Recovery at Oroton Group: Planning orders for core products

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ABSTRACT
OrotonGroup has been working to realize benefits from a number of supply chain initiatives. While a new ERP system has provided the organization with high levels of visibility in certain areas of the supply chain, they are still finding that the stock replenishment requires fine grained data analysis and consolidation that has been difficult to achieve within the ERP system. This paper outlines a VBA for Excel application that has been implemented to facilitate the stock replenishment process in OrotonGroup. The VBApp provides the user with complete visibility of the unique data environment required to establish orders, and also allows orders to be collected and efficiently reported to other managers. The system is currently in use in the organization.

Keywords: *Forecasting, VBA for Excel, Cusum, Shiryayev-Roberts*

INTRODUCTION

OrotonGroup Australia Pty Ltd is made up of a range of brands. Products marketed under these brands are often referred to within the business as either indent or core. Products that have a limited life are managed as indent products. Orders for these products process is biased to single overall manufacturing orders, a project management style of production planning and a staged flow of material over a limited period. Core products are those products that have an extended life, possibly sourced as complete items from third party suppliers such as Polo Ralph Lauren (Polo), and have an inventory management process that requires repeated resupply. This paper reports on work done as part of a larger study of the supply chain recovery strategies at Oroton. The focus in this paper is on the product planning process for core products.

This work is set within a context dictated by supply problems experienced in OrotonGroup supply chain in 2004 (Freed 2005). Over the last five years OrotonGroup has implemented a number of key changes to the way it conducts it business. Critical aspects of this process has been a move to aggressive low cost country sourcing, an extension and increased dependence on ERP systems with the Australian components of the supply chain, warehouse consolidation, and the use of third party agents as facilitators for their low cost country sourcing in China. While the causes of the supply problems are still to be completely defined, the degree to which the supply problems affected company performance was well publicised. Freed (2005) reported that OrotonGroup saw its half year profits and its distribution decline with a 24% fall in earnings despite a 5% increase in revenue, with $3.3 million of the fall in earnings directly attributable to the organization’s inability to supply material into the Christmas period. This view is consistent with that contained within published company documents. The annual report for 2005 for example notes that "the disruption was associated with the implementation of a new group-wide enterprise resource planning (ERP) system" (OrotonGroup Annual Report 2005, p.02).   The response of OrotonGroup to this situation has been to restructure the supply chain, and to appoint a number of new people to roles within this supply chain. Early indications are that the changes are proving to be very beneficial. Key indicators are increased sales and successful delivery into the Australian supply chain for the Christmas 2005 selling season. This outcome is however an early sign; the improvement has been associated with a maintenance of overall inventory as a percentage of overall revenues, and this is clearly a factor that will be the focus of future improvement programs. (Interim result for six months ending 28 January 2006)

METHODOLOGY

The researcher has been working with managers from Oroton over the last six months on methods to improve the process of developing and placing replenishment orders for core products. When attempting to apply professional knowledge in a work place the first objective should be to discover what help is needed. Issues may need to be structured in order to discover what help is needed, and action may finally flow from the helping process (Mitchell, 1993). In this paper I describe the issues related to the control of inventory at Oroton, and then justify and describe briefly action that has been implemented in response to the analysis. The utility of CUSUM and the Shiryayev-Roberts tests have been reviewed in the context of what is a complex inventory control situation. Action in response to the analysis is enacted in a Visual Basic Application for Microsoft Excel that is briefly described in the concluding section of the paper.

Source of data

A product controller established a formal query and data was downloaded from the system ERP. No post processing of data took place, all processes operated on the worksheets as produced by the ERP reporting function. This constraint was imposed in order to facilitate further use in the workplace without researcher intervention. The Visual Basic Application for Microsoft Excel (referred to as the VBApp henceforth) described in this paper did not access or have any point of contact with the ERP system. Data was produced as simple tables where columns contained week based data, and rows contained SKU level data. Data was produced on historical sales, inventory and orders.

CUSUM test

There are two forms of the CUSUM test; the tabular or the V-mask form. The tabular is preferable in the view of Montgomery (1996) and it is the form used for this project. The description outlined below follows the approach used in Montgomery (1996)

The CUSUM chart plots the evolution of two variables formed from results taken from a sequence of samples.

$$Shi = \max[0, x_i - (\mu_0 + K) + Shi_{i-1}]$$
$$Slo = \max[0, (\mu_0 - K) - x_i + Slo_{i-1}]$$
$$\text{where the starting values for } Shi = Slo = 0$$

These equations define the form that uses raw data from the process results, and where the values of K and μ_0 are expressed in process units. K is usually called the reference value (or allowance or slack value) and is often chosen to be about halfway between the target value (μ_0) and the out-of-control mean that we wish to detect quickly. It sets a window of indifference in the test such that process values that differ from the target value by less than K do not contribute to an expansion of the CUSUM value. Large values of K lead to very unresponsive CUSUM tests.

If either Shi or Slo exceed a decision interval *H* then the process is deemed to be out-of-control. When this occurs the test will assert an alarm and reset the value of Shi/lo to zero. In the context of forecasting then we will deem the level of demand to have shifted by an interesting amount. High values of H will also lead to unresponsive tests; low values will lead to false alarms

Standardized data is used for the tests discussed in this paper, and so the following equivalent forms of the equations are applicable:

where

$$\mathrm{z}_\mathrm{i} = \frac{x_i - \mu_0}{\sigma}$$

$$Shi_i = \max[0, z_i - (\mu_0 + k) + Shi_{i-1}] \qquad (1)$$

$$Slo_i = \max[0, (\mu_0 - k) - z_i + Slo_{i-1}] \qquad (2)$$

where the starting values for *Sh*i = *Slo* = 0

The sensitivity of the test will be measured by the Average Run Length (ARL). The ARL of the test is the average number of samples following a change that is required to trigger the alarm. This is a generally used approach to measuring the performance of the CUSUM test (Montgomery 1996; Arnold and Reynolds 2001) A good test will have a low value of the ARL for a process that is out of control, but a high value for a process that is in control. The ARL is also used to set parameters controlling the sensitivity of the Shiryayev-Roberts test discussed below. Montgomery considers that setting h at a value of 4 to 5, and k at a value of 0.5 will generally give a CUSUM with good properties when testing for a 1σ shift in the process mean.

Under these values the CUSUM test will signal an alarm if the value of Shi is ≥ 5 or Slo ≤ -5

These values will be applied in tests on Oroton data as there are no grounds to suggest any specific value of a shift in the process mean is preferable to a 1σ shift.

Shiryayev-Roberts test

The formulation of this test is based on the formulation and notation used by Ergashev (2004). The test is described in further detail by Eragashev (2004) and Kennett and Pollak (1996) and those authors can be referred to for a more complete history of the test. In this test we compute the value of a statistic *R*, where *R* responds to the value of a process variable; X_i and recursively to the last calculated value of *R*. This is analogous to the technique of an exponentially smoothed forecasting strategy. The calculation of R is modulated via a parameter *m*, and this value controls the sensitivity of the test. The value of B, the decision interval variable, is set such that when R_i equals or exceeds *B* an alarm is asserted. The value of *R* is reset to zero whenever this occurs.

Values of R are calculated using the relationship set out in equation (3):

$$R_n = (R_{n-1} + 1) \cdot \exp\left\{ mX_n - \frac{m^2}{2} \right\} \qquad (3)$$

This relationship will give values of *R* that increase as the value of *X* increases. As *X* takes on negative values, when we have values less than the target or average value then the value of *R* becomes very small, and becomes an ineffective indicator of out of control values. In response we also compute the Shiryayev-Roberts value for the negative value of *X*. This allows us to track values less than the mean with the same sensitivity as those above the mean. This is shown in equation (4)

$$R_n = \left(R_{n-1} + 1\right) \cdot \exp\left\{ -mX_n - \frac{m^2}{2} \right\} \qquad (4)$$

When this test is used for a continuous stream of date the value of the decision interval (*B*) can be chosen to be equal to the desired ARL. For data in discrete time, this equality does not hold and approximations were used by Ergashev (2004) to set the value of B. For the work reported in this paper a value of B has been selected based on the results of the Monte-Carlo simulations discussed in Jenkins and Breach (2006). The value of B used in this study is 350. With this value in use an alarm will be raised if SR+ $\geq$ 350 or SR- $\geq$ 350. Notation used in this paper is that the terms Shi and Slo refer to the CUSUM function on the high side and the low side, while SR+ and SR- refer to the values of the Shiryayev-Roberts function for the positive and negative values of the standardized variable.

RESULTS

The VBApp is current being evaluated with over 200 products. In this paper some particular aspects of the problem are illustrated using four products, a bag, a belt, a bracelet, and a leather care cream. The products illustrate issues related to sales variability, and more importantly the interaction between sales and inventory in this company.

The Bag

Data was collected from weeks 20 – 46 in order to set parameters for the CUSUM and Shiryayev-Roberts tests. This period was chosen as it was early in the life of the product and managers would be expected to set these parameters as soon as they were reasonably confident of the performance of the product. The same criteria were used for the other four products reviewed in this paper.

Statistics for this period were:

Target value	77
StDev	28
Skew	0.9

Target value is the average for the calibration period; it is used to normalize sales data for use in the CUSUM and Shiryayev-Roberts tests. Variability in the sales data is moderate for this business and skew suggests the Normal distribution could be reasonably used to model the sales data.

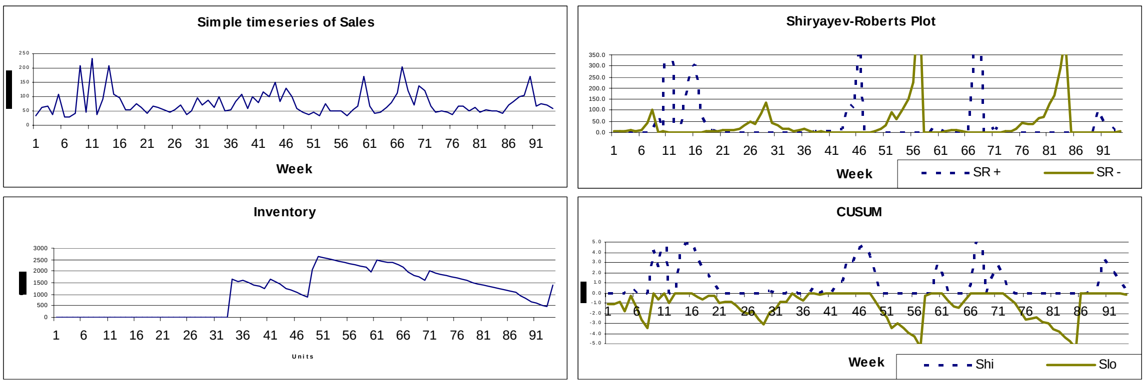

Figure 1 Test plots for the Bag

In this period it is possible to see a significant signal from the Shiryayev-Roberts test and the CUSUM test at week 84 and 85. This is associated with relatively high inventory and so it can be taken as a real drop in demand.

Table 1 Test results for the Bag

Week	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Inventory	1407	1351	1301	1248	1202	1143	1061	956	853	677	609	530	448	1383
Sales	46	56	48	52	43	71	83	98	103	169	66	77	70	58
z	-1.1	-0.8	-1.0	-0.9	-1.2	-0.2	0.2	0.7	0.9	3.2	-0.4	0.0	-0.3	-0.7
CUSUM test														
Shi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.6	3.4	2.5	2.0	1.2	0.0
Slo	-3.6	-3.9	-4.4	-4.8	-5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2
Shiryayev-Roberts test														
SR +	0	0	0	0	0	1	1	3	6	102	42	26	13	4
SR -	130	169	291	433	2	2	2	1	0	0	1	1	2	3

We can also observe the emergence of a new negative alarm at week 92 – 93, but this is associated with what may be a low inventory (when considered across the full chain) and so there may be some ambiguity in the interpretation of this signal if these conditions had continued. In this case a new delivery was received, and we do not have sufficient data to observe the trend.

The belt

Data was collected from weeks 50 - 70 in order to set parameters for the CUSUM and Shiryayev-Roberts tests. Statistics for this period were:

Target value	4.8
StDev	3.7
Skew	1

Variability in the sales data is very high, and skew suggests the Normal distribution could be reasonably used to model the sales data.

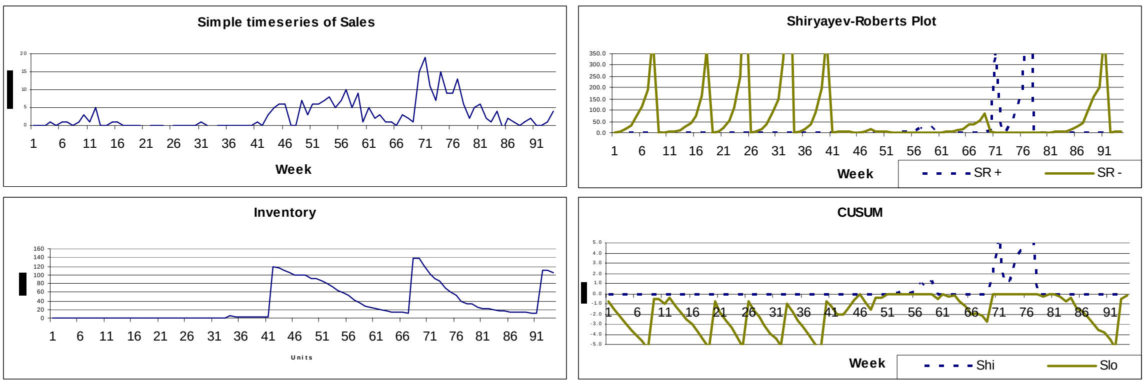

Figure 2 Test plots for the Belt

A visual examination of the timeseries data suggests that sales for the Belt are highly variable. Part of this variability is due to the impact of two periods where the supply chain had insufficient inventory to maintain sales. This can be more clearly seen in the following tabulation of results.

An examination of the latter period, from weeks 80 – 94 reveals that the clear signal from the Shiryayev-Roberts test and the CUSUM test were in response to a low inventory from about week 88. Sales data for week 85 is a negative value, the cause of this is not clear.

Table 2 Test results for the Belt

Week	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94
Inventory	26	23	21	20	16	17	15	14	14	13	11	11	110	109	104
Sales	5	6	2	1	4	-1	2	1	0	1	2	0	0	1	4
z	0.1	0.3	-0.7	-1.0	-0.2	-1.5	-0.7	-1.0	-1.3	-1.0	-0.7	-1.3	-1.3	-1.0	-0.2
CUSUM test															
Shi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Slo	0.0	0.0	-0.2	-0.8	-0.5	-1.5	-1.7	-2.3	-3.0	-3.5	-3.8	-4.6	-5.3	-0.5	-0.2
Shiryayev-Roberts test															
SR +	1	2	1	0	1	0	0	0	0	0	0	0	0	0	1
SR -	2	1	3	6	5	18	24	42	94	158	202	442	2	5	5

The Bracelet

Data was collected from weeks 16 - 36 in order to set parameters for the CUSUM and Shiryayev-Roberts tests. Statistics for this period were:

Target value	8.8
StDev	7
Skew	0.8

Variability in the sales data is very high, and skew suggests the Normal distribution could be reasonably used to model the sales data.

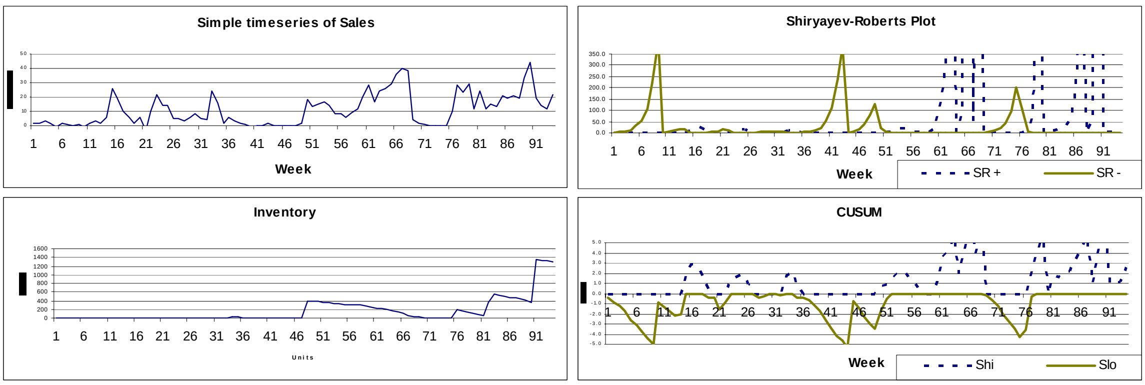

Figure 3 Test plots for the Bracelet

The period between weeks 66 – 82 is of interest. We have strong positive alarms, with a weak negative alarm (alarms are shown in the shaded cells of the following table). In weeks 66 – 68 both tests are showing a positive alarm. Week 67 signal is below the alarm level because after the function reaches the alarm level it is reset to zero. The test signal has immediately begun to accumulate a new positive value.

Table 3 Test results for the Bracelet

Week	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82
Inv	100	60	19	15	13	12	12	8	6	6	196	166	143	113	75	51	357
Sales	36	40	38	4	2	1	0	0	0	0	10	28	23	29	12	24	12
z	3.9	4.5	4.2	-0.7	-1.0	-1.1	-1.3	-1.3	-1.3	-1.3	0.2	2.7	2.0	2.9	0.5	2.2	0.5
CUSUM test																	
Shi	7.7	4.0	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	3.8	6.2	0.0	1.7	1.6
Slo	0.0	0.0	0.0	-0.2	-0.6	-1.3	-2.0	-2.8	-3.5	-4.3	-3.6	-0.3	0.0	0.0	0.0	0.0	0.0
Shiryayev-Roberts test																	
SR +	2642	52	2101	0	0	0	0	0	0	0	1	18	87	955	1	10	11
SR -	0	0	0	1	4	8	20	44	95	203	104	4	0	0	0	0	0

In this period we can clearly observe the impact of a low inventory on sales. At week 68 as inventory levels fall to 19 units across the chain, sales decline to 4 units. Sales then fall to zero for the next 4 weeks and do not recommence until inventory is replenished in week 76, whereupon sales immediately rise to 10 units and then 28 the following week.

Leather care cream

Data was collected from weeks 20 - 40 in order to set parameters for the CUSUM and Shiryayev-Roberts tests. Statistics for this period were:

Target value	123
StDev	36
Skew	1

Variability in the sales data is moderate, and skew suggests the Normal distribution could be reasonably used to model the sales data.

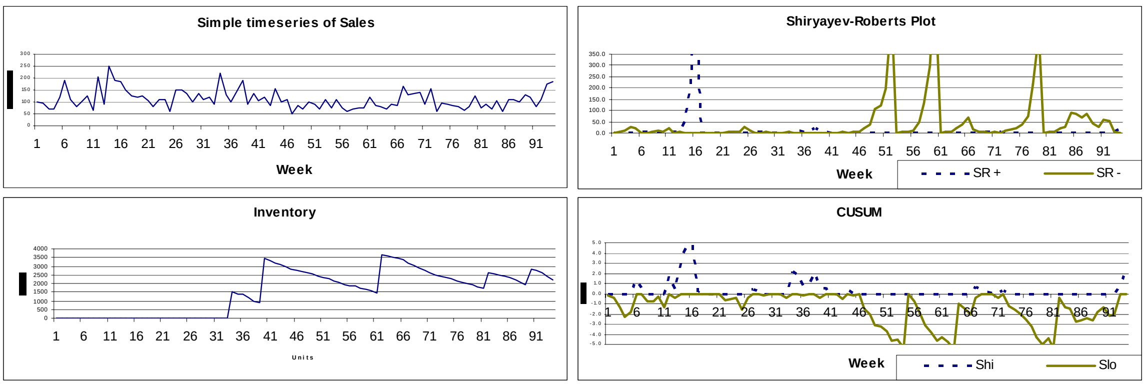

Figure 4 Test plots for Leather care cream

This product exemplifies the problems facing this company. This product is locally sourced and has relatively short lead times and has a low coefficient of variation of sales (and thus demand, as there were no stockouts in the observed period).

DISCUSSION AND CONCLUSIONS

The researcher approached the study of the problem of inventory control with the expectation that formal levels of analysis such as the Shiryayev-Roberts test and some form of statistical evaluation of safety stocks would be the principle outcome. Analysis of the above four products however suggested a different response. There is one key issue that emerged from the analysis. This is the significant number of products where the sales history had been affected by stock outs. This was so frequent that the manager simply would not make ordering decisions based on sales history in isolation. This led to the situation where a substantial amount of work was required in order to assemble different views of the product. It has not yet been possible to develop unified reports from the ERP system to provide a total view of these aspects of the product history. This then has led to a high workload in the ordering process, and thus an ordering cycle that may be longer than optimal.

The focus of the VBApp has been strongly influenced by this stock out problem. Initially the VBApp was to be a vehicle for analysis; during the course of the project it has become a vehicle for data integration and presentation. The manager is now presented with a single screen containing historical levels of sales, inventory, an exponentially smoothed record of sales for the same period last year, and a small spreadsheet that calculates projected inventory based on suggested orders. A toolbar allows rapid navigation through the list of products, and a small subroutine produces a summary of all orders developed in the session. The VBApp does contain plots of the CUSUM and Shiryayev-Roberts tests, and statistical estimates of ranges of probable demand over the next 3 and 6 months, but the key elements are the presentation of data in one place. A screen shot of the VBApp is shown in Figure 5.

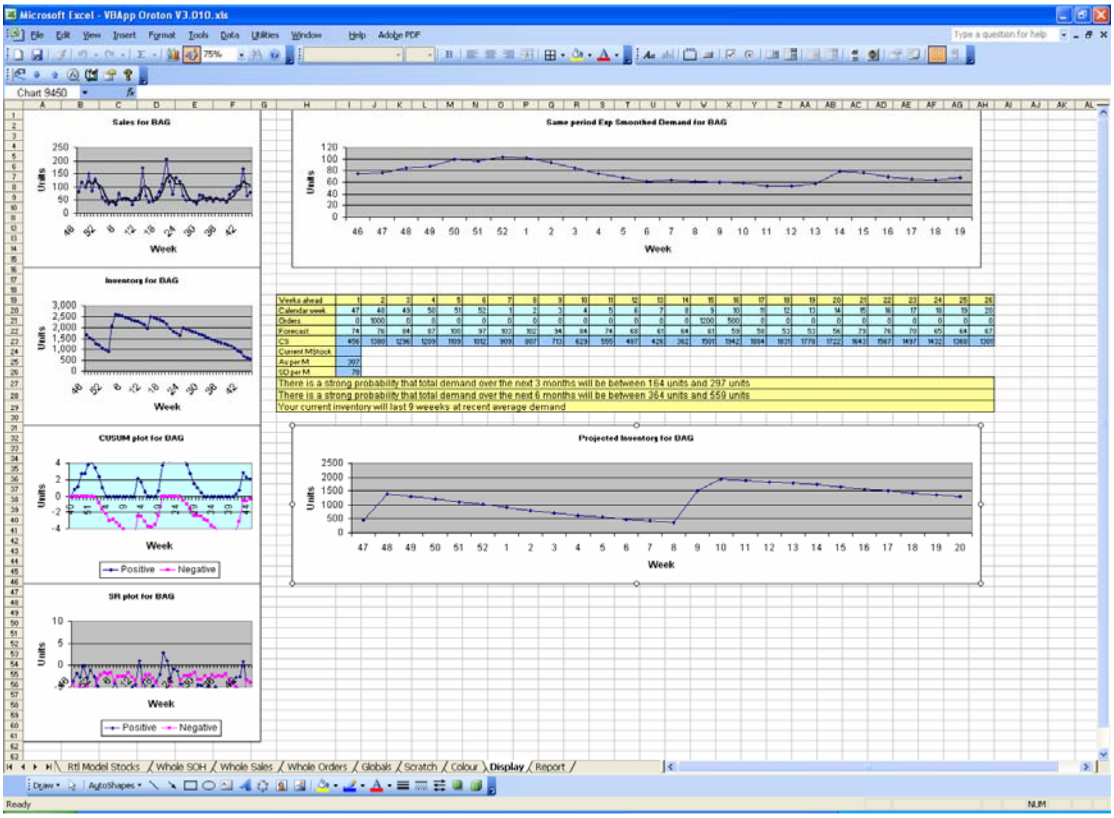

Figure 5 User screen for Order placement VBApp at Oroton

The preference for simplicity and direct measures such as raw sales and raw inventory data, are reminiscent of the observation made by Zuboff (1988) who when researching the impact of IT on a range of workplaces reported the following comments from one worker:

> *'I used to listen to the sound the boiler makes and know how it was running. I could look back at the fire in the furnace and tell by its color how it was burning. I knew what kinds of adjustments were needed by the shade of color I saw. A lot of men said there were smells that told you different things about how it was running. Now I only have numbers to go by. I am scared of that boiler, and I feel that I should be closer to it in order to control it.' (Zuboff 1988, p. 63)*

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This is an attitude echoed in work done on the control strategies adopted in the tightly coupled systems of the US nuclear submarine fleet. Bierly and Spender (1995) noted that control strategies adopted in these environments were designed to achieve high levels of reliability through the use of simple measurement systems that directly displayed the results of operator intervention whenever possible. At this stage of the project with OrotonGroup the manager is asserting the importance of staying as close to the data as possible. There are too many potential ways in which the data may need to be interpreted. Derived indicators such as the Shiryayev-Roberts test make too many assumptions of regularity in the data for the manager to consider them a reliable basis for decisions. Managers at Oroton then have responded most strongly to the data presentation aspects of the VBApp. As the group recovers from the shock of the 2005 problems it is understandable that they maintain a very conservative attitude to control mechanisms. It is possible that the introduction of ERP exacerbated the problems during the transitions. Eventually however simple tools will be expensive to maintain, and as can be seen currently, will introduce delays into the supply chain control system. Delays will always erode performance. It will be interesting to see if managers are willing to invest more trust in derived indicators such as the Shiryayev-Roberts and CUSUM tests as they bring the overall process of inventory management under more reliable control.

Tools such as the Shiryayev-Roberts and CUSUM tests clearly can provide useful levels of automation for alerting managers to issues of slow moving items in particular. This is not so important for reordering policy as lead times are so long that rapid response to demand and sales is of little help in controlling inventory. It is however useful as the organization considers promotion strategies. Discounting price can have very significant impact on sales volume and this can be implemented with a short time cycle. It would seem reasonable to attempt to utilize some form of automation reporting on slow moving stocks (stocks with high SR- values).

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