003): 567-590.

Disney S.M. & Towill, D.R. 2006. "A methodology for benchmarking replenishment-induced bullwhip". Supply Chain Management: An International Journal 11/2 (2006): 160-168.

Force Majeure, reference: http://www.askoxford.com/concise_oed/forcemajeure?view=uk

Forrester, J., 1958. "Industrial Dynamics – a Major Break Through for Decision-Makers. Harvard Business". Harvard Business Review Vol 36 No. 4 (1958): 37-55

Hamilton, S. 1981. "Evaluating Information System Effectiveness – Part 1: Comparing Evaluation Approaches". MIS Quarterly Vol 5 No. 3 (1981): 55-69

Leach, Peter. 2008. "The Bullwhip Effect". The Journal of Commerce February 11 (2008): 16-18.

Lee, Hau L, Padmanabhan, V & Whang, Seungjin. 2004. "Information Distortion in a Supply Chain: The Bullwhip Effect". Management Science Vol 50 (2004): 1875-1886.

Lee, Hau L, Padmanabhan, V & Whang, Seungjin. 1997. "The Bullwhip Effect in Supply Chains". Sloan Management Review, Spring (1997): 93-102.

Levy, D.L. 1995 "International Sourcing and supply chain instability. Journal of International Business Studies Vol. 26. No. 2 (1995) 343-360

Mason-Jones, Rachel & Towill, Denis R. 2000. "Coping with Uncertainty: Reducing "Bullwhip" Behaviour in Global Supply Chains". Supply Chain Forum No 1. (2000): 40-45.

Olhager, J. & Persson, F. 2006. "Simulating production and inventory control systems: a learning approach to operational excellence". Production Planning and Control Vol 17 (2006): 113-127.

Sterman J. 1989. "Modelling managerial behaviour: Misperceptions of feedback in a dynamic decision making experiment." Management Science Vol. 35 (1989) 321-339

Sugimore, Y. Kusunoki, K, Cho, F & Uchikawa, S. 1977. "Toyota production system and Kanban system, materialization of just-in-time and respect for human system". International Journal of Production Research, Vol. 15 , No. 6, pp. 553-64.

Svensson, Göran. 2005. "The multiple facets of the bullwhip effect: refined and re-defined". International Journal of Physical Distribution & Logistics Management Vol 35 (2005): 762-777.

Umeda S. & Zhang F. 2006. "Supply Chain simulation: generic models and application examples". Production Planning and Control Vol 17 (2006): 155-166.