Demand Forecasting: Do You Know Where Your Products are Going?

Daphne McCarley, Chevron Information Technology Company, San Ramon, CA  
Don Waddell, Chevron U.S.A. Products Company, Houston, TX  
Robin Reese, Chevron Information Technology Company, San Ramon, CA  
D'Arcy Dittmer, Chevron Information Technology Company, San Ramon, CA

Abstract

This paper presents how the Chevron U.S.A. Products Company used the SAS® System to solve inventory problems caused by inaccurate forecasts of expected demands. The final solution was an automated forecast system delivered on a desktop PC running SAS for Windows 6.08. Base SAS, SAS/AF®, SAS/ETS®, SAS/FSPP® and SAS/GRAPH® were all used to present a system that could easily be integrated with existing Chevron Information Systems. The application, Demand Forecasting, is used to forecast gasoline and distillate sales at Chevron's distribution locations in the U.S.A.

Introduction

In 1992, Chevron embarked upon corporatewide work process improvement projects to help meet the Chevron goal of reducing operating costs. Inventory Management headed the list with a possible one-time cash release as well as potential for large ongoing savings in inventory carrying costs. Preparing an accurate forecast for sales of one million barrels of petroleum products per day could result in a significant reduction of excess inventory held in terminal tankage to hedge against the uncertainty of demand.

The Business Problem

Each business function, from Marketing to Supply & Distribution, was creating a different forecast for the same products with each forecasting a little extra product to hedge against the uncertainty of demand. The forecasts were based on sales targets and past experiences with running out of product, and were created using anything from paper and pencil to Lotus® spreadsheets; consequently, there was little trust in the forecast along the supply chain. The results were:

- a forecast changed on a daily basis by the product schedulers
- distribution terminals unable to meet area station demands
- capital tied up in excess inventory
- the distinction between operational forecasts and sales targets or goals was not always observed
- throughput history data was not easily available to the forecasters
- the existing system did not support timely communication of the forecast and was antiquated, cumbersome and unfriendly to operate

The Business Solution

The project team formed to look at forecasting issues made the following recommendations:

- ensure that operational forecasts are kept distinct from sales targets
- clearly define responsibilities and accountabilities, ensuring only "one" forecast
- provide and use appropriate forecasts to drive inventory replenishment

- strengthen communication channels and ensure key players discuss forecasts and revisions on a systematic basis
- provide an information system that:
  - creates forecast based on historical demand and mathematical models thus increasing accuracy
  - provides the data needed by the forecaster to analyze the generated forecast
  - supports more frequent and timely revision
  - is easy to use and is portable across Chevron's standard Windows desktop environment
  - provides forecasts that match operational needs in terms of time intervals and detail
  - generates first-cut forecasts that can be adjusted based on business knowledge
  - interfaces with current mainframe information systems
  - compares throughput actuals to the forecast
  - prepares forecasts by location by product
  - requires little statistical training of the end users

The expected benefits of the above recommendations were reduced inventory, improved customer service, and optimized inventory levels. In addition, the tool would become a key link between marketing and supply operations.

The Software Solution

Selecting SAS

A team consisting of key individuals from Chevron's Marketing, Supply & Distribution, and Information Technology groups was formed. The team reviewed various off-the-shelf forecasting software solutions, but none fit the petroleum marketing business or the technical standards of the Information Technologists. The team then reviewed the SAS System implemented on the Windows platform. The statistical modeling power and extensive application development tools of the SAS System proved to be a good fit. The SAS set of tools for forecasting time series, including STATESPACE which picks the model that best fits the data, provided the breakthrough needed since the end users have little statistical training and may not be able to select the most appropriate model. STATESPACE was also the only model that allowed us to forecast multivariate series, which the team viewed as critical due to the nature of petroleum sales.

Data Flow

Each week the forecaster receives a flat file containing the last 30 days of throughput history. The data is loaded into a SAS data set and used to update all throughput history files. The forecaster then checks for any series (defined as the combination of a terminal and a stock) reporting throughputs for the first time. If there is a new series, the forecaster determines where its throughput history should be mapped (see data maintenance below). Once the data has been cleaned up, a forecast is run for each series the forecaster selects. Using reports and graphs, the forecaster analyzes the generated information. Adjustments can be made based on the forecaster's expert business knowledge. When s/he is satisfied with the forecast,
s/he exports the forecast to a flat file to be read into the existing mainframe systems. At the time of export, a SAS data set is saved with the forecast, effectively creating a 'snapshot' in time. This file is used later to compare the forecast accuracy with the actual sales.

Data Maintenance

With Chevron's many supply points and an average of four products per supply point, you cannot expect each time series to be forecast in exactly the same way. We created a screen (see Figure 1) that would allow the forecaster to customize each series. Customizable options include:

- how often to forecast (weekly or monthly)
- which forecast model to use
- whether the forecast of one series affects other series
- whether to differentiate the time series before forecasting
- the current status of the series (F - forecast, C - confirmed, E - exported)

Early on in the implementation process we discovered gaps in the time series. Due to the nature of the petroleum industry, an aggregation of data was required to give complete and consistent data. Each throughput enters the system associated with a terminal and stock. We describe this as a child record. The forecaster only prepares records.

Because of new environmental regulations (the Clean Air Act), Chevron is required to sell different types of gasoline during a calendar year. Using the Relations table, the forecasters are able to aggregate all similar products into one product (per distribution terminal) to create a consistent time series. However, forecasts need to be generated based on season, location, and type of gasoline. To address this problem we created a Seasons table (see Figure 3) to allow the forecaster to specify the percentage by week of each of the products they were forecasting. When the final forecast is exported, the parent forecast is divided among the specified products based on the percentage entered.

Figure 1

Each of the above screens was created by basing an extended table object in SAS/AF on a SAS data set.

Forecasting

Key requirements of the new system were ease of use and little statistical training. We created a screen that requires you to merely select the series you want to forecast, enter how much throughput history you want to use, and enter how many weeks into the future you want to forecast. Clicking on Start references the Directory screen (see Figure 1) for the selected mathematical model with the default being STATESPACE. The historical data specified by the forecaster is then passed into a SAS/ETS procedure (based on the selected model), and a forecast is produced for each selected series.

Analysis

Once a forecast is created, you can look at how the forecast compares to history by printing a report to the SAS output window, by analyzing various statistics generated by the forecast model or by graphing the data (see Figure 4). PROC REPORT is used to create the various reports, and PROC GRAPH is used to create the graphs.

Figure 2

Cumulative Lead Time Table

<table>
<thead>
<tr>
<th>FACILITY=COLUMBS STOCK=USUP LEADTIME=4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecast Week</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>94-05-05</td>
</tr>
<tr>
<td>94-05-12</td>
</tr>
<tr>
<td>94-05-19</td>
</tr>
<tr>
<td>94-05-26</td>
</tr>
<tr>
<td>94-06-02</td>
</tr>
</tbody>
</table>

1102
Adjustments

We developed a screen (see Figure 5) that allows the forecaster to make adjustments based on his/her business knowledge to enhance the initial forecast. Essential to the acceptance of this tool in the field was a way for the forecaster to use business knowledge to make final adjustments for events to predicted by sales history.

Figure 5

Exporting

Once a forecast is finalized, we need to load it into existing systems. The flexibility of SAS allows us to create two different file formats dependent on where we want to load the data. The Export screen uses PROC FSVIEW to display the forecast exactly as it will be loaded into the selected system (see Figure 6). This is the final opportunity for you to verify any adjustments and/or percentage splits to the forecast. Once you okay the forecast, two files are created—the export file and a SAS data set containing the forecast for future analysis.

Figure 6

Accuracy

A key management requirement of this project was the ability for you to compare your forecast to actual sales. As each week in a forecast passes, the sales data is loaded back into Demand Forecasting. Using the Analysis screen, you can pick by date the forecast files created each time you export. You can specify which week of a forecast you want to analyze and then run a report (see figure 7) that will display forecast vs. actual sales as well as differences between the two values.
Conclusion

The improved forecasting process is a big success. Demand forecasts are timely and accurate and are relied upon to manage Chevron inventories. As we have rolled out Demand Forecasting, the forecast accuracy of the sales regions using the tool has consistently been better than those still relying on manual forecasts.

In our 1992 benchmark, Chevron ranked near the bottom among our competitors in our forecasting process. After Demand Forecasting was installed, another comparison was done, and we were rated near the top.

The farther back you can look, the farther forward you are likely to see. - Winston Churchill

Evaluations

- SAS/AF allows us to rapidly prototype our screens for early user approval and acceptance.
- SAS/ASSIST® allows the exploration of data outside of the Demand Forecasting tool. Ideas generated from this exploration can then be included in the Demand Forecasting application.
- SAS/ETS creates forecasting code that can be easily dropped into our application. As new models are required, modifications are quick and easy.
- SAS/BASE allows us to import and export files in formats that could be used by existing Chevron systems.
- SAS/FSP allows us to maintain our documentation externally from the SAS System and view it in SAS.
- The space required by SAS on the desktop PC caused each sales region to purchase a new hardware.
- The cross platform capability of the SAS System seems to have led to a less than robust implementation of Windows features. We understand that 6.10 will be a much better implementation of Windows features.

All in all, the SAS System provided us with a set of tools that allowed the development of a user friendly application that met the stringent requirements of our business and clients.

SAS, SAS/AF, SAS/ASSIST, SAS/ETS, SAS/FSP, SAS/GRAPH are registered trademarks or trademarks of SAS Institute, Inc. in the U.S.A. and other countries. © indicates U.S.A. registration.

Other brand and product names are registered trademarks or trademarks of their respective companies.