The MIT Global Supply Chain and Logistics Excellence (SCALE) Network is an international alliance of leading-edge research and education centers, dedicated to the development and dissemination of global innovation in supply chain and logistics.

The Global SCALE Network allows faculty, researchers, students, and affiliated companies from all six centers around the world to pool their expertise and collaborate on projects that will create supply chain and logistics innovations with global applications.

This reprint is intended to communicate research results of innovative supply chain research completed by faculty, researchers, and students of the Global SCALE Network, thereby contributing to the greater public knowledge about supply chains.

For more information, contact
MIT Global SCALE Network

Postal Address:
Massachusetts Institute of Technology 77
Massachusetts Avenue, Cambridge, MA 02139 (USA)

Location:
Building E40, Room 267
1 Amherst St.

Access:
Tel: +1 617-253-5320
Fax: +1 617-253-4560

Email: scale@mit.edu
Website: scale.mit.edu

Research Report: ZLC-2010-1
Impact of Point of Sale Data on Demand Planning for a Two Level Supply Chain
Luis Diego Artiñano and Kavita Keerthi
For Full Thesis Version Please Contact:
Marta Romero
ZLOG Director
Zaragoza Logistics Center (ZLC) Edificio Náyade 5, C/Bari 55 – PLAZA 50197
Zaragoza, SPAIN
Email: mromero@zlc.edu.es
Telephone: +34 976 077 605
Impact of Point of Sale Data on Demand Planning for a Two Level Supply Chain

By Luis Diego Artiñano and Kavita Keerthi
Thesis Advisor: Dr. Rogelio Oliva

Summary
This thesis explores ways to improve the planning process at a Master Distribution Center through the development of a trend analysis technique based on point of sale data that provides supportive insights about the demand’s behavior to the current forecasting activities. In addition, an order revision model was built to ensure a stable incoming order stream and consequently improve the accuracy of the trend analysis.

KEY INSIGHTS
1. Demand signals received at upstream players do not represent end customer demand as they get distorted and amplified.
2. The trend analysis of point of sale data to anticipate trends in the orders provides valuable insight to validate the order based forecast.
3. The control of order variability based on a predicted range of demand reduces the error of the trend analysis and in turn, improves the forecast accuracy.

Introduction
Most firms base their planning decisions on demand signals coming from immediate downstream players. These signals are not representative of the end customer demand and are usually distorted and amplified as they move upstream. To overcome this situation the analysis of point of sale data (POS) can add value to upstream players, as they bypass the abovementioned distortion and get better insights on the demand’s behavior.

Although the benefits of POS seem to be unquestionable, many have argued how this data should be utilized to materialize them. Some suggest using POS data to directly forecast sell-in demand; others argue using it to calculate future sell-in demand based on a sell-through demand forecast.

Our approach identifies ways of how POS data can complement the order based forecast. This contrasts with older approaches which analyze the benefits of POS and orders history separately.

The thesis studied the use of POS data collected at the Distribution Centers (DCs) to enhance the planning process at the Master Distribution Center (MDC) by providing a valuable trend analysis of demand and a model for reducing variability of incoming orders. The figure below shows the flow of POS data from DC to MDC and the impact on demand signal variability.

With the use of a seasonal exponential smoothing model to predict 13 weeks of POS data, the trend analysis proved to give accurate insights about next periods’ orders arriving to the MDC.

A complementary order revision model was developed to bring orders closer to POS demand. And based on the confidence intervals of the POS data forecast, this order revision model suggests changes to the orders’ quantity to keep it within the predicted range of demand.

Luis Diego Artiñano graduated from the ZLOG program in 2010. He continued his studies to pursue an MBA degree at INCAE Business School in Costa Rica. Prior to ZLOG, Luis Diego worked as a Manufacturing Engineer in the medical device industry.

Kavita Keerthi graduated from the ZLOG program in 2010. After the program, she worked in Beiersdorf AG. Prior to ZLOG, she worked as a SAP consultant in Tata Consultancy Services in India.

Summary
This thesis explores ways to improve the planning process at a Master Distribution Center through the development of a trend analysis technique based on point of sale data that provides supportive insights about the demand’s behavior to the current forecasting activities. In addition, an order revision model was built to ensure a stable incoming order stream and consequently improve the accuracy of the trend analysis.

KEY INSIGHTS
1. Demand signals received at upstream players do not represent end customer demand as they get distorted and amplified.
2. The trend analysis of point of sale data to anticipate trends in the orders provides valuable insight to validate the order based forecast.
3. The control of order variability based on a predicted range of demand reduces the error of the trend analysis and in turn, improves the forecast accuracy.

Introduction
Most firms base their planning decisions on demand signals coming from immediate downstream players. These signals are not representative of the end customer demand and are usually distorted and amplified as they move upstream. To overcome this situation the analysis of point of sale data (POS) can add value to upstream players, as they bypass the abovementioned distortion and get better insights on the demand’s behavior.

Although the benefits of POS seem to be unquestionable, many have argued how this data should be utilized to materialize them. Some suggest using POS data to directly forecast sell-in demand; others argue using it to calculate future sell-in demand based on a sell-through demand forecast.

Our approach identifies ways of how POS data can complement the order based forecast. This contrasts with older approaches which analyze the benefits of POS and orders history separately.

The thesis studied the use of POS data collected at the Distribution Centers (DCs) to enhance the planning process at the Master Distribution Center (MDC) by providing a valuable trend analysis of demand and a model for reducing variability of incoming orders. The figure below shows the flow of POS data from DC to MDC and the impact on demand signal variability.

With the use of a seasonal exponential smoothing model to predict 13 weeks of POS data, the trend analysis proved to give accurate insights about next periods’ orders arriving to the MDC.

A complementary order revision model was developed to bring orders closer to POS demand. And based on the confidence intervals of the POS data forecast, this order revision model suggests changes to the orders’ quantity to keep it within the predicted range of demand.

Luis Diego Artiñano graduated from the ZLOG program in 2010. He continued his studies to pursue an MBA degree at INCAE Business School in Costa Rica. Prior to ZLOG, Luis Diego worked as a Manufacturing Engineer in the medical device industry.

Kavita Keerthi graduated from the ZLOG program in 2010. After the program, she worked in Beiersdorf AG. Prior to ZLOG, she worked as a SAP consultant in Tata Consultancy Services in India.
The procedure for selecting the forecasting model, the trend analysis tool and the order revision model is discussed in brief below. The criteria defined for classifying demand as non-recurring is also presented.

**Forecasting Model Selection**

The objective of the model selection process was to define a base model capable of functioning with all SKUs and providing accurate predictions. Simplicity over performance was preferred; nevertheless, with the flexibility to adjust to different demand patterns by tailoring the model’s parameters to each case. To have an accurate trend analysis a representation of the pattern is enough rather than having point to point accuracy.

A total of 30 models were run for a sample of SKUs and it was observed that the Seasonal Exponential Smoothing Model with a 53 seasonality period was the best fit based on the Schwarz Bayesian Criterion (SBC) criteria. SBC avoids selecting over fitted models by penalizing the number of parameters used. Thus, this model uses only two parameters: the level smoothing weight and the seasonal smoothing weight to forecast. And to have an even simpler approach, category-average parameters were used (the categories of lifecycle stages and demand variability were used to classify the SKU sample). The chart below shows the forecast of one SKU. Notice how the prediction follows the demand pattern.

**Trend Analysis**

The traditional trend analysis consists of using only history data without considering predicted values. Since this prediction has information about the product seasonality, the traditional trend line is not able to adjust for changes and therefore it can mislead the decisions taken upon this result. In the following chart, this trend analysis is shown for one SKU compared to the future actual data. Notice the high difference in trend line direction.

**Order Revision Model**

The accuracy of the proposed trend analysis depends on a constant relationship between POS and orders. It is for this that the order variability must be controlled to make this a more reliable tool.

The order revision model was developed to control this variability by keeping the orders within the predicted range of demand. Through the use of the POS forecast confidence intervals, arriving orders at the MDC that go beyond this range are returned for revision to the DCs. This revision indicates an increase or reduction in the order quantity. The DCs would not know upfront what the limits are to avoid influencing the original DC decision which might contain valuable local market information.
A simulation for this model was run on the SKU sample. The four key performance metrics monitored during this exercise were variability and inventory reduction, service level and revised orders. The only assumption was that no quantity updates were made for those orders falling within the range and that followed a revised order in the previous week.

The following chart shows the order revision model applied to one SKU for the 13 week forecast period. Notice that the first and second orders were trimmed and the fourth order was increased.

![Chart showing order revision model](chart.png)

The average sample results showed an order variability reduction of 5.24%, an inventory reduction of 8.26%, a service level reduction of 1.66%, and a percentage of revised orders of 11.78%. In addition to these key metrics, the trend line error to analyze the revised orders reduces by 2.13% as a result of the improved order variability.

Regarding the negative impact on service level, this would have been less in a real situation considering the assumption made about no order updates. As order patterns become more stable and managers gain confidence in this model, it is possible to systematically increase the performance of the system by gradually narrowing the confidence intervals. Experimentation with different intervals and their corresponding required safety stock proved positive results without impacting service level. It also suggested a method to determine the optimal confidence level policy to manage orders more proactively.

**Non-recurring Demand**

The upper bound of the 95% confidence interval of the POS prediction was defined as the criterion to identify demand as non-recurring. This will facilitate the communication between MDC and DC about overruled order revisions. If the MDC is aware an order is responding to a legitimate high demand, it will allow the original quantity to go through. In addition to this, this criterion will allow the MDC’s forecasting system to label those outlier orders that should not be considered in the history data analysis. However, this will require the detection of high orders following the observed peak in demand and labeling them as such in the forecasting system.

**Conclusions**

The recommended forecasting model to use with POS data is seasonal exponential smoothing with a seasonality of 53 weeks. This model is flexible enough to work with all SKUs and allows for easy implementation and operation as it only requires two parameters. This model can use category-average parameters but these should be revised periodically at least every six months.

The trend analysis based on POS data is a useful tool to complement the MDC order forecast. It allows the demand planner to identify discrepancies between demand and forecasted orders, and then resolve them through the current forecast validation process.

The order revision model showed a positive impact in variability and inventory reduction with a minimum invasion to original orders. As a result, this made orders more predictable by POS and consequently improved the trend line error. However, the service level requires close monitoring to avoid stock out situations. As for implementing this model, one crucial point is to have the agreement and collaboration of the DCs, since due to their active participation their views should be considered before launching this initiative.

Finally, the criterion for non-recurring demand will serve the order revision model so as to facilitate the communication between MDC and DC, and it will provide useful information for the order forecasting process.

**References**


