Determining Production Lot Sizes and Reorder Points in the Manufacturing of Moulded Fibre

Ville Hämäläinen

Master's Thesis

___. ___. _____   _____

Master's degree (UAS)

SAVONIA UNIVERSITY OF APPLIED SCIENCES
THESIS

Abstract

Field of Study			
Technology, Communication and Transport			
Degree Programme			
Degree Programme in Industrial Management			
Author(s)			
Ville Hämäläinen			
Title of Thesis			
Determining Production Lot Sizes and Reorder Points in the Manufacturing of Moulded Fibre			
Date	23.1.2013	Pages/Appendices	28
Supervisor(s)			
Jarmo Pyysalo LicEng, Senior Lecturer			
Client Organisation/Partners			
Moulded fibre factory			

Abstract

Competition in the target company`s business branch has tightened. Improvements in stock management would improve the competitiveness of the company.

Targets of this study were to create cost effective systems to releasing capital tied up to the finished storage and defining and assuring customer service level and with the help of that improving the profitability. The fourth goal was to explore the possibility to build up a fast, simple and cheap tool for planning the production of finished goods.

The study is were applied action research methods. This study is third and last part of LEKA – subprojects series done to target company.

The company follows finished good inventory on general level with minimum and maximum inventory levels. The current system sets limits to the inventory levels of total finished goods and it gives a general view to warehouse. Inventory monitoring on product group- and item level is not in focus. Good finished goods in ventory management would shift focus on product group- and item level by calculating safety stocks, order points and economical production quantities for items that should be kept in storage

The Study gives overlook to company`s warehouse management and points out areas for improvement. One of the suggested improvements has already been taken into use and other suggestion is presented to one of the key customers. The study has highlighted the importance of inventory management and management tools will be developed more in future.

Keyword			
production lot size, reorder point, warehouse management			

CONTENTS

1   Introduction

The target company of this thesis project is a producer of egg packages. Because of the high service level and especially short delivery time requirements, company must keep a large storage of finished goods. This work will concentrate on the storage management of finished goods in the target company. The aim of this project was to study how production lot sizes of the finished goods and re-ordering points were defined and to find ways to improve it.

Recently the competition in this business branch has tightened. Therefore improvements in stock management would improve the competitiveness of the company. This study is the third, and last, part of a series of LEKA -subprojects in the target company. In this study action research methods are applied. The writer has been working as Production Manager for 5 years in the company. Research includes confidential information about organization`s performance and therefore the real data shown in tables is very restricted.

The main targets of this work were to create cost-effective systems to release capital tied up to the finished storage, and to define and assure customer service level, and by that improve the profitability. The fourth goal was to explore the possibility to build up a fast, simple and cheap tool for planning the production of finished goods.

The company divides its customers to A, B, C and D groups according to yearly sales. This study was restricted to customer group A. The company guarantees best service level for group A customers. In order to provide 100% service level and fast deliveries, it means that the factory has to have their goods in the finished goods storage ready to be shipped.

The short delivery time is one of company`s key advantages compared to other competitors. On the other hand, in this case, short delivery time creates a need for storages od finished goods. Unnecessary high storage levels tie a lot of capital. When the storage size is right customer service level, the production can still run smoothly and there is no extra capital and the storage costs will decrease.

The basic data of sales and production for this study is collected from firm's Enterprise Resource Planning system's database.

The next chapters consist of the general information of the target company, its customers, its competitors and production. The theory part of warehouse management is gathered to chapters 3 and 4. Chapter 5 is about case study and conclusions are in chapter 6.

2 The packaging corporation

The corporations' headquarters are situated in Denmark. The organization employs approximately 1500 people in 10 countries. The organization has five production units in Europe and one in North-America and twelve sales offices around the world. The organization has customers in fifty countries. The organization has approximately a 40 percent market share in Europe in moulded fibre eggpackages.

The corporation has two business branches. The main business branch is agricultural packages and secondary business branch is industrial packages. In addition the organization has its` own technology unit which develops and produces package production machinery. Technology unit also sells production lines to external customers. (Taija Räsänen 2012)

2.1 Target unit

The target company is located in Finland and it started package production in 1959 .The factory has had many owners before the contemporary firm. It has been the owner of the factory since year 2000. The company employs approximately 45 people.

The target unit is focused only on agriculture packages. During the study period the semi finished package production portfolio contained four different package types in five different colors. The semi finished packages were mass customized to finished goods with 185 different print models. Yearly production volume is from three to four thousand tons of packages. The main market of the company is western Scandinavia, where it has a leading market share. (Taija Räsänen, 2012)

The target company is one of the corporation's smallest factories. The organisation has an efficient team: people is able to multitask: quality, safety, maintenance and production are close together in daily tasks and they develop factory in many different areas.

Moreover, finance, payroll and sales are located outside of factory area. The target company is planning to build more offices to the factory, so the administration would be located under the same roof, and this way it would get even more synergy benefits.

The operative organization is lean and effective. Therefore every shift has a first man, who participates in production, and he is also responsible for activities in the factory in the evenings, at night and at weekends.(Jarmo Suomalainen, 2012)

2.2   Customers

The company`s main customers are packing stations. Packages are also sold to wholesalers, who sell the packages to small packing stations. Depending on the market, company negotiates sales contracts with the packing stations, and wholesalers, or also with retail chains.

The company`s customers are divided into groups, A, B, C and D. Group A includes the main customers and represents 80 percent of yearly sales. The Group A customers has the best service level and the organization is committed to keep goods ready for shipment in the storage. Group B is for medium size customers. The factory has their fast moving packages ready in storage, and for slow movers the company will require a couple of day's delivery time. Group C and D include small customers. They have the longest delivery times: normally it`s 4-7 days. Customers are reviewed yearly and divided into groups. (Sari Kiira, 2012)

2.3   Competitors

The market for target company's products in Europe is mainly shared with a few large producers. Most of the competitors have their own package production in Europe. Also Chinese package producers have found their way in Europe. (Sari Kiira, 2012)

During the last few years competition has tightened. Competitors who were not interested in target company`s markets earlier, have activated and offer packages actively to target company`s customers. The competitors' product quality, which was earlier poor, has improved a lot during the past years. Good product quality combined to competitive pricing increase customers will to try the competitors' packages. (Sari Kiira, 2012)

Some considerable competitors, who have limited production capacity, offer package batches to the target company`s customer. They deliver full lorry packages to target company`s customers every now and then. It has impacts on target company's sales forecasting. Demand from target company decreases suddenly, when customer receives shipment from competitor. This increases target company`s inventory levels because forecast didn`t see competitors shipment. (Sari Kiira, 2012)

All of these changes in competition affect negatively target company's profitability and lay stress on the need for development. Competition in sales prices emphasizes the need for cost and capital effectiveness.

2.4 Production process of egg packages

Package production is represented in picture 1 on this page. It starts from collected waste paper. Fibers are released from each other by using warm water and rotation. This process is called pulping. When wastepaper is pulped, impurities are taken away with paper pulp cleaning device.

Clean pulp is transferred to package machine. The machine modifies paperpulp to the requested package shape.

Wet packages are transferred into drying oven.

After the oven the package is handled in finishing line. Finishing line irons package surface with hot tools.

Finished packages are stored to intermediate storage.

When a customer`s order is received packages are mass customized in printing machine according to customer`s needs.

Printed package is ready for shipment to customer.

Picture 1. The egg package production process (Sustainability report, 2010)
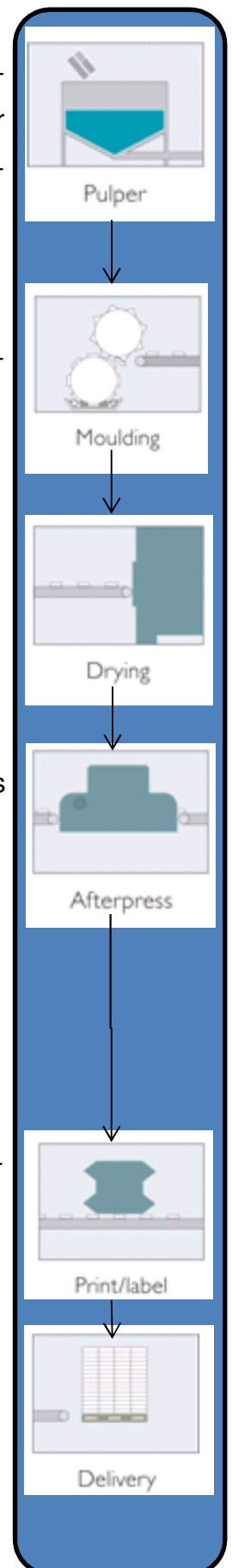
3   Inventory functions

Production complexity and customer`s needs often creates a need for inventories. In  perfect manufacturing there would be LOT for LOT sizing ( make to order ).  LOT for LOT sizing has a lot benefits, but it`s not always a possible inventory strategy.

Inventory's main function is balancing between supply and demand. In many business branches there are high and low seasons in sales. During the low season it might be wise to prepare for high season and build extra inventory. But on the other hand, high stocks create high risks to inventory. Concerns about obsolescence or item getting spoiled can make high inventories less tempting or too risky compared to advantages.

Safety stocks are created to protect against all possible uncertainties. Creating safety stock can be seen in two different ways. On one hand setting levels knowledge is often based on history data. On the other hand estimating future can be difficult, because future can be different compared to the past. Demand can suddenly grow if a customer forgets to inform about his sales campaign. A breakdown or sudden sick leaves in production could shut down production line suddenly for a couple of days or at least delay shipments to customers. These things could have an effect on customer service and in the worst case competitor can supply your customer when you cannot and you wil lose a customer. Overstocks are often a result of poor control and safety stock planning. (Coile 2009, 247,248,249)

3.1   Inventory for functional areas

For marketing, inventory's main task is to help answer to the changing demands of the customers. The correct level of the right item is vitally important in fulfilling demands and needs. Marketing often has a habit of having some extra inventory, for making living easier for them.(Coile 2009, 331)

Improving production efficiency with batching economies, cheap production with long series and minimum amount of changeovers lowers production setup costs per item, but on the other hand it increases inventory costs. (Coile 2009, 325) If business has seasonal

demand pattern, it may have really high inventories before high season for minimizing production costs. (Coile 2009, 331)

When looking at inventories with the eyes of finance department, they often want to see inventories as low as possible. No more capital tied up to storage than is really needed. (Coile 2009, 331)

All of these three organizations functional areas have a bit different point of view to inventory. Finances want to have low inventory for keeping inventory turn fast, but sales and production wants to maintain high inventory levels to retain good service level and low production costs. In addition, when production has a long production series and the sales sell something that they do not have on stock, it immediately creates conflict between those two functions. (Coile 2009, 331)

It is important to understand that inventory management has a great influence on customer but also on organization`s functional areas. Inventory is a major expense in logistics, but on the other hand, it gives advantages to business. Setting inventory levels is a compromise between costs and resulting service. (Coile 2009, 331)

3.2   Cost of carrying inventory

Calculating carrying cost includes three phases. First phase is a value of items in inventory. It includes materials, direct labor, overheads and transportation from production to warehouse. In other words cost of goods sold. (Coile 2009, 333)

Second phase is to find out price for each component of carrying expense. The costs are divided into two; to variable-based and to value-based costs. Freight to distribution center, Labor costs in distribution center, space cost and insurance are variable-based costs. Interest, taxes, loss and damage and obsolesces are counted to value-based costs. (Coile 2009, 334)

Third phase is to divide inventory carrying expense with the cost of goods sold. The result is inventory carrying cost percent. (Coile 2009, 334)

3.3   Setup cost

Costs coming from product change on production line are included into setup costs. Operator salaries used for product change, lost production during change, and startup / adjusting waste are the most common setup expenses. (Coile 2009, 336)

Changeovers in production line can have effects on upstream production processes. If organization has intermediate storage before production line, where changeovers are done, it´s possible that extra changeovers decrease production line`s output and intermediate storage gets full. Full intermediate storage will then close upstream production. Costs coming from closing upstream production can be much more than direct cost included into setup costs. (Coile 2009, 337)

4   When to produce

The remanufacturing point in inventory (R) is the point when manufacturing should be started to prevent possible stock out. If demand and performance-cycle are steady and well known, basic reorder formula can be used (Donald J.Bowersow, David J. Closs 1996, 258) :

$$R= D \times T$$

where R=remanufacturing point in units
    D=average daily demand
    T= average performance cycle length

If there are uncertainties in demand and- or performance-cycle, safety stock must be counted in for improving reliability of delivery. Instructions for safety stock calculation are on page 17. Manufacturing point formula with safety stock is (Donald J.Bowersow, David J. Closs 1996, 259) :

$$R= D \times T+SS$$

where R=reorder point in units
    D=average daily demand
    T= average performance cycle length
    SS=safety stock in units

4.1   How much to produce

Economic production quantity, also known as EPQ can be calculated mathematically. Idea of EPQ is to find production quantity, which minimizes both production setup costs and inventory holding costs. (Donald J.Bowersow, David J. Closs 1996, 261) E.W Taft founded EPQ method in 1918. EPQ is extencion for EOQ calculation. EPQ has some basic assumptions, which are good to keep in mind when using this model. (Calculate EPQ)

1. Demand for inventory items is continuous and at a constant rate
2. Inventory replenish has regular intervals
3. Production has continuous and constant rate
4. Setup cost and lead time is fixed
5. No discounts available
6. The replenishment is made incrementally

Basic EPQ is a simple tool for directional inventory planning. Basic EPQ can be extended solving more complicated. (Coile 2009, 351,352,353)

For calculating EPQ some basic variables are needed(calculate EPQ):

K= setup cost

D= demand

F= holding cost

P= production rate

X= demand / production rate (D/P)

$$EPQ=\sqrt{2KD/F(1-X)}$$

Example:

K= 80 €, D= 100000, F= 0,5€, P= 80

EPQ= $\sqrt{(2x80x100000)/0,5x(1-59,8/80)}$

EPQ= $\sqrt{16000000/0,5x0,75}$

EPQ= $\sqrt{16000000/0,125}$

EPQ= $\sqrt{128000000}$

EPQ= 13131 pcs

4.2   Compensating uncertainties

The first steps for safety stock calculating is to decide the service level for the item. Normally management defines service levels as strategic decisions. Service level needed for safety stock calculation is percent, of how many units or cases can be shipped as ordered.

Second figure to pattern is average replenishment cycle in days and standard deviation of replenishment cycle. Replenishment cycle means time from order to shippment.

Third and last is average daily demand in units and standard deviation of daily demand in units. When knowing those variables it`s possible to create formula for safety stock calculation (Coile 2009, 353-360):

$$\sigma_c = \sqrt{R\sigma^2_s + S^2\sigma^2_r}$$

where σ_c= safety stock size in units for satisfying xx %

   R = average replenishment cycle in days

   σ_r= standard deviation of average replenishment cycle in days

   S= daily demand in units

   σ_s= standard deviation of daily demand in units

5   Target companys inventory analysis

The company has divided customers in to A , B , C and D groups. Customers in group A have the best service level, which in this case means that company is always committed to keep their goods in storage. Some of group A customers have defined a minimum safety storage level for storage items. In most case safety storage levels are not defined to items.

Logistical difference between B, C, and D customer groups is delivery time. If demand has been stable, the production has produced products to B, C or D customers to storage. In some cases there has been two to six months demand on inventory for B,C or D group customers. This is because of batching economies. If there has been time and recourses for producing extra items after filling an order, production has seen opportunity to reduce two to six extra changeovers from production line.

At the moment the company has no special focus on inventory costs on item level. Organization has defined minimum and maximum level to final goods inventory. According existing inventory policy, final goods inventory level is good when it`s between defined minimum and maximum level.

Item lot sizes are determined regarding what fits production best. Reordering can happen even if a lot of old inventories exist.

The company has an ERP-system. At the moment it is mainly used for production information collection and for monthly inventory checks.

Chart 1 show maximum and minimum inventory levels and visualizes how inventory has changed during selected twelve month study period. The inventory level decreased during third and fourth month near to minimum inventory level. After fourth month inventory level increased till eleventh month. After eleventh month inventory level started to decrease again. Inventory level is mainly fine between the defined minimum and maximum levels.
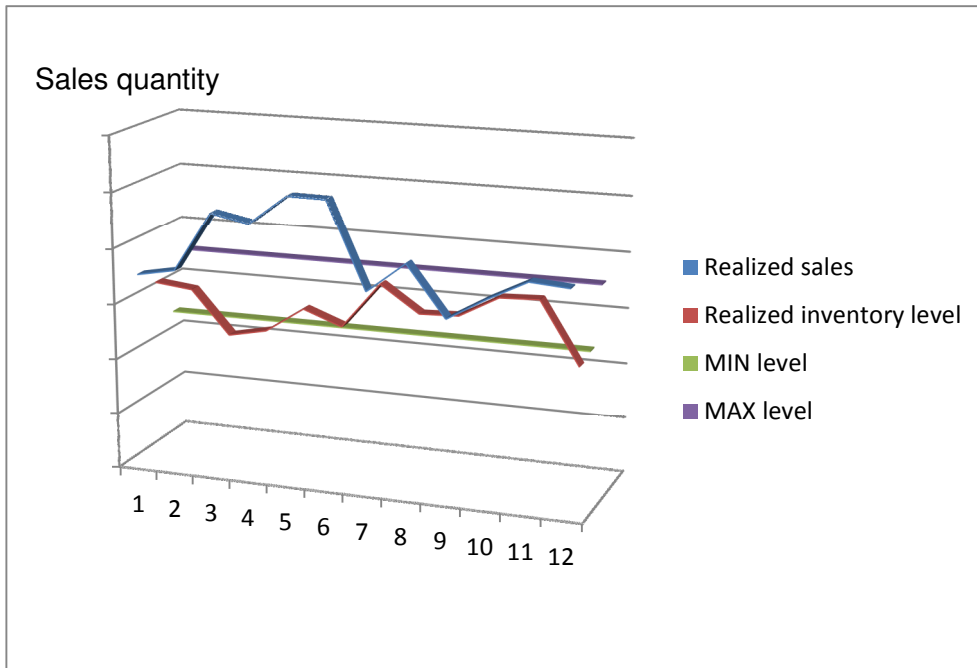
Sales quantity

Chart 1. Movement of inventory level during a twelve month research period.

5.1 Product groups in inventory

The company's storage of finished goods consists of four different kinds of packages. All packages are provided in four colors and mass customized according to customer`s needs. Chart 2 shows how four package types are divided according to total sales volume.
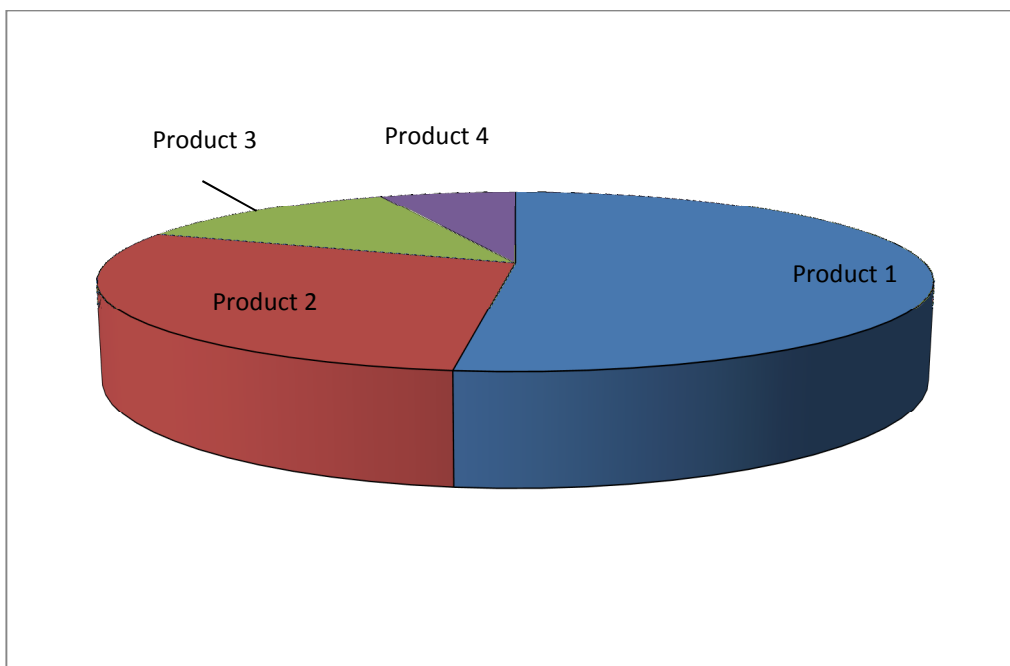

Chart 2. Product groups share from total sales volume.

The main part of the sold items belongs to Product group 1. 77 percent of product group 1 sales belong to customer group A. Customer group A has 19 different items in product group 1 which production organization is requested to keep always printed in storage.

Product group 2 is the second largest product group. 73 percent of product group 2 sales belong to customer group A. Customer group A has eleven different printed items in product group 2 which production organization always keeps in storage.

Groups 3 and 4 are the smallest product groups. 49 percent of product group 3 sold items belongs to customer group A. Product 4 items are printed based on orders. Product group 3 has three items for customer group A, which are kept in storage.

All in all during the study period the company printed 33 different items for customer group A. Totally 185 different items were printed during the study period. Approximately 80 percent of printed items belong to customer group A.

5.2 Product group 1

Product group 1 has the highest impact on inventory and, it has the biggest share of sales. Almost eighty percent of total sales volume is for customer group A. During research period sales for customer group A have varied relatively little. (Chart 3).

The B and C customers have sales peak between periods three and six. The capacity for producing extra product group 1 products was taken from product group 4. Product group 4`s high inventory level allowed decrease of inventory level and it made extra product group A production possible. (Chart 9).

The total Inventory level has increased gradually after the third period. The highest level was in the first period, when the inventory level correlated to period`s sold item volume. The lowest level was during the fifth period when inventory level was half of the period sales (Chart 3).
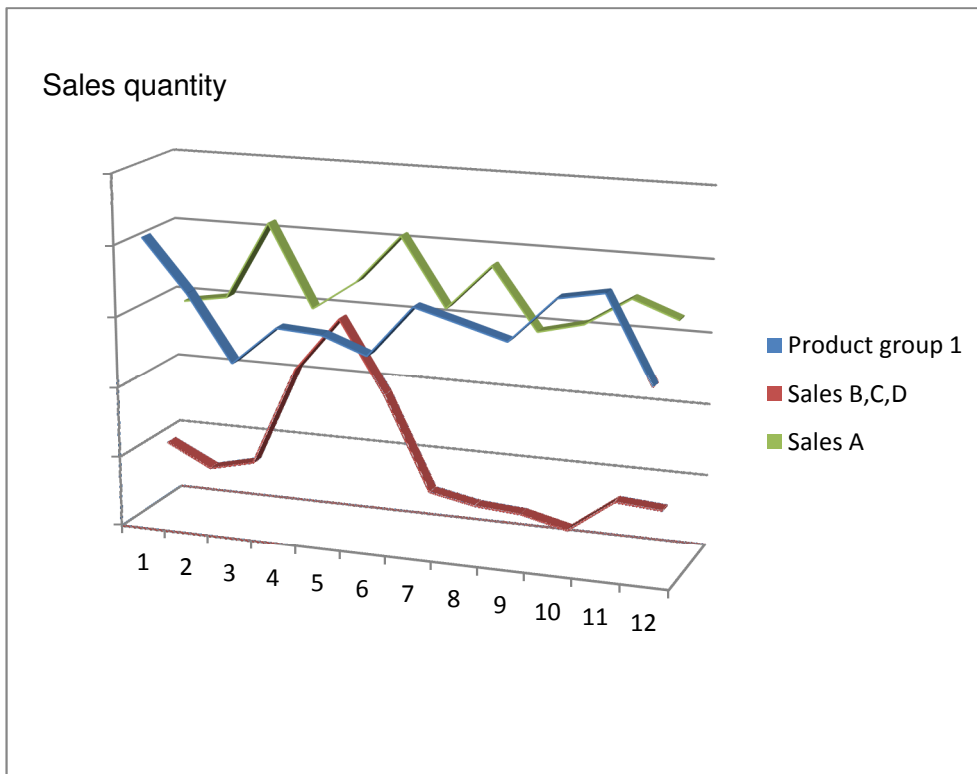
Sales quantity

Chart 3. Product group 1`s inventory level and sales volumes for customer groups.

When comparing the forecast and realized product group 1 sales, it can be seen that the forecast and realized sales are balanced together with the exception of the increased B and C customers sales during periods three and six (Chart 4).
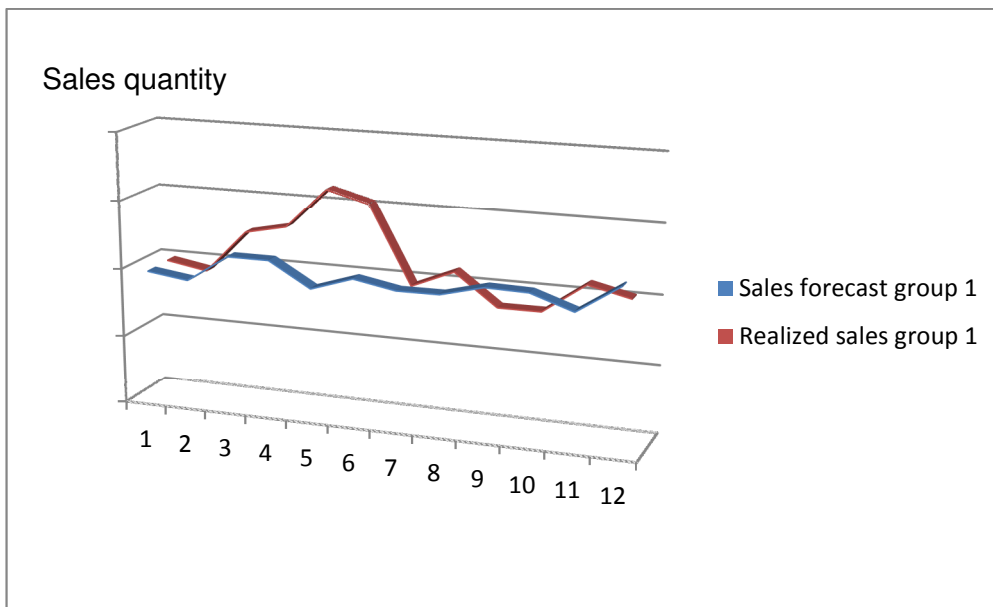
Sales quantity

Chart 4. Forecast and realized sales in product group 1.

5.3   Product group 2

The product group 2 is the second largest group. Approximately 70 percent of total sales of product group 2 belong to customer group A. Sales for customer group A hava been relatively stabile, excluding the first period. It could be that some part of period one sales were transferred to second period (Chart 5).

Sales for B and C groups have been constant during the research period (Chart 5).

The product group 2`s inventory level has been rising from the first to the eleventh period, in the twelfth period the level has decreased rapidly. The inventory level has been almost period`s sales volume at period eleven. The lowest level has been in the third period when inventory level correlates one third of the period`s sales volume (Chart 5).
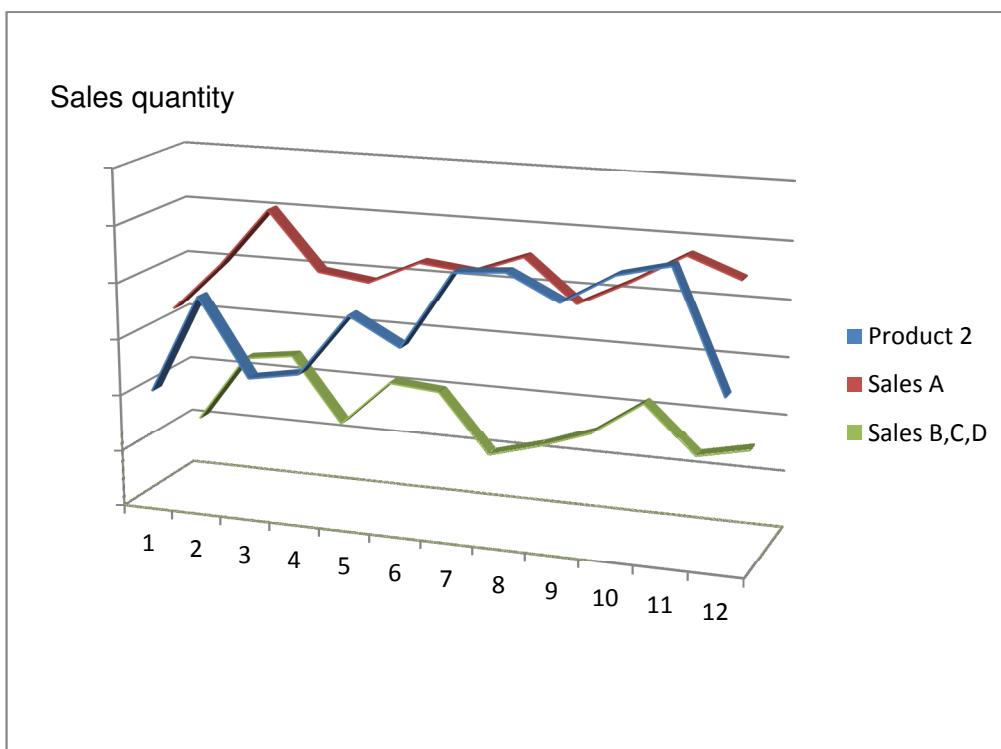

Chart 5. Product group 2`s inventory level and sales volumes for customer groups.

Chart 6 comparison of product group 2`s forecast and realized sales. The forecast has been well aligned with realized sales, except the start of the research period, when sales have been a couple months higher than what it was forecast.
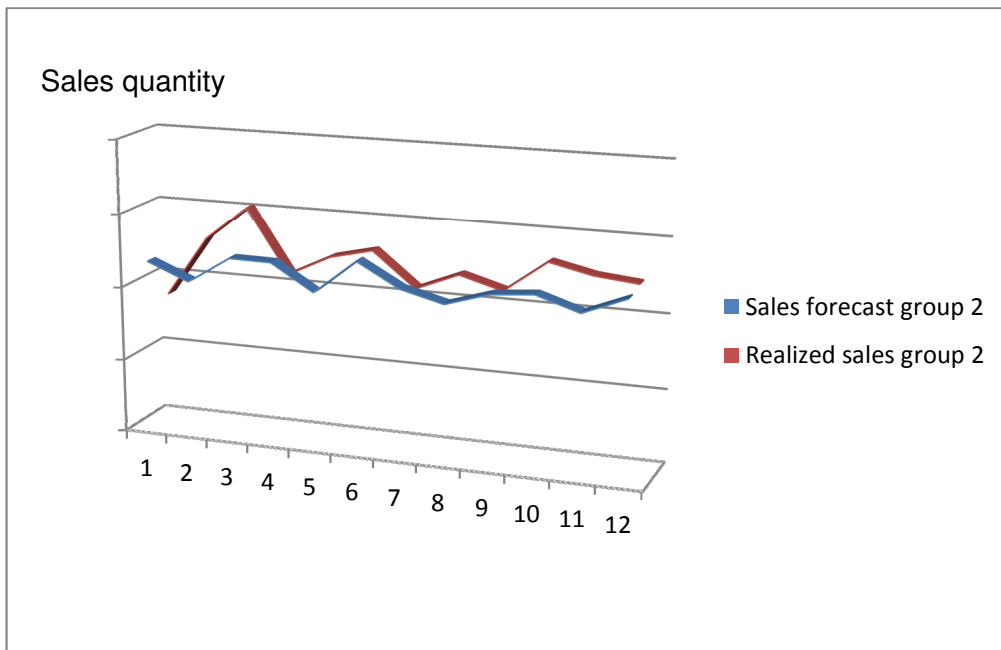
Sales quantity

Chart 6. Forecast and realized sales in product group 2.

5.4   Product group 3

Product group 3 has the second smallest sales volume. Sold amounts for customer groups A and B+C have been equal during the research period. Storage level has been around one period`s sales volume and even more during the first seven research periods. During the rest of the period the inventory has decreased.
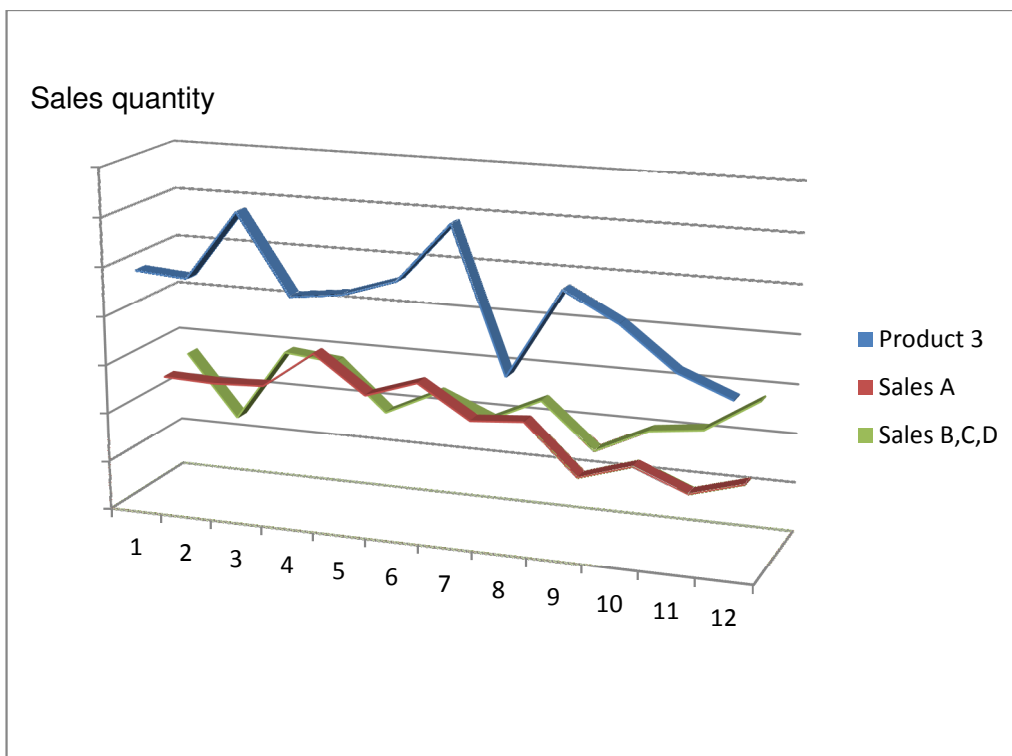
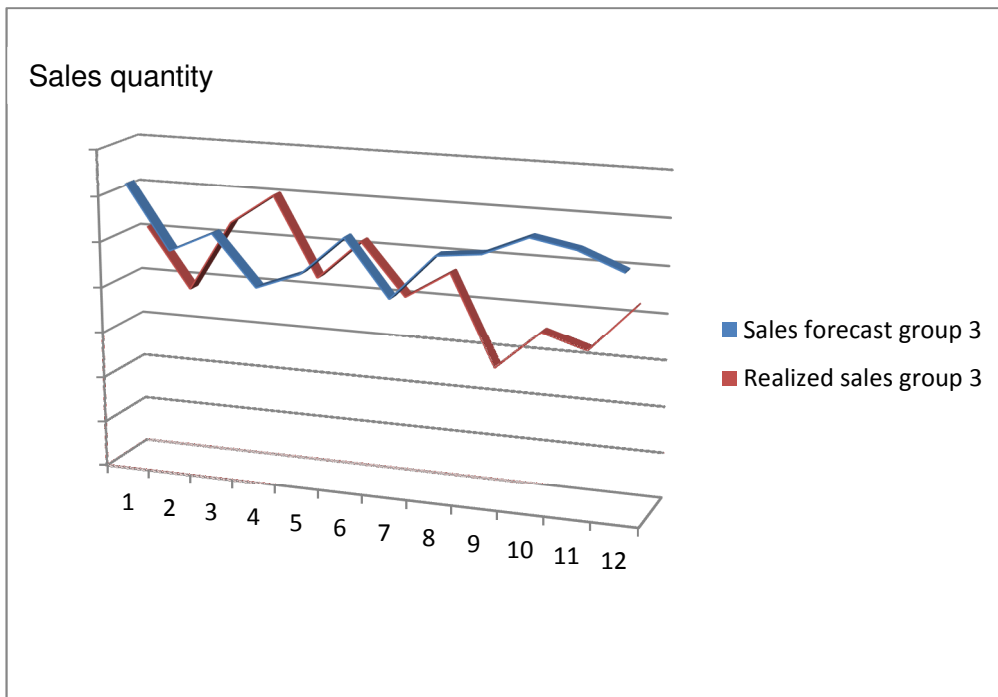Chart 7. Product group 3`s inventory level and sales volumes for customer groups.

Chart 8. Forecast and realized sales in product group 3.

5.5   Product group 4

Product group 4`s sales and inventory levels have varied a lot during the research period ( Chart 9 ). Because of the small market volume, group 4 items are manufactured in large batches. Customer group A does not have any items in product group 4, so items to storage are produced based on customers` orders.
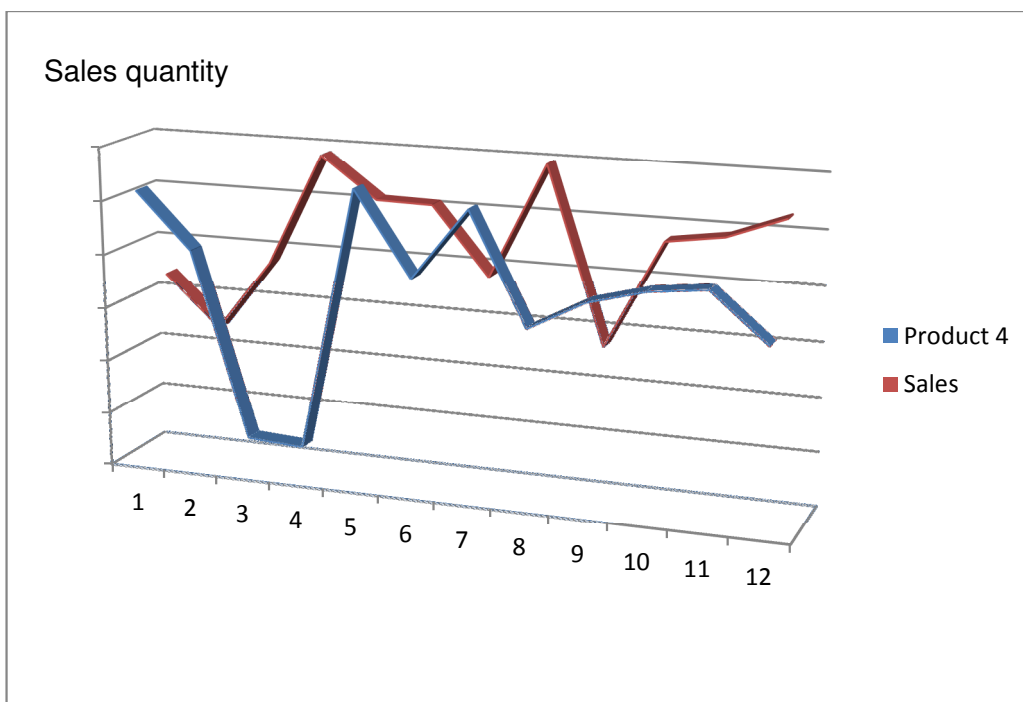

Chart 9. Product group 4`s inventory level and sales volume for customer group.
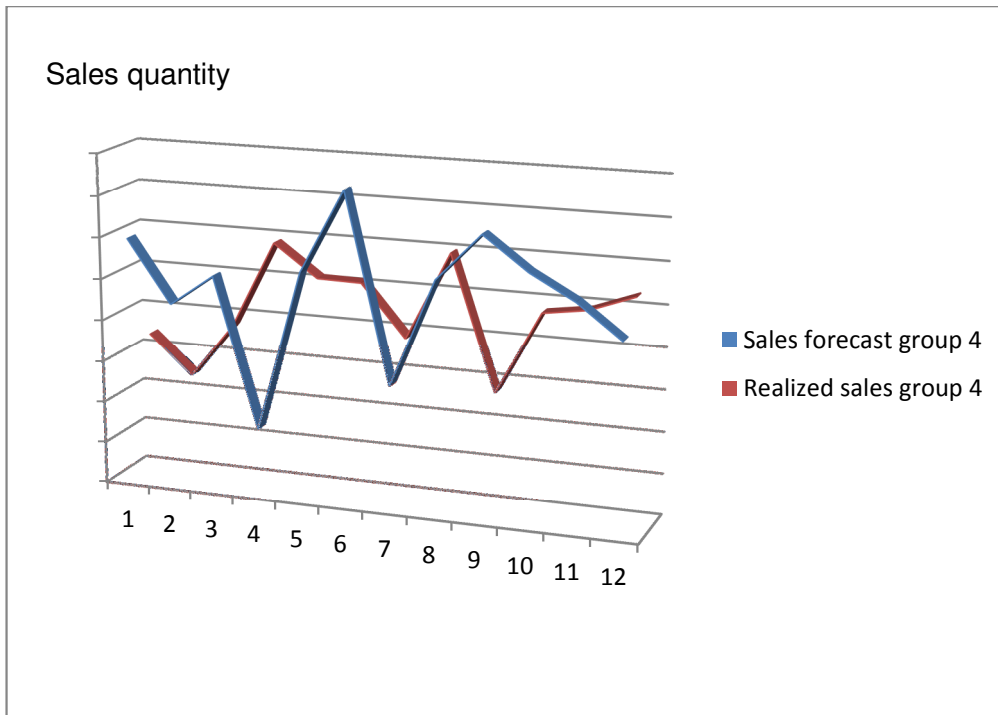
Sales quantity

Chart 10. Forecast and realized sales on product group 4.

Chart 10 shows how product group 4`s forecast and realized sales have matched. There has been a variation between the realized sales and forecast, especially on fourth month.

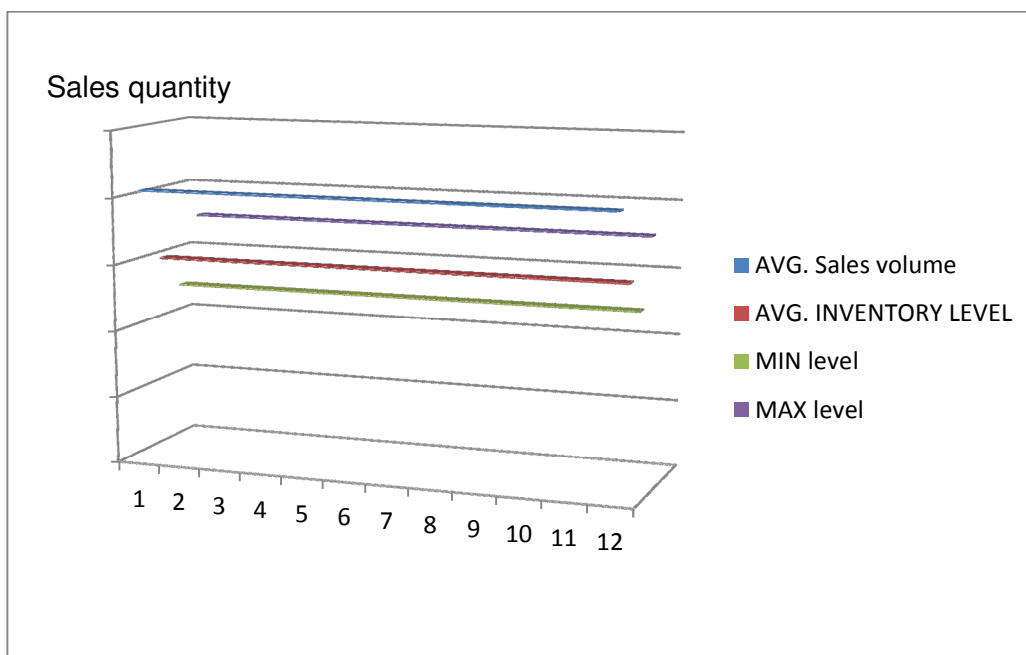## 5.6   Summary of inventory analysis

Sales quantity

Chart 11. Average sales and inventory levels.

The average inventory level has been between the issued minimum and maximum levels. Depending on the research periods the inventory management; inventory has stayed on an accepted level. The average inventory level has been about 70 percent of average sales.

There is no clear logic in, how reorder point and lot size are defined for customer group A. The decision, when to produce items to final goods storage ready for shipment, may vary from zero inventory to several days demand. If the production has manufactured all orders for B, C and D customers, it starts to manufacture storage items for customer group A. On the other hand, if the production manufactures items for B, C or D customers and sales receive order from customer group A and shipping is missing ordered items in the storage, the sales will ask, if the A -customer could wait a day or two. If the customer is able to wait, the production manufactures the lacking items by the new agreed shipment date. If the customer cannot wait, the production does the needed changeover immediately to production line and manufactures the needed item as soon as possible. These situations may happen because many customers use the same printed item, and if orders occur in the same week, it is possible that the production is not ready for it.

The lot size decisions, when to print customer group A items to final goods storage, varies. If production is busy manufacturing orders for B, C or D customers, lot sizes get smaller and it also works the other way around. The sales have defined upper storage limits for customer group A items. If upper limit is going to be exceeded, production must inform sales about it. Sales makes the final judgment if limit can be exceeded or not.

Some customers in customer group A have requested safety buffers for their items. Customers have defined safety storage levels by themselves. Requested levels vary from two to four weeks demand. Most of the customers have not placed any requests on safety stocks.

However, high final goods inventory level, averagely 70 % of one month sales, increases production flexibility in many ways. Supply variables, for instance sick leaves and sudden machinery breakdowns, can be handled without overwork in manufacturing. High level of

final good inventory provides better service level than promised for customers B,C and D. Cost for all these benefits is higher inventory carrying cost.

During the 12 month study period sales forecast and realized sales had 2 % average difference. Monthly variation between forecast and realized sales was higher. Highest monthly forecast error was in company`s main product group, there was a 40% gap between forecast and realized sales.

5.7   Improvement suggestions

During the research period, 80 % of the delivered items belonged to customer group A. Basic economic production quantity, EPQ, calculation could be done for customer group A inventory items in order to improve storage turnover. Customer group A had 33 different inventory items during the research period. In practice it would mean 33 different EPQ calculations. Because of the high sales percent in customer group A, also reorder points and safety storages should be calculated. Safety storage levels set by customers should also be viewed, recalculated in co-operation with customer.

Reorder points and safety storages can be calculated and used daily basis, but it requires a lot of time to do the work. Company is already using ERP-system which might include useful inventory applications. It would be worth of finding out how the existing system could help the daily inventory management.

Items for B, C and D customers should be printed according orders, not by production batching economies, if capital tied to final good storage is to be minimized.

Because most of the customers in group A have a long history with the supplying company, it would be worth of trying to build more strategic co-operation with the main customers. Vendor managed inventories would give benefits to both supplier and customer. In vendor managed inventory system, the ownership of inventory items does not change, but the supplier has visibility to customers' inventories. The supplier generates orders for the customer, according to demand information sent by customer. When supplier has visibility

to real consumption, it could manufacture items according real need, and inventory levels could be re-adjusted. (http://vendormanagedinventory.net/benefits.htm)

Well operating vendor managed inventory needs good trust between a customer and supplier. Especially the customer needs to give precise information about its business. VMI-system normally uses a computer software which collects and sends information between supplier and client. VMI is an not easy or cheap system to build, but when the system is working both the supplier and the customer can focus on the same issue: how to sell products to the end users more cost effectively. (www.dataalliance.com/vmi.pdf)

6 Conclusions

The company has a lot of room for inventory management improvements. The current system sets limits to total inventory levels and it gives a general view to warehouse. Current inventory monitoring system can be useful high for management but contribution for production management is very little. Inventory planning and monitoring on product group- and item level would offer more valuable information.

Company`s inventory turnover during study period was 16. Corporation's best inventory turnover is 44. Figures are not fully comparable because production units have different inventory strategy.

Some of suggested improvements for better inventory turnover were taken into practice while writing this study. Items for B, C and D customers are printed according orders, not by production batching economies. Vendor managed inventories model was presented to one key customer, and project for better utilization of ERP applications for inventory management has started.

REFERENCES

Räsänen Taija 2012, Quality-, Safety- and Enviroment Manager. Hartmann-Varkaus Oy. Varkaus. 10.9-15.11.2012. Discussions.

Suomalainen Jarmo 2012, Maintenance Supervisor, Hartmann-Varkaus Oy. Varkaus 10.9–15.11.2012. Discussions.

Kiira Sari 2012, Market supervisor, Hartmann-Varkaus Oy. Varkaus 9.11–20.11.2012. Discussions.

Donald J.Bowersow, David J. Closs 1996. Logistical Management. Mc Graw-Hill companies.

John J. Coyle 2009. Supply chain management: A logistics perspective. Mason, OH: South-Western Cengage Learning

Benefits of vendor managed inventory [webpage] [Accessed 15.October 2012] Available from: http://vendormanagedinventory.net/benefits.htm

VMI [webpage] [Accessed 15.October 2012] Available from: www.dataalliance.com/vmi.pdf

Company`s sustainability report 2010

Calculate EPQ [webpage] [Accessed 21.1.2013] Available from: http://www.ehow.com/how_8780932_calculate-order-determine-niventory-value.html