

A hybrid replenishment model, the best fit in fast growing industries.

A practical framework for balancing customer service and stock levels to improve product availability at the lowest possible cost.

Hartevelt R. – roy.hartevelt@philips.com

04-05-2011

Abstract

During the design supply chain control processes, balancing cost versus service plays an important role. To select the most suitable replenishment strategy is the main enabler in reaching the goal of finding the optimal balance. In this article a framework is developed which will help to select the right replenishment strategy and to design a supply chain control process that supports companies to secure the results of improvements. During the evaluation of replenishment strategies in the design phase of the project it becomes clear that in specific situations one single replenishment strategy will not cover the overall control need in supply chains, especially in fast growing or emerging markets. In those specific situations the best replenishment strategy is a combination of re-order-point and kanban. This paper is based on experience gained during a supply chain control study at a Philips business.

Keywords: Supply chain design, Supply chain control process, Replenishment strategy, Planning methodology, Supply chain performance management

1. Introduction

Common to all manufacturing companies, regardless of size, type of product or manufacturing process is the need to control the flow of materials from suppliers, through manufacturing and distribution to the customer (Stevens, 2007). In all business configurations the role of supply chain is crucial. This research will identify which criteria are relevant to determine optimal stock values and deliver an advice model for stock level calculation for the midterm (monthly) and the short-term (weekly). Those advice models generate stock advices on the one hand based on customer demand and it's variance and on the other hand the supply and it's variance. For midterm planning, those models can help to determine

further tactical decisions. The result of the models (midterm and short-term) can help to take decisions for these challenging considerations. This research investigates these future considerations and there will be provided recommendations how to use the advice models in practice based on the Philips case.

The research focus is on improving service level and optimizing stock levels. The replenishment strategy must be used and understood by several business lines. These business lines will have different backgrounds, goals and work levels. Attention to this multi-actor setting is important and frequent contact and information sharing will contribute to this. Within the specific Philips business case, actors are spread over four locations in three continents. As a result of the global

dispersion cultural differences are a second factor in the complexity of communication. Recognizing the multi-actor setting and the multi-cultural setup for stock level adjustments is important. A system of component suppliers and an assembly and test manufacturer all have the intention to optimize stock levels in a structured and mutually agreed way. The goal of the assembly and test manufacturer is creating a demand/supply advice for the component manufacturer and to get insights on the supply chain risks from the models at the other hand the component supplier owns and controls its own production process and internal optimization. The drive to local optimization is strengthened due to the geographical distance between the four production locations. Extra attention in the control model is required to safeguard the overall gain in supply chain performance against possible local drawback.

2. Research method

The goal of this paper is to develop a framework to understand the selected replenishment strategy and to assist in the question whether to change and setup an extended communication framework or not. The pillars to build such a framework an analysis is made based on existing literature. With the goal to implement a framework there is a focus to design an optimal supply chain control model that fits in a fast growing market.

One of the deliverables of this research is to deliver a tool and guidelines with the goal to optimize the stock levels and to introduce supply chain controls. The decision support tool will enable management to make the right decisions before we make the wrong one (Shannon, 1998).

The goals of the research are determined by the stakeholders. A clear formulation of goals is essential to create suitable and accepted design and control afterwards if the design fits the desires of the stakeholders. The goals are translated into objectives and constraints. These objectives and constraints are matched with the design space. The design space

is formed by the boundaries of the specific situation. The research boundaries in combination with time and data restrictions determine the design space for this research. With respect to the design space first a conceptual model is designed. This conceptual model is discussed with experts and stakeholders and when necessary adapted. After adapting the input of the field experts and stakeholders the conceptual model will be translated in a real model. This model is tested and discussed again with stakeholders and experts. After this evaluation the final model is designed and steps to use it in practice are provided. Finally, results are used to test how good the model fits with the design objective. The design method used in this research is based on the complex multi actor and multi requirements methodology (Herder and Stikkelman, 2004).

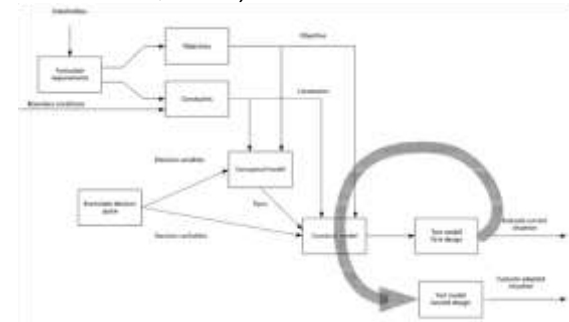


Figure 1 design methodology (adapted from Herder and Stikkelmans, 2004)

3. Supply chain uncertainties

Supply chain control means coping with uncertainties of activities in scope of business, like variance in customer demand, supplier performance and manufacturing and last but not least it means to follow the demand pattern of our customers (T. Davis, 1993). At the end of the day management is most interested in customer satisfaction and low inventory levels.

Uncertainties in the supply chain are daily business; beating the uncertainties will never result in satisfaction or in a different way an uphill battle will never end in a great victory. Living with uncertainty in

supply chain means integrating variances of each part of the process into a stock calculation model. Figure 2 shows the supply chain uncertainty as published by Davis in 1993. Unfortunately, not all uncertainties can be eliminated. However, other initiatives can redesign the supply chain to reduce the impact of uncertainties (Davis, 1993).

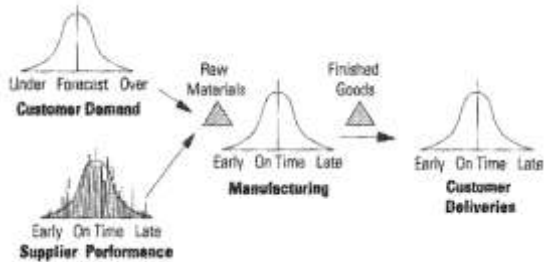


Figure 2 Uncertainty in the supply chain (Davis, 1993)

The real challenge is to manage the uncertainties in the supply chain in relation with customer service level without incurring an undue burden of cost. Balancing the activities in the chain is the main goal to achieve the necessary balance between cost and customer service.

Inventory has a stabilizing effect in supply chains (Baganha, 1996) as a buffer to absorb demand variability. The stabilizing function of stock will result in a lower variability in production than the variability in market demand.

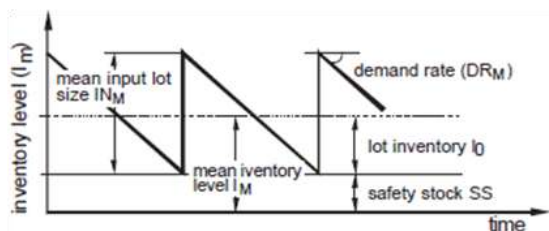


Figure 3 Inventory level with safety stock (Lutz, 2003)

Figure 3 shows the development of inventory over time for a process with input and output quantities. In case no uncertainty is involved the mean inventory can be lowered with the safety stock. With the safety stock (SS) the described process can guarantee the deliveries. The mean inventory level is the sum of the

safety stock and half the quantity of input (lot size) into stock necessary to cover the usage during lead-time (Lutz, 2003).

The next step into supply chain control after understanding and reducing the supply chain uncertainties; translate all remaining known uncertainties into an inventory stocking policy. Thus the inventory stocking policy is a dynamic process. Suppliers delivery reliability can become better or worse over the time. In general, demand for products becomes more predictable as products become more mature.

In creating a dynamic stock policy, commonly use generic settings for A/B/C stock-keeping units. The classification of items by transaction volume does not necessarily reflect the combination of all uncertainties of the total supply chain (Lee, 1992). In the default setup of the model the possibility should be there to differentiate the service levels based on a potential ABC-classification. Typically for fast growing markets is that no classifications are made due the fact that all products are rather new and product launches are planned twice a year. For managing the long term and the day to day business, more complex calculation models are necessary for creating the most optimal and suitable supply chain. Consequences of calculating stock levels and customer deliveries with wrong uncertainties results in overstock on some items but under-stock on others. Miscalculating the lead times for material movement along the supply chain could result in investing in the wrong resources for performance improvement.

4. Supply chain control process

Setting up a control model based on design requirements as set by the organization and the business characteristics ends with tools to manage the business in a proper way. At the other hand models without embedded processes at the involved organizations will not bring success after closing the project (Lee, 1992). Figure 4 shows the implemented processes with the designed control model as backbone and a meeting

structure based on terms of references (TOR). The backbone is at the left side of Figure 4, the monthly and weekly planning sheets are integrated in an overall control process based on a fix structure. The daily execution is the result of the day to day scheduling based on the weekly replenishment orders. The backbone starts with a forecast (Sales and Operations Planning), based on the forecast a production planning is made. This production plan includes also the performance of the production processes in the period before. Control loops are the linking pins between the several meetings at monthly /weekly and daily rhythm as well. The performance input is a bottom up process meanwhile the planning guidelines are top down managed. With the designed models and the supporting processes supply chain becomes a competitive edge (making the difference).

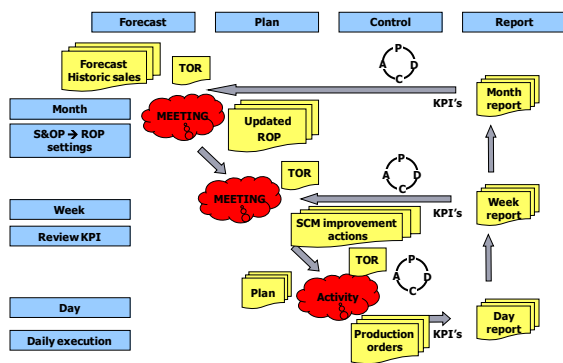


Figure 4 Planning rules and deploy control model

5. Calculating safety stocks

Control of the supply chain means understanding and managing the uncertainty in the scope of the chain. In a simplistic way the cycle stock (demand during lead-time) will be increased with a certain percentage or some extra days of inventory. For calculating the safety stock levels as part of a replenishment strategy model several variants are available to use, the question is which calculation method of the safety stock is the most suitable for a business in a fast growing market situation and what are the differences and explain them. Based on

Chopra (2004), Suwanraji (2005) and Chandandeep (2010) three safety stock calculation methods have been selected.

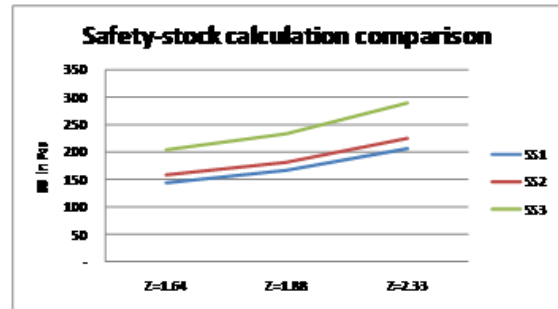


Figure 5 Safety-stock calculation comparison

With the help of a small example the three calculation methods SS1 – Atkinson (2005), SS2 – Linfort (2006) and SS3 – Piasecki (2009) are compared. The result of the comparison is visualized in Figure 5, which shows a safety stock level (presented by the y-axis) at three different service levels (x-axis). In making the right choice related to the safety-stock calculation it is most important that the calculation method is able to deal with the different types of Supply Chain uncertainties. The limited possibilities in SS3 to integrate the different uncertainty factors drop out this calculation method. Calculation method SS2 needs a lot of not standard available information and secondly the calculated safety-stock level is very close but slightly higher than the SS1 calculation method.

Based on the characteristics (fast growing and many different uncertainties) besides the direct available information as provided by the systems the safety stock calculation of Atkinson (SS1) has the best fit and will be used in further stock level calculations.

6. Replenishment strategy

A proper selection of a replenishment strategy is one of the keys to achieving low inventory while maintaining high customer delivery performance based on Suwanraji (2005). In Table 1, a comparison is made between three replenishment strategies; using DRP /MRP (Distribution /Material Requirement

Planning), ROP (Re-Order-Point) and KBN (Kanban) were compared. The replenishment strategies were all integrated with the safety stock calculation method of Atkinson (2005) as described in the previous section.

Using DRP/MRP strategy requires full visibility of order and inventory information across all locations in the Supply Chain with periodic review. ROP is a reactive strategy with replenishment decisions based on continuous review. KBN is a reactive replenishment strategy; inventory within a replenishment loop is controlled by a fixed number of cards. Kanban cards in a replenishment loop were allocated to inventory at a location, inventory in transit to a location and unfilled orders placed to an upstream location.

The three replenishment strategies are compared under two levels of Manufacturing Constraints (MC) No time-delay capacity constraint and Time-delay capacity constraint. No time-delay capacity constraint ignores time delay operations

by setting all setup and part processing times equal to zero (manufacturing resources have no capacity constraint). The time-delay capacity constraint, production resources at manufacturing are able to process one order at a time. A capacity constraint exists and batches waiting to be processed must join the queue.

The second level of challenge is found in the Demand pattern (DP): level demand and seasonal demand. During a level demand pattern the expected period demand was assumed for not having seasonal effects which can be a stable demand pattern or an unpredictable /fast growing demand pattern. For the seasonal pattern, the demand pattern is assumed to follow a sinusoidal pattern with a cycle length equal to one year.

Manufacturing constraint (MC)	Demand pattern (DP)	Replenishment strategy (strgy)		
		DRP/MRP (strgy 1)	ROP (strgy 2)	KBN (strgy 3)
No manufacturing capacity constraint	Level demand	Responds slow to changes introduced by demand uncertainty.	Responds directly to changes by demand & supply uncertainties.	Results in steadiest stream of arrivals which in turn results in shorter average queues.
	Seasonal demand	Responds on demand variation including a season correction based on history and forecast input.	Responds on demand variation forecasted for the next period.	Does not use forecasting information and cannot utilize backorders information.
Manufacturing capacity constraint	Level demand	Effective at co-ordinating material flow and limited waiting time for the same level of component inventory	Score between KBN and MRP – managing the material flow and anticipates on the demand uncertainties.	Beneficial when demand uncertainty is of a random nature, results in relatively low inventory in front of capacitated resources
	Seasonal demand	Responds on demand variation including a season correction based on history and forecast input, capacity limitations are integrated.	Backorder information is taken into account in the next calculation but frequency is lower than at the MRP strategy.	No backorder information is maintained.

Table 1 Replenishment strategies (Suwanruji, 2005)

Suwanruji (2005) concludes based on data analysis that the replenishment strategies as mentioned in table 1 not always have a best possible fit in each scenario. The green framework indicates the generic best suitable replenishment strategy per MC & DP combination.

Key characteristics of a Supply Chain in an emerging or fast growing market are directly linked to extreme business growth and the many uncertainties in the current Supply Chain. Seasonal effects are not visible at the current state, meaning no bullwhip effects of seasonal demand in the Supply Chain. This implies that for replenishment method a ROP or Kanban replenishment strategy is most suitable (depending on the existence of capacity constraint).

Figure 6 shows the model calculation for the most optimal situation and the situation as it was without the new control models (based on Philips business case). It shows the (safety) stock needed to cover the demand during lead-time (vertical) and the sales per week in Million(s) (horizontal). Due to using the right replenishment method lead time and the effects of supply chain variances are optimized.

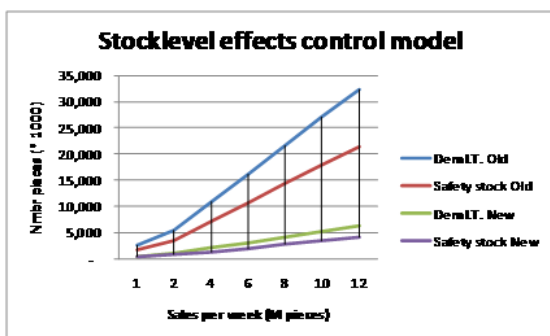


Figure 6 Results supply chain control model

Next to the Philips case the way of thinking behind the models can be useful to optimize other multi-actor and global supply chain. The combination of the safety stock calculation and the replenishment strategy is powerful to gain an optimal integral supply chain performance without having one integrated ERP system.

7. Conclusion and Discussion

The goal of this paper was to develop a comprehensive decision making framework which will help to make the right decision in selecting the most suitable replenishment strategy and secondly to design a supply chain control model.

The need to focus more on integral supply chain planning and optimization instead of local optimization plans has ascended the past few years. There are some appropriate ways to determine an optimal solution for the optimization challenge. Research has indicated required actions to optimize a supply chain in fast growing markets. Without actions there will be too high inventory levels with resulting financial losses. All these different kinds of behaviour provoke business losses and will harm continuity. In case industrial consumers decide not to purchase, major sales loss is incurred.

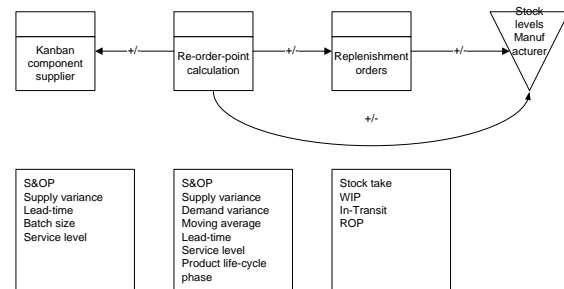


Figure 7 Concept advice model

The advice models (Re-Order-Point, Replenishment and Kanban) are based on specific risks (lead-time and uncertainties) (figure 7). The models generate advice based on these risks for a desired service level. The models give product specific advice for safety stock, economical stock levels and quantities to produce based on the requested service level. The results of the advice model (Figure 7) indicate that a product safety stock level can optimize to the most suitable stock positions: meaning high customer service with the right underpinning stock levels in the chain (at the right balanced cost levels). The benefits of the Supply chain control model are enormous. Without a suitable replenishment strategy and the right

supply chain controls a business in a fast growing market needs approximate 9 times more stock (see Figure 6) to prevent out of stock situations.

Acknowledgements: The author wishes to thank H. Rulkens for his valuable comments on an earlier draft of the article.

References

- Affonso R. , Grabor B., Marcotte F.(2009). Coordination Model for Supply Chain Management, University of Toulouse.
- Baganha M. P. and Cohen M. A. (1998). The Stabilizing Effect of Inventory in Supply Chains, *Operations Research*, Vol. 46, No. 3, Supplement: Focus Issue on Manufacturing Logistics (May - Jun., 1998), pp. S72-S83.
- Bowersox, D.J. (1990). The strategic Benefits of Logistics Alliances. *Harvard Business Review*, 86 (4):p.36-43.
- Bowersox D.J., Stank T.P. and Daugherty P.J. (1999). Managing introduction risk through response-based logistics.
- Chopra, S., Dada, M. and Reinhardt, G. (2004). The effect of lead time uncertainty on safety stocks. *Decision sciences*, 35 (1):p.1-24.
- Corsten, D. and Gruen, T.W. (2004). Stock-Outs Cause Walkouts. *Harvard Business Review*:p.26-28.
- Davis T. (1993). Effective supply chain management.
- Eppen, G.D. and Martin, R.K. (1988). Determining safety stock in the presence of stochastic lead time and demand. *Management Science*, 34 (11):p.1380-1390.
- Fisher, M.L., Hammond, J.H., Obermeyer, W.R. and Raman, A. (1994). Making Supply Meet Demand in An Uncertain World. *Harvard Business Review*, 72 (3):p.83-93.
- Fleisch, E. and Tellkamp, C. (2005). Inventory inaccuracy and supply chain performance: a simulation study of a retail supply chain. *International Journal of Production Economics*, 95 (3):p.273-385.
- Graham C. Stevens (2007). *Integrating the Supply Chain*, Peat Marwick McLintock, London.
- Herder, P.M. and Stikkelman, R.M. (2004). Methanol-based industrial cluster design: a study of design options and the design process. *Industrial & Engineering Chemistry Research*, 42:p.3879-3885.
- Jammerneegg, W. and Reiner, G. (2007). Performance improvement of supply chain processes by coordinated inventory and capacity management. *International Journal Production Economics*, 108:p.183-190.
- Johson J. D. (2005). Managing variability in the semiconductor supply chain.
- Kok T.G. de and Fransoo J.C. (2002). Planning supply chain operations: definition and comparison of planning concepts.
- Kok T. de, Janssen F., J. van Dorenmalen, E. van Wachem, M. Clerckx and W. Peeters (2005). Philips Electronics Synchronizes Its Supply Chain to End the Bullwhip Effect.
- Lee H.L. and Billington C. (1992). Managing supply chain inventory: pitfalls and opportunities.
- Lutza S., Loeddingb H., Wiendahl H-P. (2003), Logistics-oriented inventory analysis, *Int. J. Production Economics* 85 (2003) 217–231.
- Marmostein, H. and Zinn, W. (1990). Comparing two alternative methods of determining safety stock levels: the demand and the forecast systems. *Journal of Business Logistics*, 11 (1):p.95-110.
- Orcun S., Çetinkaya S. and Uzsoy R. (2007). Determining safety stocks in the presence of workload-dependent lead-times.
- Shannon R. E. (1998). Introduction to the art and science of simulation, *Industrial Engineering*, Texas A&M University, College Station, Texas 77843-3131.
- Sanajian N. and Balcioglu B. (2009). The impact of production time variability on make-to-stock queue performance, *European Journal of Operational Research* 194 (2009) 847–855.
- SUWANRUJI P. and ENNS S.T. (2005). Evaluating the effects of capacity constraints and demand patterns on supply chain replenishment strategies, *International Journal*

of Production Research, Vol. 44, No. 21, 1 November 2006, 4607–4629.

Tien-Yu Lin (2010). An economic order quantity with imperfect quality and quantity discounts. *Applied Mathematical Modelling* 34 (2010) 3158–3165.

Zhao, X., Xie, J. and Leung, J. (2002). The impact of information sharing and ordering coordination on supply chain performance. *Supply Chain Management: an International Journal*, 7 (1):p.24-40.

Zinn W. and Marmorstein H. (1990). Comparing two alternative methods of determining safety stocks levels: the demand and the forecast system