**PROJECT - FORECASTING**

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**FORECASTING**

Forecasting is the prediction of the future value of a variable of interest, such as demand. Forecasting is essential to the success of many business functions, and forecasting is a critical part of the decision making process in any business. For example, in Accounting forecasting is used to provide cost and revenue estimates. In Finance, forecasting is used to estimate cash flow, and provide sources and uses of funds. Human Resources utilizes forecasting methods for hiring and training plans, Marketing departments use forecasting to determine pricing and promotions, and finally, Operations departments utilize forecasting for production planning purposes.

**Approaches to Forecasting**

There are various forecasting techniques, which can be separated into two main categories; qualitative techniques and quantitative techniques. Qualitative techniques rely on factors that cannot be directly measured. Qualitative forecasting techniques, such as the Delphi technique, are based on human judgment and a system of ratings to produce a result. Quantitative techniques, on the other hand, utilize numerical [facts](http://www.businessdictionary.com/definition/fact.html) and prior data as the basis of prediction. Some examples of quantitative forecasting techniques, which we will discuss in further detail, are Time Series Analysis and Causal Relationship Forecasting.

**Delphi Technique**

Delphi is a forecasting technique, which uses the opinions of experts in a specific field to obtain a forecast of that respective field. Experts are surveyed anonymously for their opinions on an area such as demand. A facilitator compiles the responses and provides a summary of responses back to the experts, who are then re-surveyed. After conducting two or more rounds of surveys, the facilitator will find an average and that level will be assumed as the demand. Through this process each member of the panel is told what the group thinks as a whole, so the Delphi Method seeks to reach the "correct" response through consensus. The word "Delphi" refers to the Oracle of Delphi, a site in Greek mythology where prophecies were passed on.

**Time Series Analysis**

Time Series Analysis is used to determine if trends or patterns in data exist over time. By using data from the past, we can hope to better predict the future. Examples of Time Series Analysis include Moving Average and Exponential Smoothing, but the most simple and least expensive type of Time Series Analysis is known as Naïve Forecast.

**Naïve Forecast**

Naïve forecast obtains its forecasts values for next period by matching it with the values for actual in the current period. Thus, the naïve forecasting method is very cheap, simple, and easy. Its simple derivation makes it ideal to use as a base to compare it to the quality of other forecasting techniques. If the quality of other forecasting techniques is lower than naïve forecasting, then the latter is always preferred since it would be cheaper, easier, and perform better as well.

The variable F represents forecast and A represents actual. T represents this period, thus, T plus 1 is the next period. (If T is 1, T plus one is 2; If T is 5, T plus one is 6) At actual demand in period T, F(T+1) is the forecast of demand for period T+1.

Although time series can measure any variable of interest, we will focus on measuring the variable of demand unless stated otherwise. Time series shows systematic and random components.

***There are three different types of systematic components.***

* Level: Where we think demand is
* Trend: Growth or decline. This will change upward or downward over time
* Seasonality: Predictable fluctuations

We can identify and quantify systematic components. The random component is the part that deviates from the systematic component and there is no control over this component. This is why forecasts will never be 100 percent accurate, because we are predicting them by assuming perfect conditions.

**Moving Average**

Moving Average is a quantitative forecasting technique that relies on historical data to predict the next period's forecast. It is called Moving Average because it uses the average of the most recent actual data in a certain period to forecast the next period. Furthermore, as time passes, there is more information about the actual demand. Moving Average calculates the forecast using the newest pieces of data and drops the oldest data as time passes. Therefore it is called Moving Average because the average moves as new data is available.

Now let’s suppose that we are manufacturing company that recently started six months ago and want to obtain the Moving Average to forecast the next month's level of production. We use the actual demand **A** of the past period to obtain the Moving Average. Let’s note here that this period's (month) Moving Average becomes the next period’s forecast.

Two period moving average for period 7:

***MA72 = (A6+ A7)/2***

Three period moving average for period 4:

***MA73 = (A5+ 63 + A7 )/3***

There is no limitation on how many periods should be used when calculating Moving Average, however using different numbers of periods will yield different results.

The general formula to calculate Moving Average for any ***n*** period moving average for period ***t*** is as follows:

**n** period moving average for period **t**

***MAtn = (At+ At-1+ At-2 +At-3+ ….+ At-n+1 )/n***

**MA** = Moving Average

**At** = Actual demand in period *t*

**Ft+1** = Forecast for a period t+1

**t** = period

**n** = Number of periods in a Moving Average

Each time new data is available, the oldest piece of data is substituted to calculate the new Moving Average. As we have already explained, this period Moving Average becomes the next period's forecast, therefore can we assume the following:

The Forecast for period **t+1** is equal to the moving average for period **t**

***Ft+1 =MAtn***

**Example 1:**

Suppose you were recently hired at the Hot Wireless store, a new smartphone store that opened a few months ago. In your first week there your boss mentions to you that he is concerned about the amount of smartphones the store should keep in stock. He doesn't want get overstocked with merchandise that he will not be able to sell. It is important to your boss not to invest lot of money in inventory because as entrepreneur and new business owner he is on a tight budget. Smartphones are supplied, on order, every two weeks by a local supplier. Remembering your Production and Operations Management coursework at Pepperdine, you think you could calculate the sales of smartphones to obtain a forecast. You explain to your boss that you think you can help, and he hands you the bi-weekly sales figures since the store opened six months ago.

The biweekly sales are as follows:

|  |  |
| --- | --- |
| Period (Biweekly) | Actual Demand |
| t | At |
| 1 | 43 |
| 2 | 56 |
| 3 | 79 |
| 4 | 75 |
| 5 | 84 |
| 6 | 87 |
| 7 | 91 |
| 8 | 99 |
| 9 | 96 |
| 10 | 108 |
| 11 | 106 |
| 12 | 113 |

You use the 3 period Moving Average of the 12th period to forecast the demand for smartphones for the coming two weeks. Therefore you are able to place the order for inventory with more accuracy.

***MA123 =*** (108+106+113)/3 = 109

Our forecast for the smartphone sales for the next period (13th) will be a demand of 109 smartphones. Your boss usually places inventory orders based on the last period’s demand plus a markup of 20% to prevent being understocked. He realized that he was holding thousands of dollars in inventory that could be used for other important part of the business. Therefore, he places an order based on your forecast.

To your boss’s delight, your forecast turned out to be really close to the actual demand of 109. Now he is able to free some cash from inventory to reinvest in the business. As a result, he puts you in charge of keeping track of sales and placing orders for the store.

**Exhibit 2.1 Continuous forecast**

As the time passes, Hot Wireless is attracting more customers but it still does not produce enough revenue to maintain a large inventory. Your boss actually likes to have low inventory so that Hot Wireless does not risk having large stocks of outdated smartphones when new models are released. Therefore, you decide to analyze your data even further.

|  |  |  |
| --- | --- | --- |
| Period | Actual Demand | 3 period Moving Average  |
| t | At | MA |
| 1 | 43 |  |
| 2 | 56 |  |
| 3 | 79 | 59.33 |
| 4 | 75 | 70.00 |
| 5 | 84 | 79.33 |
| 6 | 70 | 76.33 |
| 7 | 91 | 81.67 |
| 8 | 99 | 86.67 |
| 9 | 90 | 93.33 |
| 10 | 108 | 99.00 |
| 11 | 106 | 101.33 |
| 12 | 113 | 109.00 |
| 13 | 110 | 109.67 |
| 14 | 116 | 113.00 |
| 15 | 120 | 115.33 |

***MA123 =*** (108+106+113)/3 = 109

The following period Moving Average is calculated using the most recent demand for smartphones and data from the oldest period is dropped.

***MA133  =*** ((-108) +106+113+110)/3 = 109.67

***MA143  =*** ((-106)+113+110 +116))/3 =113

It continues in the same manner for the following periods.

***MAtn = (At+ At-1+ At-2 +At-3+ ….+ At-n+1 )/n***

To gain a better understanding of your demand you can also use the Moving Average with a different number of time periods. For Example, 4 period moving average, 5 period moving average, 6 period moving average, and so on, it is your choice how many periods to use.

Continuing with our Hot Wireless example, we have created the chart with two different moving averages; 3 period moving average and 6 period moving average:

|  |  |  |  |
| --- | --- | --- | --- |
| Period | Actual Demand | 3 period Moving Average  | 6 period Moving Average  |
| t | At | MA^3 | MA^6 |
| 1 | 43 |  |  |
| 2 | 56 |  |  |
| 3 | 79 | 59.33 |  |
| 4 | 75 | 70.00 |  |
| 5 | 84 | 79.33 |  |
| 6 | 70 | 76.33 | 67.83 |
| 7 | 91 | 81.67 | 75.83 |
| 8 | 99 | 86.67 | 83 |
| 9 | 90 | 93.33 | 84.83 |
| 10 | 108 | 99 | 90.33 |
| 11 | 106 | 101.33 | 94.00 |
| 12 | 113 | 109.00 | 101.17 |
| 13 | 110 | 109.67 | 104.33 |
| 14 | 116 | 113.00 | 108.17 |
| 15 | 120 | 115.33 | 112.17 |

Although, we are using the using the same method to forecast the demand for the next period, the results for the 3 period Moving Average and the 6 period Moving Average are different. This is due to the smaller moving average being more reactive to the most recent changes in data. As larger moving average takes into consideration older pieces of data and as result changes forecasts will be smoother and less reactive to the actual demand.



As you can see in the above scatter diagram, the 3 period moving average is more reactive to the changes in demand. While the six period moving average has a smoother curve. From this comparison we can conclude that a smaller period moving average is better able to forecast the demand in the short term. As such, the larger period moving average is better in the long run when a company wants to have an overall view of the demand or any other item of interest that want to forecast, for example cost and profit. But which method is best forecast for our example? That is determined by the size of the error between actual and forecast. We need to find the Mean Absolute Deviation that we will use as a system to measure error between different periods moving average.

**Exponential Smoothing**

Exponential Smoothing is another Time Series forecasting technique, which involves using weighted averages based on the previous forecast plus a percentage of the forecast error. The formula for Exponential Smoothing is as follows:

Ft = Ft-1 + a (At-1 – Ft-1)

Where:

Ft = Forecast for period t

Ft-1 = Forecast for the previous period

A = Smoothing constant

At-1 = Actual demand or sales from the previous period

Smoothing helps to remove random variation from historical demand data. By using a smoothing constant, or a percentage of forecast error, we are better able to identify trends and more accurately to predict future demand. Exponential Smoothing is easy to do in Excel.



In the example above, demand ranges from a low of 68 in Week 2 to a high of 87 in Week 7. Exponential Smoothing helps to even out the wide variation when determining the forecast. But how do we determine the Smoothing Factor? There is no one correct answer for determining the Smoothing Factor. Different factors can be tested by a business to see which returns the most accurate results. As the Smoothing Factor becomes larger, the predicted values will exhibit more variation because they are more responsive to the demand in the previous period. Prior to determining a Smoothing Factor, it is advisable to run “what-if” scenarios to see how these calculations react to demand changes that may not currently exist in the demand data the business is using for testing.

**Comparing Forecasting Methods**

When it comes to forecasting, it is important to understand which method to use for various business purposes. All forecasts have four common characteristics:

1. Forecasts are usually (always) inaccurate (wrong).
2. Forecasts should be accompanied by a measure of forecast error.
3. Forecasts for aggregate items are more accurate than individual forecasts
4. Long-range forecasts are less accurate than short-range forecasts.

The aggregate items are more accurate than individual forecasts because aggregate forecasts reduce the variability – actual demand for some items come out less than forecast, while the others come out greater than the forecasts, and they compensate for each other. The reason long-range forecasts are less accurate than short-range forecasts is due to the fact that forecasts further into the future tend to be less accurate than those of more recent events. As time passes, we get better information, and as a result we can make better predictions.

**Measures of forecast error: MAD, Tracking Signal**

**Mean Absolute Deviation (MAD)**

As we have already noted, different period moving average will give us different results. Although, the data is still the same, a 3 period moving average will yield different results than a 6 period moving average. How do we know which system is the best forecasting technique? The **Mean Absolute Deviation** (MAD) is used to determine the deviation of the forecasts compared with the actual numbers of a given period.

Mean Absolute Deviation (MAD) = *(Sum | At - Ft |) / Number of Periods*

One measure of effectiveness to find out whether our forecasting techniques are good for our data is summing out the difference between actual and Forecasts. Because the differences sometimes are positive and negative, the summation of the differences adds up to zero or close to zero. Therefore, to find the mean error of the whole data, we need to get rid of the negative signs.

The best way to get rid any number’s sign is to find its absolute value. For example, if we have a forecast for the sale of smartphones for this week of 140 and actuals sales were 135 smartphones, the difference, or error, between actual and forecast was 140 – 135 = -5. The absolute value of the error would be -5 = | 5 | and since we got rid of the negative sign, we can compute the mean absolute deviation MAD. MAD is the summation of the absolute value between actual demand and forecast divided by the number of observations.

**Tracking Signal (TS)**

The tracking signal helps to monitor the forecast by relating the cumulative forecast error to the average absolute error (i.e., MAD). The tracking signal is computed by period using the following formula:



The intent of the tracking signal is to detect any bias in errors over time (i.e., a tendency for a sequence of errors to be positive or negative). A major weakness of the tracking signal approach is its use of cumulative errors. Individual errors can be obscured so that large positive and negative values cancel each other.

**Casual Relationship Forecasting**

Causal relationship forecasting relates the demand to an underlying factor other than time. Examples of causal forecasting are linear (single and multi-variables) and nonlinear (single and multi-variables). The measures of accuracy of forecasting are mean absolute deviation and tracking signal.

**Example:**

Here is an example of how businesses can gain from forecasting techniques. The San Pedro Bay Ports includes the ports of Los Angeles and Long Beach. Based on the container handling volume, the San Pedro Bay Ports are ranked 5th in the world, after the Port in Singapore and three ports in China. More than 50 percent of containers coming to the United States pass through the San Pedro Bay ports.

What is the competitive edge of the San Pedro Bay Ports? Deep water facilities for post Panama ships, which may contain more than 8,000 containers; state of the art on-dock facilities to transfer containers between ship and train; intermodal transfer between ship, truck, and train; consolidation and distribution facilities for trans-loading from 20-foot containers and 40-foot containers to 56-foot containers, which are allowed to move on California roads, but as important as this capability is and maybe more important than this capability, are the two last characteristics of all forecasting techniques.

If we want to transfer the load from Far East to East Coast, it will take 4 weeks. From Far East to West Coast, it takes 2 weeks, and from Far East to the mid-United States it takes something between 2 to 4 weeks. Now, if I am going to ship loads from Far East to East Coast, I should forecast the demand of the East Coast 4 weeks in advance. If I am going to ship from Far East to West Coast, I should estimate the demand for the West Coast 2 weeks in advance. Estimates of the West Coast, which requires a forecast of 2 weeks, is more accurate than for the East Coast, which is 4 weeks in advance.

Shorter time provides more accuracy. Look at the other property. The forecast for East Coast, West Coast, and mid-United States, all of them are less accurate than the forecast for the total demand in the United States. So instead of forecasting for East Coast alone for 4 weeks and West Coast alone for 2 weeks and mid-United States for 3 weeks, I forecast the demand for all the United States for 14 days, 2 weeks in advance. Then when I send the container here, in one day I may transfer it to anywhere in California, in 2-3 days to somewhere in the mid-United States and 3 to 4 days somewhere in the East Coast. Now instead of estimating the demand of the East Coast alone, which is less accurate than the demand for the whole United States, and instead of forecasting it for 4 weeks from now, I can forecast it for 14 days plus 3 days, which is 17 days from now. The forecast for the United States for the whole United States between 14 days and 17 days in advance is much more accurate than the forecast for the East Coast, 4 weeks in advance and forecast for the mid-United States, which is 3 weeks in advance.

**Comparing Moving Average Forecasting Methods**

Let’s demonstrate how to determine the preferred model using the previous example of 3-period moving average vs. 4-period moving average.

For each method, calculate the following:

1. Error for each forecast period (Actual - Forecast)
2. Absolute Deviation for each forecast period (absolute value of error value)
3. MAD (average of all AD values for each method)



Comparing these two methods based on their MAD, we see that in this example 3-period moving average has the lower MAD value. Therefore, 3-period moving average is the preferred method over 4-year moving average. In this sample set, using a shorter number of periods is a better method. However, remember this is not always necessarily the case. For your own situation, you should try several different time window sizes, calculate MAD for each method, and then select the best method based on the lowest MAD value.