Chapter 5

Forecasting

"We are out of stock of toilet paper, hand sanitizer, Lysol and Clorox wipes."

"Expired surplus swine flu vaccines to be incinerated. Another estimated 30 million doses will expire soon."[34]

The above headlines are examples of a forecasting faux pas. Obviously, no one could have forecasted the mass hysteria created by the COVID-19 (corona virus) in 2020. The panic buying did expose flaws in the just-in-time supply chains and forecasting lead times.

The need for Swine Flu vaccine was obviously forecast wrong. The above referenced article states, "About a quarter of the swine flu vaccine produced for the U.S. public has expired — meaning that a whopping 40 million doses worth about $260 million is being written off as trash." This is a very serious forecasting error. This is not the only forecasting error in business. But it does show the need to have a good forecast – especially important in forecasting the need or demand for perishable items such as the Swine Flu vaccine. According to reports on the 2009/2010 Swine flu vaccine approximately 43% of the vaccines will be destroyed.

The story of the swine flu vaccine was the subject of business case studies for the ability to react, forecast and produce the vaccines. The Food and Drug Administration, the Center for Disease Control, and the manufacturers will now become the subject of case studies for the

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[34] Srobbe, Mike, Associated Press, http://www.news-sentinel.com/apps/pbcs.dll/article?AID=/SE/20100701/NEWS/7010342, accessed July 18, 2010

inability to forecast properly and get the product to the market in time to be used by the consumers.

Lessons were not learned from the Swine Flu vaccine issues as the same issue was again seen in 2019 when there was a shortage of flu vaccine again. This time the result came from the move of the preponderance of medical supply manufacture and pharmaceutical production from the US mainland to China and Puerto Rico. The hurricane season of 2018 decimated Puerto Rico's manufacturing capabilities resulting in a shortage of flu vaccine and this was followed by a shortage of plastic bags for fluids in the hospitals. The bag shortage was a combination of the shortage of the vaccine resulting in a flu epidemic that increased the demand for fluid bags in the hospitals to treat those with the flu.

Forecasting Impacts

Forecasting has impacts on multiple areas of operations management. Many of these we will look at in greater detail in this course. Take a look at some of the key areas of the chain impacted by forecasting: (The impacts on each of these areas will be clear by the end of the chapter.)

- **Sales – a forecast of what the company will sale.**
- **Production – a forecast of what should be made to meet the sales forecast.**
- **Inventory – a forecast of how much the company should have in finished goods to meet normal demands and to cover fluctuations in demand.**
- **Facilities – a forecast of how large the facility should be and where should the facility be.**

- **Raw Materials – a forecast of how much should the company have in raw materials to meet the production forecast**
- **People – a forecast of how many people are required to support the customer and to make the products necessary to support the production forecast.**
- **Profits – a forecast of how much profits the company will make based on the other forecasts.**
- **Products – a forecast of what products the company should make now and in the future, as well as a forecast of what products should be retired or eliminated as they reach their planned end of life.**

The issue with using the sales forecast as the foundation for the other forecasts is that historically companies have rewarded sales personnel with bonuses for exceeding forecasts. This practice incentivized the sales force to under forecast in order to get a bonus. The under forecasting result was that the rest of the company was always behind the demand curve trying to catch up.

Forecasting may be accomplished using a number of different models and techniques. We could spend the entire semester on forecasting models and techniques. The goal of this chapter is to provide the operations manager tools necessary to make educated forecasts in order to support decision making and the requirements placed on the managers by their bosses. Forecasts can be presented in graphs, tables, spreadsheets and can even be used in "what if" analyses to improve operations for the company. Regardless of how the forecast is used and presented; regardless of what technique or formula is used, the key is to use a presentation technique that the boss understands and that you understand and can explain in plain language to

the boss and his/her advisors. Regardless of the value of the forecast, if you cannot explain how the forecast was derived, it will be of no value to you, the boss or the company.

Examples of using the wrong forecasting model

- **Iraq Rebuilding.** The original forecast for the rebuilding of Iraq was based on the intelligence provided at the time. This proves that a forecast with flawed information will be a flawed forecast. The forecast was for a very short occupation and a very quick rebuild of the infrastructure. Obviously the infrastructure was in worse shape than the intelligence reported and the strength of the insurgency was stronger than the intelligence reported.

- **Overstock.com/Big Lots.** These two corporations have made a business out of other people's forecasting errors based on flawed forecasting models.

- **End of Season Sales.** These sales are obviously a result of flawed forecasts either by the store or the corporation coupled with a push strategy. The purpose of the end of season sale is to get rid of inventory to prevent having to return the items to the distribution center. We will discuss this issue in the chapter on reverse logistics.

- **Shortage on the shelves of stores.** When a shelf is empty it is usually the result of a forecasting error. The pictures in Figure 5.1 and 5.2 show empty shelves in Florida in March 2020 after the pandemic buying started. Obviously, this could not have been forecasted accurately, but if the forecasters at the manufacturers and distribution centers were looking forward, they would have forecasted increase sales demand as buyers started panic buying. As it was, it took 4-5 months for some supply chains to catch up with demand for the products.

2020 Shelves in Publix

Figure 5.1: Empty Shelves

2020 Walmart Shelves in Florida

Figure 5.2: Empty Shelves in Walmart

- **Going out of Business sales.** A good forecasting model should prevent this type of sale. Obviously, sometimes this type of sale comes from the owners just getting tired

of the business or the owner passes away and the children are not interested in keeping the family business. However, most going out of business sales are the result of bad forecasting on what should be stocked, how much should be stocked and when the stocks should turnover.[35]

What is Forecasting?

Forecasting is simply a prediction of a future even or future demand for products. Most common forecasts involve what will happen with the weather tomorrow or for the weekend. In operations management we are still concerned with forecasts. Depending on the where we are in the operations management chain, the weather forecast may be important. However, we are really concerned with how much we need to have, make, stock, ship or return. In operations management, the true benefits of forecasting will be the amount of inventory remaining at the end of the season or the ability to meet the need of the customer. Forecasting based on historical data assumes that the events of history will repeat themselves.

Joe's Rules of Forecasting

The first and most important rule of forecasting is that **forecasts are usually wrong**. In fact, forecasts are always wrong. There are lots of models and techniques for forecasting, but there is no way to accurately forecast the future. Companies establish a margin of error for forecasts and as long as the "wrongness" is within that margin then the company is satisfied.

Every good forecast should include an estimate of error or margin of error. Actually, every good forecast should and usually does have an estimate of error. The estimates

[35] We will discuss the concept of inventory turnover during the discussions of inventory management.

that are made every election year based on the polls have a margin of error. This margin of error tells the user of the forecast how accurate the forecaster believes the forecast to be.

Forecasts are more accurate for families or groups. This is the rule of aggregation. The forecast for the product family should always be more accurate than the forecast for the individual models or colors. Automobile manufacturers can more accurately forecast the number of a particular car model that will be sold than they can forecast the number of red ones, blue ones or yellow ones that will be demanded by the customer. A printer of college T-shirts should be able to better forecast how many of a particular slogan shirt will sell than they will be able to forecast the colors and sizes that will be demanded by the customers.

Forecasts should be more accurate the closer we are to the forecast period. The closer the event is the more accurate the forecast should be. Even in the weather forecasting business it is easier to forecast tomorrow's weather than to forecast next week's weather. It is easier to forecast the sales for this week than the sales for next year. One company that I recently worked with had a series of forecasts. They forecasted sales eleven weeks out with an accuracy of 59% (there was no reason for a forecast that far out except, "We've always done it that way!" I am guessing somewhere in the past this corresponded to their replenishment times). They also forecasted four weeks out with an accuracy of about 90% (this was tied to their current replenishment cycle time). And, they had a forecast one week out for next week's sales that was about 95% accurate. This company's forecasts help to prove the theory that the closer to the event the more accurate the forecast. The most amazing thing about this company was that the only forecast that they reported to their corporate management was the eleven week forecast (because they had always reported that forecast).

The Importance of Forecasting

The ability to forecast as accurately as possible may very well impact the profitability of the company and the stock of the company. In addition, the ability to improve demand forecasting for customer demands and then sharing that information downstream will allow more efficient scheduling and inventory management throughout the entire operations management chain.

In 1997 Boeing wrote off $2.6 billion as a result of forecasting errors by themselves and their suppliers. They deemed these shortages as not only raw material shortfalls (read that to be a forecasting error) but also internal shortfalls and supplier shortages as well. Each of these shortfalls, internal and external, were the result of forecasting errors, very expensive forecasting errors. This error was compounded about fifteen years later when Boeing once again delayed the shipments of their new 787 Dreamliner aircraft. The excuse they used then was the same one they used fifteen years later – "internal and supplier parts shortages." The most common cause of these issues is a lack of communication in the supply chain.

A few years earlier in 1993, US Surgical suffered from forecasting errors that resulted in excess supplies that ended up costing the company approximately $22 million, representing a 25% decrease in sales. This forecasting mistake came from not knowing what their customers had in stock at the hospitals. Knowing the customer and the customers' requirements is essential to accurate forecasts.

In 2010 a leading sporting goods retailer sent out a flyer for a sale on a Saturday morning. This particular flyer contained an ad for a fly-fishing rod and reel combination. This company had this fly rod for sale for a four-hour period and thought that they had forecasted enough rods to last the entire four-hour period of the special sale. Unfortunately for this retailer, the forecast

was only off by about two hours. The result was having to place another more expensive rod on sale to meet the demands of customers that came from several states to shop the specials.

In 2014 the Kansas City Chiefs, along with the rest of the National Football League, mandated the use of clear bags in lieu of backpacks or purses when entering the stadium. The message went out first to season ticket holders informing them of the change in policies and notifying them of the availability of the bags for free for all season ticket holders -one free bag with the Chiefs logo per season ticket account. The bag is shown in Figure 5.3 below. The demand for the bags was not forecasted well as it was week three of the season before there was a sufficient number of bags to meet season ticket holder demand – which meant a longer delay for non-season ticket holders that wanted a clear Chiefs bag.

Figure 5.3: Chiefs plastic game day bag

Forecasting is essential for smooth operations of business organizations. Forecasting provides the company with estimates of the occurrence, timing, or magnitude of uncertain future events. Forecasting is not free – there are costs associated with forecasting future demand or future events for the company. These costs to provide a smooth operation include the costs of lost revenues from forecasting wrong as we saw with IBM when forecasting on the short side. On the other side of the forecast are the costs of having too many people or too few employees

on the job or in the factory/store; excess materials or material shortages; or having to expedite shipments and paying for expedited freight to meet customer due dates.

If forecasting is so important to the company and the operations management chains how do you ensure that you get the right data in order to improve the forecasts? The first tip is to capture the data in the same way that you will be using the data. If the forecast is for a monthly period, the data capture has to be in monthly time buckets. If your forecast is for daily demand or daily production, monthly data will not work. One company wanted to take daily data and extrapolate hourly production from the daily data. What the company wanted to do was take eight hours of demand data and average it over the day. The problem with this technique is that in actuality none of the hours had the average demand. If there are certain circumstances that may skew the data if not taken into consideration, these should be recorded. An example of this is the impact on building materials after Hurricane Katrina. Building material demand actually increased the cost of materials by almost 10% as far away as Kansas. Another area that may impact the ability to more accurately forecast demand or production may be to separate customers into different demand groupings. This is basically what General Motors used to do with the Chevrolet (the working man's car), Pontiac, Oldsmobile, Buick and Cadillac. If customers are segmented for marketing purposes, their demands and resultant forecasts should also be segmented.

Forecasting inaccuracies (forecasting errors – more on this later in the chapter) can increase the total cost of ownership for the company for products being produced or stored. These increased costs come in the form of:

- Increased inventory carrying costs as a result of forecasting the production of more product than the customer is buying.

- Obsolete inventory (although this may be considered part of carrying costs) as a result of grossly over forecasting to the point that there is so much stuff on the shelf that it becomes obsolete before it can be sold. This is common in the electronics industry where items become obsolete about ninety days after produced and in the fresh foods industry.

- Not forecasting for sufficient quantities of raw materials to meet production levels and having to expedite more materials in or worse accept less than quality materials to make up for the shortfall in the forecast. This particular problem results in the potential of producing substandard quality because of the substandard materials substituted for the forecasting shortfalls.

- The cost of expediting finished products to the customer to meet customer due dates or required delivery dates as a result of the forecasting shortfalls. Because the product is not ready in time to meet normal delivery methods, the company may be forced to ship via expedited delivery in order to keep customers satisfied.

The Role of Forecasting in Operations Management

In supply chain management, as we saw in Chapter 2, forecasting is critical to the overall success of the supply chain and may be tied to the ability of the company to pass accurate information to their suppliers. I am not sure that the panic buying of 2020 could have been predicted or if better information would have prevented empty shelves in that case. But I am certain that the Bull Whip Effect created by the panic buying and attempts to ramp up production to meet the demand will result in excess stocks within a few months.

In the short term, the forecast is critical to the production of products. This includes the forecasting of the raw materials, components, assemblies and sub-assemblies, the forecasting of the personnel necessary to make the supply chain operate effectively, and the forecasting of where the finished goods should be stored based on demand forecasts. In the long term, forecasts are necessary to predict the requirements and demand for new products and how many of the new products should be stocked and where they should be stocked. The processes and facilities necessary for the production and storage of new products is part of the long-term supply chain forecast.

Since the goal of the operations management chain is to add value by satisfying customer demand, a forecast is necessary to meet the production, distribution and quality to meet the customers' demands. The forecast must be robust enough to ensure an uninterrupted flow of products and/or services for the customers. The strategic plan of the company must include some form of forecasting in order to plan where the company needs to be in the future and what capacity the company will have to have in order to meet these forecasts.

This strategic plan and the ability to meet the forecasts in the strategic plan for publicly held companies are very closely watched by Wall Street. Sometimes companies play games with their forecasts and production to meet the forecasts.

Krispy Kreme Doughnuts tried to do this. Several years ago, as Krispy Kreme tried to pump up their production and shipment numbers artificially and the resulting forecasts for future production. Seems Krispy Kreme was not actually selling and shipping the numbers of doughnuts that they were reporting. The company was actually shipping the doughnuts to their retail customers (grocery stores and convenience stores) at the end of reporting periods with the understanding that the retailers would not be charged for the extra number of doughnuts shipped.

After the reporting period was closed out, Krispy Kreme would have the retailers ship the excess doughnuts back. The quantity shipped and the not actual sales quantity was reported thus skewing the forecasts for future sales and drove the stock price through the roof while also creating a huge waste of doughnuts. When this deceptive practice was discovered the price went from approximately $40 per share to $4 per share almost overnight. The darling of Wall Street crashed and seven years later the stock price is still depressed.

Forecasting Techniques

There are basically two commonly used techniques (not methods) for forecasting or predicting future events/demand/production.

- Extrinsic Forecasting Technique. With Extrinsic Forecasting, the forecast for the future is based on external indicators that are related to the product being forecasted. For example, a distributor of refrigerators may use the extrinsic technique to forecast sales of refrigerators based on the historical correlation between the sales of new homes and the sales of refrigerators. Another example: Every summer approximately 800 mid-grade US Army Officers move to Fort Leavenworth, Kansas for a year-long Intermediate Level Education program. These officers and their families transfer to Fort Leavenworth from all over the world and include foreign officers attending the education program. Extrinsic forecasting techniques would allow local merchants to base their stocks of household products on the number of families moving into the area and the historical correlation between families moving into the area and the number of household products such as blinds, cleaning supplies, rugs, etc., are sold.

- Intrinsic uses straight historical data to forecast future demand or production. These techniques are more common and will be discussed in greater detail by looking at the different methods of forecasting used under the Intrinsic Forecasting umbrella.

Intrinsic Forecasting

Intrinsic forecasting basically falls into two categories of methodologies. These methodologies are qualitative and quantitative methods. Qualitative forecasting is based on subjective methods when quantitative data is not available. Conversely, quantitative forecasting is based on mathematical models and formulas.

Qualitative Forecasting

Qualitative forecasting is subjective in nature. It is based on best guesses, opinions and judgment. A Qualitative forecast may be used for marketing, production or purchasing decisions. The problem with opinion-based forecasts or expertise-based forecasts is that it is critical to have a well experienced person making the forecast. Anyone can make a forecast based on an opinion but if the opinion is not based on experience in that particular area, the forecast may not be of any value.

Another qualitative technique used in academia frequently is the Delphi method of forecasting. The Delphi method uses a panel of "experts" to come to a consensus to make forecasts or predictions for the future. The Delphi methodology takes its name from the Oracles of Delphi in Greek Mythology. This technique's validity is obviously dependent on picking the right "experts" for the panel.

Several years ago, I had the opportunity to participate in a Delphi panel looking at the future trends that would affect supply chains into the future. The panel submitted a list of

potential trends. These lists were consolidated and redistributed to the panel members for rank ordering of the trends. The top 25 trends were sent out again to the panel with the goal to get the top 10 trends that would impact supply chain management in the future. We were fairly accurate; however, the panel of "experts" did not forecast the increase in fuel/crude oil prices that hit supply chains in 2004 and again in 2008 or the recession that followed closely in late 2008/early 2009. Had we possessed the "expertise" to foresee these issues, we would all probably be retired now from shorting the stock market and placing the timely puts and calls on oil futures.

No Delphi Panels predicted the market crash in 2020 or the pandemic and mass hysteria caused by the corona virus.

Quantitative Methods

Quantitative methods for forecasting employ the use of mathematical formulas and calculations to predict the future. These models and calculations assume that what happened in the past will happen in some form in the future. Qualitative methods may take the form of a linear trend line, a regression analysis, an average, a moving average, a weighted average or another more complicated method.

Each of these methods looks at the trends, cycles, seasons, random events that may impact the forecast and indices from business that may also impact the forecast. In 2005, the Fortune Business Council conducted a survey on what indices companies used to shape their forecasts. Some of these indices are still used very frequently today and some of them have greater importance now than they did in 2005. The Consumer Price Index is still frequently used, the price of a barrel of oil is much more prominent in shaping forecasts today than it was in 2005 after the $140 a barrel price in 2008. As a result of the recession of 2008-2010, everyone is aware of the unemployment rates and considers these rates as part of the forecasting process. The

improved economy after the recession has produced historically low unemployment levels. This created a new forecasting problem – where will the employees come from and what will be the employee turnover rates?

A **Trend** is a gradual up or down movement in the demand of the product. A trend can be used to predict what will happen in the future. It is important for a firm to know where they are in the trend in order to accurately forecast the future. The ability to spot a trend, up or down, is critical to the forecaster and his/her company. Figure 5.4 and Figure 5.5 show trend lines.

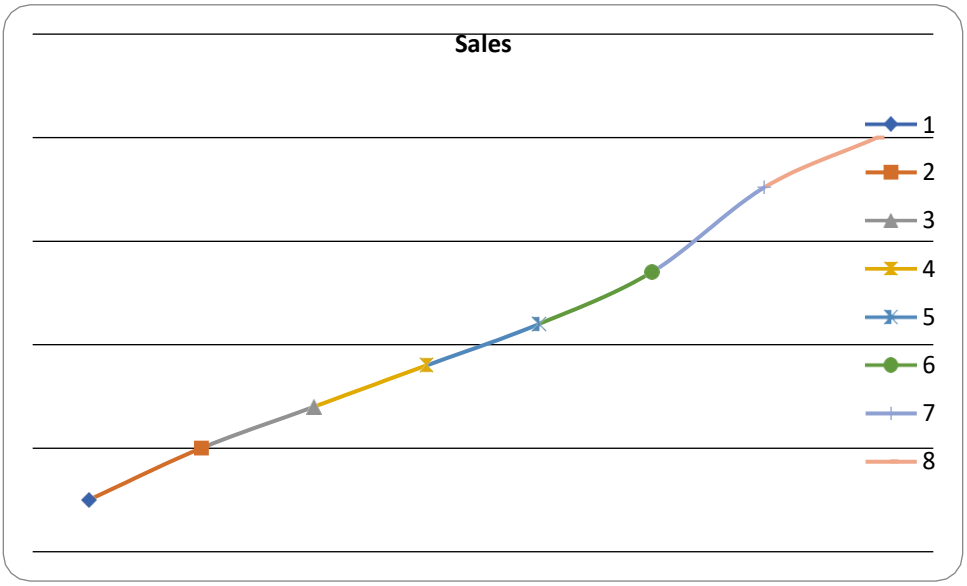

Figure 5.4: Upward Trend Line

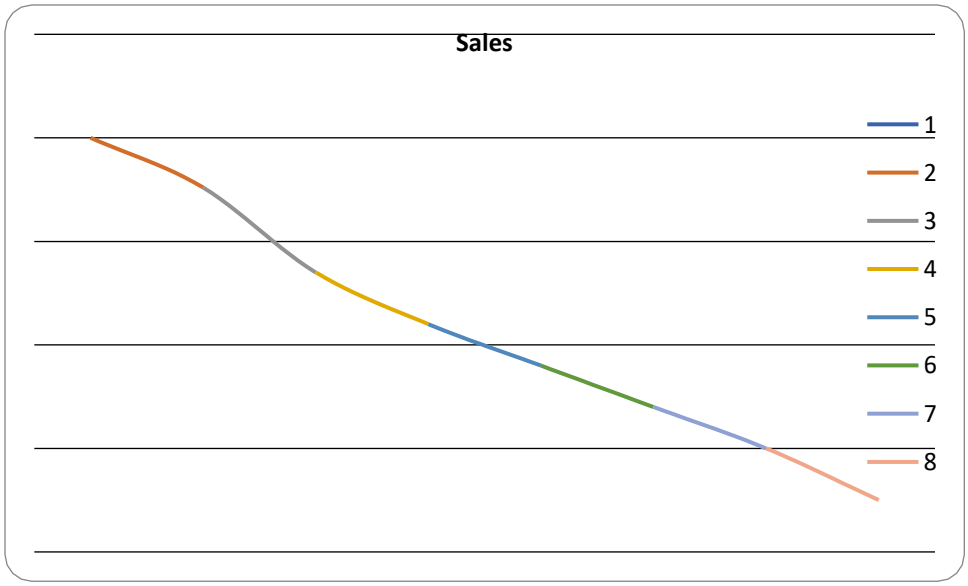

Figure 5.5: Downward Trend

A **Cycle** is usually tied to a business cycle. A cycle is a repetitive upward and downward movement of the production or demand for a product. Just like the trend, it is important for the forecaster to know where in the cycle his or her product or company is at the time of the forecasted period. Not knowing where they were in the cycle is what helped to deepen and lengthen the Recession of 2008-2010. Companies that did not identify where they were in the business cycle continued to produce products based on the previous trend and not the new business cycle that was spiraling downward. Figure 5.6 shows a cycle for the sales of a product.

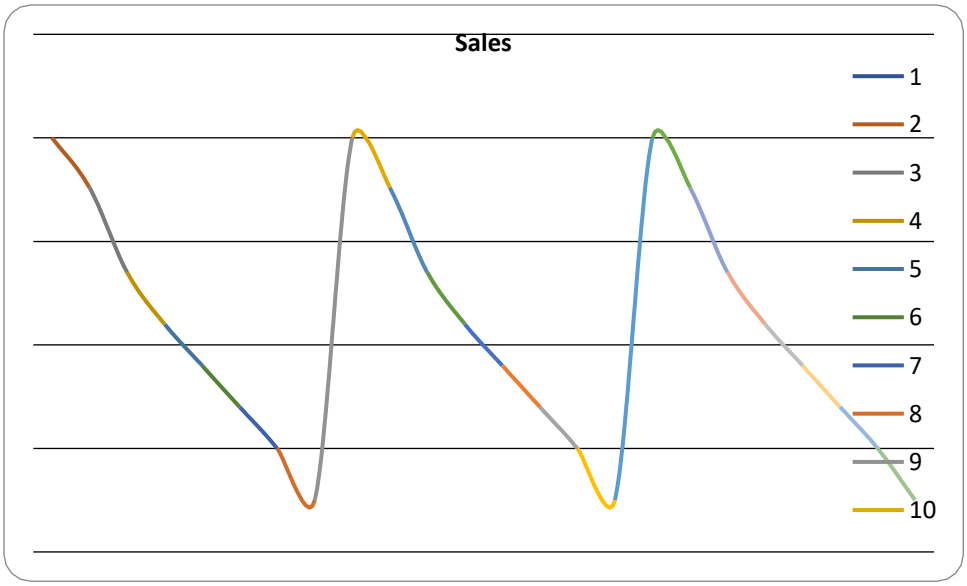

Figure 5.6: Example of a Cycle

A **Seasonal** pattern could possibly be trend line with spikes during certain seasons. Or, the seasonal pattern may be more obvious as shown in Figure 5.7 below. Seasonal items show a propensity to be sold in certain periods of the year. In Kansas, the sale of snow shovels is, thankfully, a seasonal item. Swimsuits in most parts of the country are seasonal items. Winter coats are also seasonal items. The sale of turkeys is seasonal in nature. Most turkeys sold in the United States are sold in the fourth quarter – the largest demand for turkeys comes around Thanksgiving and the Christmas holidays. After the holidays, the demand for turkeys falls off dramatically.

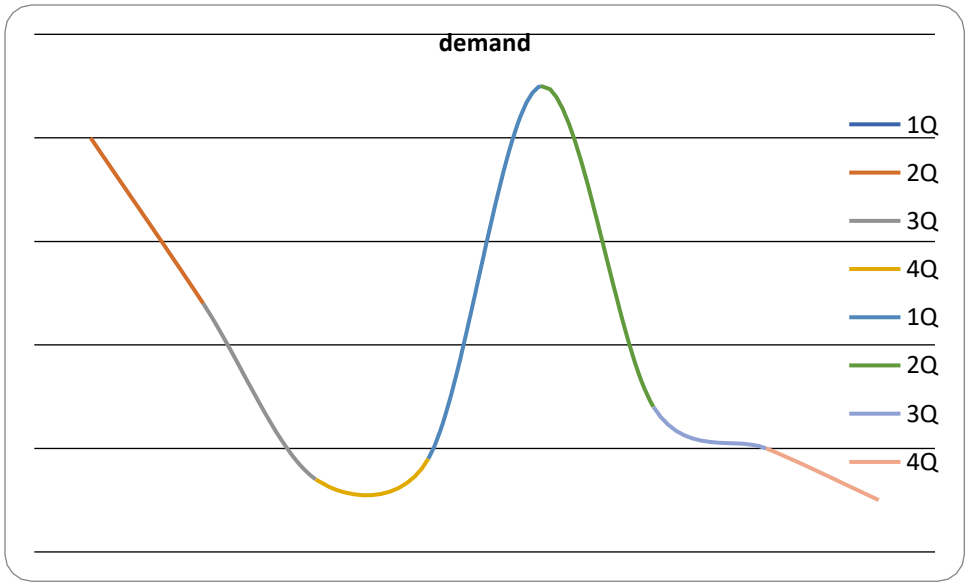

Figure 5.7 Example of a Seasonal Pattern

Time Series Quantitative Methods

Time series methods are statistical methods that use historical data with the assumption that the historical patterns will repeat themselves in the future. For the application of these techniques to operations management and supply chain management forecasting, we will focus on moving averages, weighted moving averages, exponential smoothing and seasonal forecasting.

However, a discussion of forecasting would not be complete without a discussion of the simplest technique of all – the **Naïve Forecast**. The Naïve Forecast is very easy to use. It simply assumes that whatever happened last period will repeat itself exactly in the next period. In Figure 7.6 the use of the Naïve Forecast can be seen. Whatever was demanded in the previous month is forecasted for the next month.

	Actual Demand	Forecasted Demand
January	75	
February	90	75
March	125	90
April	130	125
May	150	130
June	175	150
July	185	175
August	125	185

Figure 5.8: Example of Naïve Forecasting

The **Simple Moving Average Forecast** is also a simple methodology to use to forecast future demand, production or shipments. Stock market analysis usually starts with a moving average to show the trend line for the markets. With this technique all the forecaster to doing is averaging the demand/sales/production for previous periods. **Formula 5.1** is the formula for calculating the moving average:

$$\text{Moving Average} = \frac{\text{Sum of periods data}}{\text{Number of periods}}$$

Formula 5.1 Simple Moving Average

Using the same data as in Figure 5.8, Figure 5.9 shows the forecast using a 3 month and 5 month moving average. Which one is better? That depends on some historical analysis of the forecasts. We will discuss forecast error and comparing the techniques in another section. For example, purposes to understand the calculations, Figure 5.9 shows the decimal places in the forecast, as we move from the academic calculation to the concrete forecast for the business, we need to round to the next whole number. The rationale for this is that we cannot make a 0.666667 of a product, therefore in the example below; the forecast for April using the 3-month moving average should be rounded to 97. The moving average is a good technique when forecasting for products that are in a trend and have relatively stable demand patterns.

	Actual Demand	3 Month Moving Average Forecasted Demand	Calculation	5 Month Moving Average Forecasted Demand
January	**75**			
February	**90**			
March	**125**			
April	**130**	**96.666667**	**(75+90+125)/3**	
May	**150**	**115**	**(90+125+130)/3**	
June	**175**	**135**	**(125+130+150)/3**	**114**
July	**185**	**151.66667**	**(130+150+175)/3**	**134**
August	**125**	**170**	**(150+175+185)/3**	**153**

Figure 5.9 Simple Moving Average Forecast

The Weighted Moving Average

The **Weighted Moving Average** method sometimes creates confusion with students the first time they encounter forecasting. The Weighted Moving Average method does not involve any division as in the Simple Moving Average method. This method is called Weighted Moving Average because weights are assigned to the data. The weighs are usually provided by the forecasting team, marketing department based on the validity of the data or the manufacturing department based on their assessment of the data. The weights may be subjectively assigned which may reduce the value of the forecast. The weights can be used to place more emphasis on the most recent data by placing a higher weight on the most recent data or can be used to place more importance and value on the older data by weighting that data more heavily. All the weights must add up to 1. The weights are multiplied by the corresponding data and all the products of the multiplication are added together to get the forecast. The goal of this method is to consider and account for data fluctuation. The formula for the Weighted Moving Average method is shown in **Formula 5.2** while Figure 5.10 and 5.11 show the forecast using our previous data:

(weight 1 x data 1) + (weight 2 x data 2) + (weight 3 x data 3)

Formula 5.2 Weighted Moving Average

	Actual Demand	3 Month Weighted Moving Average Forecast	Weight	
January	75			
February	90			
March	125			
April	130		0.15	19.5
May	150		0.3	45
June	175		0.55	96.25
July	185			
August	125			
		(.15*130) + (.3*150) + (.55*175)		160.75

Figure 5.10: Weighted Moving Average for July – this forecast must be rounded up to 161

	Actual Demand	3 Month Weighted Moving Average Forecast	Weight	
January	75			
February	90			
March	125			
April	130			
May	150		0.15	22.5
June	175		0.3	52.5
July	185		0.55	101.75
August	125	176.75		
		(.15*150) + (.3*175) + (.55*185)		176.75

Figure 5.11 Weighted Moving Average for August – this forecast must be rounded up to 177

So far, we have forecasted August's demand to be 170 using a 3 Month Simple Moving Average, 153 using a 5 Month Simple Moving Average, and 177 (176.5) using a 3 Month

Weighted Moving Average. Which forecast is best? We will discuss that later when we look at forecasting error.

Exponential Smoothing Forecasting

The **Exponential Smoothing** method is widely used in business to help shape a more accurate forecast. Like the **Weighted Moving Average** method, this method also uses weights to smooth the forecast. And like the Weighted Moving Average, the weights must add up to 1. This method uses a smoothing factor (**α**). The smoothing factor must be between 0 and 1:

$$(0 \leq \alpha \geq 1)$$

The closer the smoothing factor is to 1, the more emphasis that is being placed on the recent data; consequently, the closer the smoothing factor is to 0, the more emphasis that is being placed on the older data. There are four basic steps to applying the Exponential Smoothing method to create a forecast:

1. **The first period** (and only the first period) that will be forecasted using this method will be **the Naïve Forecast** – the actual demand/production/sales from the previous period.
2. (Steps 2-4 will be used for the remaining periods) The next period forecasted will use the first part of **Formula 5.3**, Exponential Smoothing Forecast by taking the ACTUAL DEMAND from the PREVIOUS PERIOD and multiplying the demand by the smoothing factor.

Forecast = (Actual Demand Previous Period x ά) + (Previous Demand x (1-ά))

Formula 5.3 Exponential Smoothing Forecast

3. Using the second part of **Formula 5.3,** multiply the FORECAST from the PREVIOUS PERIOD by (1- the smoothing factor). This is the forecast that you just made in the previous period

4. In step 4, add the results of step 2 to the results of step 3 and round if necessary; this is your forecast for that period.

Figure 5.12a and 5.12b show examples of Exponential Smoothing Forecasting using the same data that we have used for the other forecasting methods.

	Actual Demand	Forecast	
January	75	1	
February	90	75.00	
March	125	84.00	4
April	130	108.60	
May	150	121.44	
June	175	138.58	
July	185	160.43	
August	125	175.17	
Calculations:	2	3	
March	(.6*90) + (.4*75)		
April	(.6*125) + (.4*84)		
May	(.6*130) + (.4*108.6)		
June	(.6*150) + (.4*121.44)		
July	(.6*175) + (.4*138.58)		
August	(.6*185) + (.4*160.43)		

Figure 5.12a: Exponential Smoothing Forecasting with .6 Smoothing Factor

	Actual Demand	Forecast	
January	75	1	
February	90	75.00	
March	125	84.00	4
April	130	108.60	
May	150	121.44	
June	175	138.58	
July	185	160.43	
August	125	175.17	
		3	
Calculations:			
March	(.6*90) + (.4*75)		
April	(.6*125) + (.4*84)		
May	(.6*130) + (.4*108.6)		
June	(.6*150) + (.4*121.44)		
July	(.6*175) + (.4*138.58)		
August	(.6*185) + (.4*160.43)		

2

Figure 5.12b: Exponential Smoothing Forecasting with .7 Smoothing Factor

You will notice that the first step both examples is the same data. The naïve forecast will not change when you change smoothing factors.

Seasonal Adjustments to the Forecast

In some cases, a **Seasonal Adjustment** may be necessary to provide a more accurate forecast for a period. The Seasonal Adjustment is designed to do just that. A Seasonal Forecast and forecast factor is necessary when there is a repetitive increase or decrease in the demand tied to a particular set of periods. The sale of winter sports apparel is seasonal by design but becomes even more seasonal in nature every four years after the Winter Olympics. As discussed earlier, the sale of turkeys is seasonal. When a seasonal spike is noticed then the seasonal factor can be computed, and a Seasonal Adjustment made to the forecast. Computing the seasonal factor is done using Formula 5.4.

$$\text{Seasonal Factor} = \frac{\text{Demand during period}}{\text{Total}}$$

Formula 5.4: Seasonal Factor Computation

Let's look at an example to make this concept clearer.

SALES PER QUARTER

YEAR	*1*	*2*	*3*	*4*	
2018	**172**	**26**	**3**	**125**	**326**
2019	**191**	**23**	**5**	**102**	**720**
2009	**213**	**56**	**1**	**226**	**735**

- **Sales for 1Q = 172+191+213 = 576**
- **Sales for 2Q = 26+23+56 = 105**
- **Sales for 3Q = 3+5+1 = 9**
- **Sales for 4Q = 125+102+226 = 453**
- **Total Sales for all 3 years = 1143**
- **Factor for 1Q = 576/1143 = .503 – this tells us the ~ 50.3% of all the sales for this product over the past 3 years came in the first quarter of the year.**
- **The next step is to compute the Simple Moving Average to forecast 2020 sales = 1143/3 = 381 as the forecast for total sales in 2020**
- **To get the Seasonal Adjusted Forecast: multiply 381 (total annual forecast) by .503 (seasonal factor) = 191.64 = 192 as the forecast for sales in the first quarter of 2020**

Forecasting Accuracy

So far, we have looked at methods and variations of methods to produce a forecast of future demand, production, sales, or shipments. The purpose of looking at various methods is to allow some "what if" analysis to find the most accurate method for our company and our products. Just because one method worked at your last company does not mean that it will work at your new company.

There are many ways of forecasting a forecast error. For our purposes, Forecast Error is a very simple calculation as shown in **Formula 5.5**. Forecasting accuracy is simply the actual sales/demand/production minus the forecast. Figure 5.13 shows the Forecast Error using our original example with the 3-month and 5-month Simple Moving Averages.

Forecast Error = Actual Demand – Forecasted Demand

Formula 5.5: Forecast Accuracy

	Actual Demand	3 Month Moving Average Forecasted Demand	Forecast Error	5 Month Moving Average Forecasted Demand	Forecast Error
January	**75**				
February	**90**				
March	**125**				
April	**130**	**97**			
May	**150**	**115**	**35**		
June	**175**	**135**	**40**	**114**	**61**
July	**185**	**152**	**33**	**134**	**51**
August	**125**	**170**	**-45**	**153**	**-28**

Figure 5.13: Forecasting Error

Note that in some months the forecast was over and in some months the forecast was under. Simply adding up the forecasting errors will give a distorted picture of the impact of the forecasting error. Therefore, to get a more accurate picture of the magnitude of the forecasting error over time, the Mean Absolute Deviation is used to measure the accuracy of the forecast. Figure 5.14 shows the original forecasting example for the 3-month Simple Moving Average and the calculation of the Mean Absolute Deviation. This will tell us on average how much our forecast deviated from the actual sales of our product. It is important to remember that this is an average and you will note that at no point did our forecast actually deviate by 38. This calculation does give us a mark on the wall as to how well we are forecasting.

1. **The first step is to convert all of the forecast errors to their absolute values. This simply removing the negative signs in front of the forecast errors when the forecast was short.**

2. **Sum up all of the absolute values.**

3. **Divide the sum from step 2 by the number of periods that were forecast and you have the Mean Absolute Deviation.**

	Actual Demand	3 Month Moving Average Forecasted Demand	Forecast Error	Absolute Error
January	**75**			
February	**90**			
March	**125**			
April	**130**	**97**		
May	**150**	**115**	**35**	**35**
June	**175**	**135**	**40**	**40**
July	**185**	**152**	**33**	**33**
August	**125**	**170**	**-45**	**45**
			Sum of Absolute Errors	**153**
			Mean Absolute Deviation	**38.25**

Figure 5.14: Mean Absolute Deviation Example

Another method of measuring or gauging the forecast accuracy is called a **Tracking Signal.** A Tracking Signal is used to alert the forecaster of when a forecast is out of tolerance. Remember all forecasts are wrong and a good forecast has a margin of error. The Tracking Signal provides an indicator of when the forecast is not within acceptable limits. One rule of thumb states that band of ± 3 Mean Absolute Deviations (MAD) is an acceptable Tracking Signal. This is also tied to the law of large numbers – the larger the numbers the more accurate the forecast. In our example above, if the ± 3 MADs is the standard then the forecast is not out of tolerance. However, if you are running a small company with forecasts for smaller numbers, ± 3 MADs may not be an acceptable Tracking Signal. In that case, a tolerance level based on a certain number of units may be used as the Tracking Signal. Whatever the technique used to establish a Tracking Signal; it is important to note that the larger the number the more the

forecast is out of tolerance. This is analogous to the upper and lower control limits established in quality control charts or in statistics courses.

Forecast Control

Some events are out of the control of the forecaster or the company but still may impact the accuracy of the forecast. Research is necessary to determine why a forecast is out of tolerance or out of whack. Any number of things can impact the demand for your product and therefore impact the accuracy of the forecast. The following is a short list of potential impacts to the forecast accuracy:

- Politics and political change. In 2008 the United States made history with the election of the first Hawaiian born President and the first surfing President. This caused ripples across the hunting and gun owning world as there was a fear (based on transition and campaign rhetoric) that the sale of weapons and ammunition would be severely controlled or banned. This created a "run" on the sale of handguns, rifles, shot guns and ammunition. Such a run that Cabela's had a record quarter based on the six weeks of sales after the November election. This had a serious impact on their forecasting for that quarter as well as the forecasts for future quarters to show progress. This trend continued throughout the Obama years every time there was a mass shooting. We can see the same impacts from political actions in the past several years with tariffs.

- The appearance of an unexpected business cycle. This is exactly what happened world-wide in 2008. A new and unexpected business cycle appeared. This cycle is now called the Great Recession. Forecasts drove manufacturing and retail stocks based on a continued growth trend. This drove the recession farther down as a result of increased inventories coupled with severely decreased sales. And, when no one is buying basically

no one is selling and the forecasts, based on historical data, become skewed and out of tolerance.

We saw the same thing in 2020 with the mass hysteria buying creating a new business cycle for certain products.

- Changes in the weather. After a hurricane the demand for building and rebuilding supplies goes through the roof, no pun intended. The same phenomenon is seen after a major flood. These weather changes impact the accuracy of forecasts that did not include these events and could very well impact future forecasts for demand if the abnormal demand from the weather change is not backed out of the forecast.

- The appearance of a new competitor. When Lowe's and Best Buy went into the major appliance business it impacted, or should have impacted, the forecasts of Circuit City. Apparently since Circuit City is no longer in business and Lowe's and Best Buy are in the top three sellers of major appliances, Circuit City should have altered their forecasts to consider the new competition.

- Not seeing trends. In the 1970s and 1980s there was a clothier named Merry-go-Round. This chain of stores carried the latest in fashions for the high school, college age and young professionals. It was the darling of Wall Street and consistently outperformed the competition. Then in the early 1990s, Merry-Go-Round did not see a new trend in clothing coming and forecasted the wrong merchandise – a critical and fatal mistake in the fashion industry. As a result of not seeing a trend coming, this company, like Circuit City, is no longer in business.

Summary

Forecasting has the capability to impact positively or negatively the success or failure of a company. Although forecasts are almost always wrong and a good forecast should have a margin of error, forecasting remains critical to smoothing production, getting the right product on the shelf in the right quantities to meet the customers' needs. Because everyone admits that forecasts are almost always wrong, we discussed multiple ways to create a forecast. The different methods of forecasting allow companies to conduct "what-if" analyses to tweak the forecast and get the best method to minimize forecasting error.

Discussion Questions/Thought Leaders/Problems to Assist in Grasping the Concepts

1. A_____is an up-and-down repetitive movement over a long period of time.

2. _____methods of forecasting are based on best guesses, past experience, and other subjective methods.

3. What impacts does forecasting have on the operations management chain?

4. Look at the newspaper or an online article or an Annual Report for a company and see if forecasting is a problem for that particular company.

5. Calculate the 3 and 5 month Simple Moving Average for the following data:

	Actual Demand	3 Month Moving Average Forecasted Demand	5 Month Moving Average Forecasted Demand	Forecast Error
2013	**275**			
2014	**195**			
2015	**250**			
2016	**275**			
2017	**325**			
2018	**400**			
2019	**225**			
2020	**275**			

6. Using the data above calculate the Mean Absolute Deviation for the forecast error for both the 3 and 5 month calculations.

7. Using the table below and the following weights, calculate the Weighted Moving Average starting in 2005. Most recent data = .45; next previous data - .35; next previous data = .2

	Actual Demand	Weighted Moving Average
2013	**275**	
2014	**195**	
2015	**250**	
2016	**275**	
2017	**325**	
2018	**400**	
2019	**225**	
2020	**275**	

8. Using a smoothing factor of ά = .75, calculate the forecast for the following sales data:

	Actual Demand	Forecast
January	**1100**	
February	**1125**	
March	**1125**	
April	**1300**	
May	**950**	
June	**2000**	
July	**2100**	
August	**2500**	
September		
Smoothing Factor = .75		

9. Using the data above, calculate the forecast through September using a smoothing factor of .45.

10. Which of these forecasting calculations provides the company with the most accurate forecast?

11. Think of a situation, politically or otherwise, where the actions may have impacted the forecast.