Report On

Improving Supply Chain Performance in a Multinational Pharmaceuticals Company

By

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An internship report submitted to the Brac Institute of Governance and Development (BIGD), Brac University in partial fulfillment of the requirements for the degree of Masters in Procurement and Supply Management (MPSM)

Brac Institute of Governance and Development (BIGD)
Brac University
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Declaration

It is hereby declared that

1. The internship report submitted is my/our own original work while completing degree at Brac University.
2. The report does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The report does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

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Letter of Transmittal

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Subject: Report on Improving Supply Chain Performance in a Pharmaceuticals Company

Dear Sir / Madam,

This is my pleasure to display my entry level position provide details regarding ‘Supply Chain & Materials Planning of Elanco Bangladesh Ltd.', which I was appointed by your direction.

I have attempted my best to finish the report with the essential data and recommended proposition in a significant compact and comprehensive manner as possible.

I trust that the report will meet the desires.

Sincerely yours,

____

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Date: 16 September, 2020

Non-Disclosure Agreement

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This agreement is made and entered into by and between [Name of Company] and the undersigned student at Brac University…………………………………….

Executive Summary

Supply chain management (SCM) is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements. It can be defined another way which is managing supply and demand, sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, and delivery to the customer. It is important to do right plan for getting best result in supply chain. To do right plan need to use some optimal tools like ABC Inventory, Critical Path Method (CPM), Materials Requirement Planning (MRP) and different forecasting techniques. Mentioned tools have been used in this report to analyze and show how they put vital impact in supply chain management (SCM) through demand planning, lead-time (LT) analysis and inventory classification.

Keywords: SCM, LT, CPM

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List of Acronyms

SCM	Supply Chain Management
MRP	Material Requirement Planning
MAD	Mean Absolute Deviation
MAPE	Mean Absolute Percentage Error
SS	Safety Stock
LT	Lead Time
CPM	Critical Path Method
CPA	Critical Path Analysis
WMA	Weighted Moving Average

Chapter 1

ABC Inventory Analysis

1.1 ABC Inventory

ABC analysis is an analysis of a range of items that have different levels of significance and should be handled or controlled differently. It is a form of Pareto analysis in which the items (such as activities, customers, documents, inventory items, sales territories) are grouped into three categories (A, B, and C) in order of their estimated importance. 'A' items are very important, 'B' items are important, 'C' items are marginally important. The purpose of the ABC system is to identify those items that require more attention due to cost or volume. Divides inventory into three classes based on annual dollar volume.

Class A - high annual dollar volume

Class B - medium annual dollar volume

Class C - low annual dollar volume

It is used to establish policies that focus on the few critical parts and not the many trivial ones. It has Accurate records are a critical ingredient in production and inventory systems, periodic systems require regular checks of inventory, two-bin system, perpetual inventory tracks receipts and subtractions on a continuing basis, may be semi-automated.

ABC analysis is a technique which is used to classify the items in

store based on the demand of the stock.

There may be variety of items that need to be purchased and stocked in advance for issuing the same to various production departments. One has to continuously monitor the stock according to the demand pattern of each item and issue the replenishment order. If the stock on hand of a particular item becomes less than or equal to its reorder level, immediately an order is to be placed for its economical quantity. It will be very difficult to continuously monitor the stock level of each item and place order on the above-mentioned condition. Hence, it is highly essential to classify the items of the stores into different categories. Then it will be easy to apply tight control on selected categories.

1.2 Advantages of ABC Inventory

Record Accuracy:

- Incoming and outgoing record keeping must be accurate
- Stockrooms should be secure
- Necessary to make precise decisions about ordering, scheduling, and shipping

Cycle Counting:

- Items are counted and records updated on a periodic basis
- Often used with ABC analysis
- Has several advantages

  -Eliminates shutdowns and interruptions

  -Eliminates annual inventory adjustment

  -Trained personnel audit inventory accuracy

  -Allows causes of errors to be identified and corrected

  -Maintains accurate inventory records

Control of Service Inventories:

- Can be a critical component of profitability
- Losses may come from shrinkage or pilferage
- Applicable techniques include tight control of incoming shipment

1.3 Implementation

ABC inventory has been applied in my official work, which is shown in below.

Product SL	Unit Price BDT	Annual Demand from July 2020 to June 2021	Annual Cost in from July 2020 to June 2021 (BDT)	% of Annual Cost	Cumulative % of Total	Inventory Classification	% Inventory Value	% Inventory by Product	Policy
1	24774.1	7100	175,896,110	12.97%	12.97%	*A*	69.34%	*29%*	*Strickly Control*
2	16796	7500	125,970,000	9.29%	22.25%	*A*			
3	1763.64	46500	82,009,260	6.05%	28.30%	*A*			
4	515.59	137000	70,635,830	5.21%	33.50%	*A*			
5	291.94	193500	56,490,390	4.16%	37.67%	*A*			
6	1082.96	43500	47,108,760	3.47%	41.14%	*A*			
7	493.31	95000	46,864,450	3.45%	44.59%	*A*			
8	925.95	50500	46,760,475	3.45%	48.04%	*A*			
9	712.8	54000	38,491,200	2.84%	50.88%	*A*			
10	6938.06	4800	33,302,688	2.45%	53.33%	*A*			
11	4845.98	6550	31,741,169	2.34%	55.67%	*A*			
12	479.91	60000	28,794,600	2.12%	57.80%	*A*			
13	8816	3200	28,211,200	2.08%	59.87%	*A*			
14	201.94	132500	26,757,050	1.97%	61.85%	*A*			
15	127.38	207000	26,367,660	1.94%	63.79%	*A*			
16	4166.05	6100	25,412,905	1.87%	65.66%	*A*			
17	559.44	45000	25,174,800	1.86%	67.52%	*A*			
18	429.2	56000	24,035,200	1.77%	69.29%	*A*			
19	659.6	36000	23,745,600	1.75%	71.04%	*B*	20%	27%	Relaxed or Periodic Re view
20	198.94	114000	22,679,160	1.67%	72.71%	*B*			
21	1945.86	11000	21,404,460	1.58%	74.29%	*B*			
22	5882.01	3420	20,116,474	1.48%	75.77%	*B*			
23	5318.34	3600	19,146,024	1.41%	77.19%	*B*			
24	7517.72	2370	17,816,996	1.31%	78.50%	*B*			
25	396.97	44700	17,744,559	1.31%	79.81%	*B*			
26	5010.21	3450	17,285,225	1.27%	81.08%	*B*			
27	499.49	34500	17,232,405	1.27%	82.35%	*B*			
28	10011.84	1500	15,017,760	1.11%	83.46%	*B*			
29	171.41	86000	14,741,260	1.09%	84.54%	*B*			
30	2015.52	7200	14,511,744	1.07%	85.61%	*B*			
31	195.47	64500	12,607,815	0.93%	86.54%	*B*			
32	404.85	27000	10,930,950	0.81%	87.35%	*B*			
33	1425.77	7200	10,265,544	0.76%	88.11%	*B*			
34	2765.22	3600	9,954,792	0.73%	88.84%	*B*			
35	294.63	32000	9,428,160	0.69%	89.53%	*B*			
36	160.95	54000	8,691,300	0.64%	90.18%	*C*	10%	44%	Loose Control
37	981.57	8680	8,520,028	0.63%	90.80%	*C*			
38	296.63	28200	8,364,966	0.62%	91.42%	*C*			
39	180.2	42500	7,658,500	0.56%	91.98%	*C*			
40	30053.849	252	7,573,570	0.56%	92.54%	*C*			
41	208.53	34000	7,090,020	0.52%	93.07%	*C*			
42	3418.35	2070	7,075,985	0.52%	93.59%	*C*			
43	288.12	24500	7,058,940	0.52%	94.11%	*C*			
44	121.01	58000	7,018,580	0.52%	94.62%	*C*			
45	55446.04	120	6,653,525	0.49%	95.12%	*C*			
46	94.82	70000	6,637,400	0.49%	95.60%	*C*			
47	1254.23	5200	6,521,996	0.48%	96.09%	*C*			
48	52864.35	120	6,343,722	0.47%	96.55%	*C*			
49	568.33	9700	5,512,801	0.41%	96.96%	*C*			
50	382.55	13500	5,164,425	0.38%	97.34%	*C*			
51	706.23	7200	5,084,856	0.37%	97.71%	*C*			
52	6535.79	700	4,575,053	0.34%	98.05%	*C*			
53	267.85	14400	3,857,040	0.28%	98.34%	*C*			
54	122.79	30000	3,683,700	0.27%	98.61%	*C*			
55	386.58	9000	3,479,220	0.26%	98.86%	*C*			
56	1446	1950	2,819,700	0.21%	99.07%	*C*			
57	751.9	3500	2,631,650	0.19%	99.27%	*C*			
58	1694.82	1500	2,542,230	0.19%	99.45%	*C*			
59	395.46	4950	1,957,527	0.14%	99.60%	*C*			
60	746.19	2350	1,753,547	0.13%	99.73%	*C*			
61	1719.98	840	1,444,783	0.11%	99.83%	*C*			
62	452.73	3000	1,358,190	0.10%	99.93%	*C*			
			1,355,725,928						

Figure 1.1: ABC Inventory Analysis

This ABC inventory technique which was analyzed by me helped our company remarkably for managing inventory and to do proper plan to available right inventory in right time. The analysis is given in earlier page as a figure. Now I have given the % value of calculated ABC analysis.

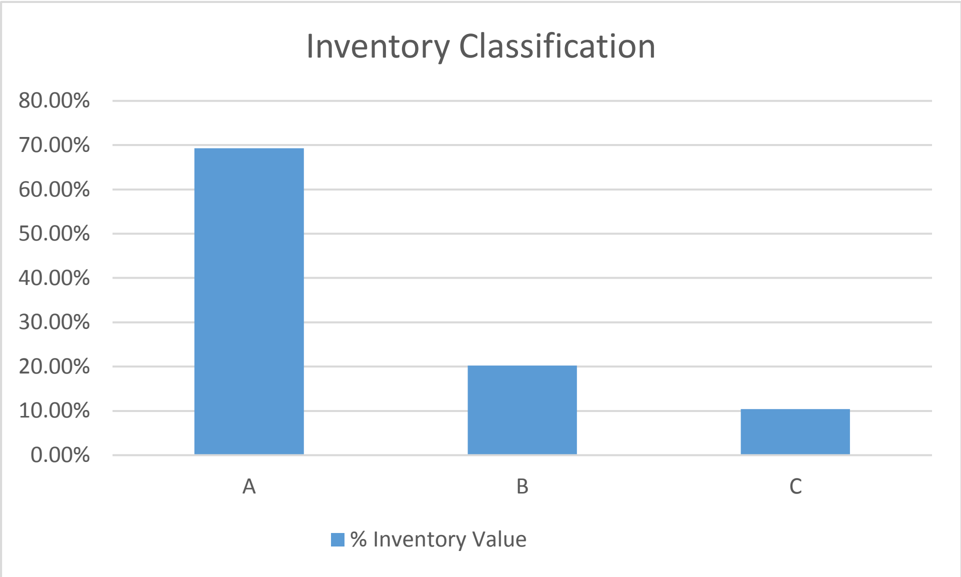

Figure 1.2: % of Value in ABC Inventory

Chapter 2

Material Requirement Planning

2.1 What is Material Requirement Planning

Material requirements planning (MRP) is a system for calculating the materials and components needed to manufacture a product. It consists of three primary steps: taking inventory of the materials and components on hand, identifying which additional ones are needed and then scheduling their production or purchase. An MRP system is typically software or cloud-based but doesn't need to be. It is simply a system that tells you when you need to purchase materials and produce inventory so that inventory is ready when it is purchased. The inputs for an MRP system are a production schedule and a bill of materials (BOM). Material requirements planning (MRP) is a production planning, scheduling, and inventory control system used to manage manufacturing processes. Material requirements planning (MRP) is a system for calculating the materials and components needed to manufacture a product. It consists of three primary steps: taking inventory of the materials and components on hand, identifying which additional ones are needed and then scheduling their production or purchase. It's important to note, however, that MRP and lean production are not the same and are considered by some practitioners to be antithetical, though some say MRP can help with lean production. MRP is considered a "push" production planning system -- inventory needs are determined in advance, and goods produced to meet the forecasted need -- while lean is a "pull" system in which nothing is made or purchased without evidence of actual -- not forecasted -- demand.

2.2 Implementation

In my office work, I have implemented material requirement planning (MRP) for doing optimal inventory planning. It helps to find out when we will need to place order to eliminate stock out situation. Moreover, we can find out when stock goes down below safety stock so that we can take preventive measurement through this planning to place order qty in right time. Here, I have given my MRP analysis for my organization. I have given it for top 4 product planning as example.

	Product 1												
Month	Current Stock	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21
Gross Requirement		8500	8500	8500	8500	8500	8500	8500	8500	8500	8500	10000	10000
Scheduled Receipt							**24000**			**24000**	**18000**		
Projected Stock Balance	**54377**	37377	28877	20377	11877	3377	18877	10377	1877	17377	26877	16877	6877
Inventory On Hand		54377	37377	28877	20377	11877	3377	18877	10377	1877	17377	26877	16877
Net Requriements		45877	28877	20377	11877	3377	-5123	10377	1877	-6623	8877	16877	6877
Safety Stock		8500	8500	8500	8500	8500	8500	8500	8500	8500	8500	8500	8500

Figure 2.1: Material Requirement Planning (1)

	Product 2												
Month	Current Stock	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21
Gross Requirement		5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Scheduled Receipt								**14400**			**19200**		
Projected Stock Balance	**36656**	25656	20656	15656	10656	5656	656	10056	5056	56	14256	9256	4256
Inventory On Hand		36656	25656	20656	15656	10656	5656	656	10056	5056	56	14256	9256
Net Requriements		31656	20656	15656	10656	5656	656	-4344	5056	56	-4944	9256	4256
Safety Stock		6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000

Figure 2.2: Material Requirement Planning (2)

	Product 3												
Month	**Current Stock**	**Aug-20**	**Sep-20**	**Oct-20**	**Nov-20**	**Dec-20**	**Jan-21**	**Feb-21**	**Mar-21**	**Apr-21**	**May-21**	**Jun-21**	**Jul-21**
Gross Requirement		25000	2000	25000	10000	5000	25000	5000	25000	5000	25000	5000	25000
Scheduled Receipt							**59904**				**59904**		
Projected Stock Balance	**101537**	51537	49537	24537	14537	9537	44441	39441	14441	9441	44345	39345	14345
Inventory On Hand		101537	51537	49537	24537	14537	9537	44441	39441	14441	9441	44345	39345
Net Requriements		76537	49537	24537	14537	9537	-15463	39441	14441	9441	-15559	39345	14345
Safety Stock		25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000

Figure 2.3: Material Requirement Planning (3)

	Product 4												
Month	**Current Stock**	**Aug-20**	**Sep-20**	**Oct-20**	**Nov-20**	**Dec-20**	**Jan-21**	**Feb-21**	**Mar-21**	**Apr-21**	**May-21**	**Jun-21**	**Jul-21**
Gross Requirement		1000	6000	1000	6000	1000	6000	1000	6000	1000	6000	1000	6000
Scheduled Receipt					**12974**				**12974**	**12974**			
Projected Stock Balance	**18333**	11333	5333	4333	11307	10307	4307	3307	10281	22255	16255	15255	9255
Inventory On Hand		18333	11333	5333	4333	11307	10307	4307	3307	10281	22255	16255	15255
Net Requriements		17333	5333	4333	-1667	10307	4307	3307	-2693	9281	16255	15255	9255
Safety Stock		6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000

Figure 2.4: Material Requirement Planning (4)

Here,

Safety Stock is known (SS)

Gross Requirement is known

Projected Stock Balance- (Inventory on hand + scheduled receipt)- SS- net requirement

Net Requirements- Inventory on Hand- gross requirement.

This MRP method is effective for optimal inventory planning.

Chapter 3

Lead Time Analysis through Critical Path Method

3.1 Lead Time

Lead time (LT) is the amount of time that passes from the start of a process until its conclusion. A conventional definition of lead time in a supply chain management context is the time from the moment the customer places an order (the moment the supplier learns of the requirement) to the moment it is ready for delivery. In the absence of finished goods or intermediate (work in progress) inventory, it is the time it takes to actually manufacture the order without any inventory other than raw materials. In the manufacturing environment, lead time has the same definition as that of Supply Chain Management, but it includes the time required to ship the parts from the supplier. Shipping time is included because the manufacturing company needs to know when the parts will be available for material requirements planning purposes.

Lead Time is an important factor for customer satisfaction. Typically, customers want goods or service as fast as possible with minimal effort. For manufacturing and assembly the concept of Lead Time is married to and has a direct relationship with the amount of inventory that exists at different points in the overall supply chain. If Customer Lead Time is less than: Material Lead Times, Production Lead Times, or Cumulative Lead Times it will result in the holding of inventory within the supply chain at some or all points. Variation and inconsistency will often compound this issue – it will cause the holding of stock or inventory to mitigate risks in the supply chain.

3.2 Critical Path Method

The critical path method (CPM) models the project by clarifying the relationships between activities diagrammatically. The critical path method (CPM), or critical path analysis (CPA), is an algorithm for scheduling a set of project activities. A critical path is determined by identifying the longest stretch of dependent activities and measuring the time required to complete them from start to finish. The critical path method (CPM) is a project modeling technique that's used by project managers to find the important deadlines and deliver a project on time. In a project, the critical path is the longest distance between the start and the finish, including all the tasks and their duration. As mentioned, the purpose of a critical path is to find the least amount of time you'll need to complete a task. Critical path analysis furthers your ability to make better estimates for scheduling, because you're mapping out every important task that must be done for a successful project.

In all network diagrams where the activities have some parallel relationships, there will be more than one sequence of activities which will lead from the start to the end of the project. These sequences of activities are called paths through the network. Each path will have a total duration which is the sum of all its activities. The path which has the longest sequence of activities is called the critical path of the network (note that it is possible to have more than one critical path if they share the same joint longest time). It is called the critical path because any delay in any of the activities on this path will delay the whole project. The network we have described so far uses arrows to represent activities and circles at the junctions or nodes of the arrows to represent events. This method is called the activity on arrow (AoA) method. CPM can be used to find out total lead time analysis.

3.3 Implementation

I have used CPM to lead time analysis in my official work. It helps to find out total required lead time from planning to receive goods in warehouse. After analyze this I have calculated right lead time for each and every product which helps to do proper planning for import purpose. Here, I have given my lead time (LT) analysis through CPM for my organization. First, all activities from beginning to ending are given below.

Activity	Description	Duaration	Precedure
A	Planning	3	
B	PO creation	1	A
C	L/C Process	14	B
D	Shipment Period	90	C
E	Goods on Port Conjestion	5	D
F	Veterinary Test	7	E
G	Custom Clearence	2	F
H	Advance Shipment Notice for delivery	1	G
I	Delivery to Warehouse	1	G
J	LSP Quality to Check	1	I,H
K	Inform GBS if any emergency to receive	1	J
L	Do PGR by GBS	1	J
M	Elanco Quality Release	2	L

Figure 3.1: Activity Description

Based on these activities, I have analyzed the lead-time through critical path method (CPM) which is shown in next page.

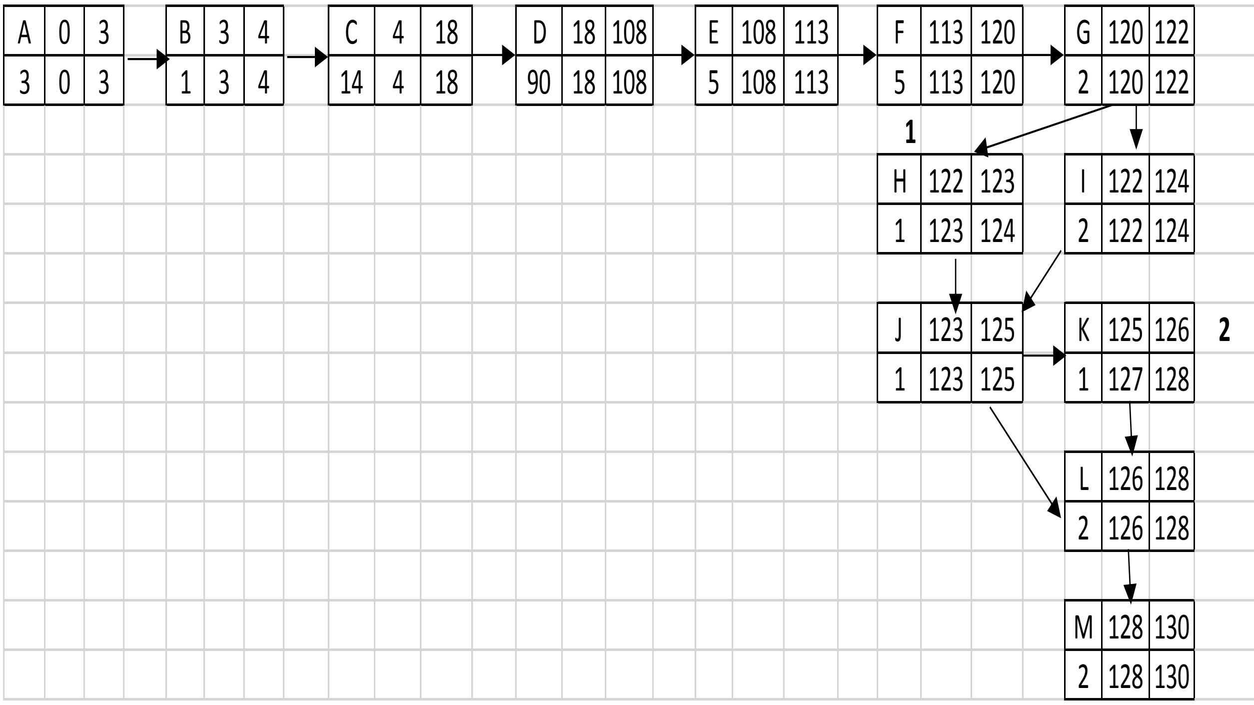

Figure 3.2: Activity Diagram (CPM Diagram)

Here, Total lead-time is 130 days which is the longest period but shortest path in CPM. The critical path is A-B-C-D-E-F-G-I-J-L-M. Slack/ Float is 1 and 2. Therefore, as per this CPM technique, the total required lead time is 130 days from beginning activity to receive goods in warehouse. It helps me to calculate proper time period during planning to available goods in right time.

Chapter 4

Forecast Analysis

4.1 What is Forecasting

All supply chain decisions made before demand has materialized are made to a forecast. Demand forecasts form the basis of all supply chain planning. All push processes in the supply chain are performed in anticipation of customer demand, whereas all pull processes are performed in response to customer demand. For push processes, a manager must plan the level of activity, be it production, transportation, or any other planned activity. For pull processes, a manager must plan the level of available capacity and inventory but not the actual amount to be executed. In both instances, the first step a manager must take is to forecast what customer demand will be. Forecasts are always inaccurate and should thus include both the expected value of the forecast and a measure of forecast error. Long-term forecasts are usually less accurate than short-term forecasts; that is, long-term forecasts have a larger standard deviation of error relative to the mean than short-term forecasts.

There are two main approaches to forecasting. Managers sometimes use qualitative methods based on opinions, past experience and even best guesses. There is also a range of qualitative forecasting techniques available to help managers evaluate trends and causal relationships and make predictions about the future.

Also, quantitative forecasting techniques can be used to model data. Although no approach or technique will result in an accurate forecast a combination of qualitative and quantitative approaches can be used to great effect by bringing together expert judgements and predictive models.

4.2 Time Series Forecast

Time-series forecasting methods use historical demand to make a forecast. They are based on the assumption that past demand history is a good indicator of future demand. These methods are most appropriate when the basic demand pattern does not vary significantly from one year to the next. These are the simplest methods to implement and can serve as a good starting point for a demand forecast. Simple time series plot a variable over time by removing underlying variations with assignable causes use extrapolation techniques to predict future behaviour. The key weakness with this approach is that it simply looks at past behaviour to predict the future ignoring causal variables which are taken into account in other methods such as causal modelling or qualitative techniques.

4.3 Weighed Moving Average Forecast

The moving-average approach to forecasting takes the previous n periods' actual demand figures, calculates the average demand over the n periods, and uses this average as a forecast for the next period's demand. Any data older than the n periods plays no part in the next period's forecast. The value of n can be set at any level, but is usually in the range 4 to 7. In statistics, a moving average is a calculation used to analyze data points by creating a series of averages of different subsets of the full data set.

The weighted moving average (WMA) is a technical indicator that traders use to generate trade direction and make a buy or sell decision. It assigns greater weighting to recent data points and less weighting on past data points. The weighted moving average is calculated by multiplying each observation in the data set by a predetermined weighting factor.

Traders use the weighted average tool to generate trade signals. For example, when the price action moves towards or above the weighted moving average, the signal can be an indication to exit a trade. However, if the price action dips near or just below the weighted moving average, it can be an indication of a favorable time to enter a trade. Using the weighted moving average to determine trend direction is more accurate than the simple moving average, which assigns identical weights to all numbers in the data set.

4.4 Exponential Smoothing Forecast

There are two significant drawbacks to the moving-average approach to forecasting. First, in its basic form, it gives equal weight to all the previous n periods which are used in the calculations (although this can be overcome by assigning different weights to each of the n periods). Second, and more important, it does not use data from beyond the n periods over which the moving average is calculated. Both these problems are overcome by exponential smoothing, which is also somewhat easier to calculate. The exponential smoothing approach forecasts demand in the next period by taking into account the actual demand in the current period and the forecast which was previously made for the current period. It does so according to the formula $Ft = \alpha\ At-1 + (1 - x)Ft-1$; where α = the smoothing constant. The smoothing constant α is, in effect, the weight which is given to the last (and therefore assumed to be most important) piece of information available to the forecaster. However, the other expression in the formula includes the forecast for the current period which included the previous period's actual demand, and so on. In this way all previous data has a (diminishing) effect on the next forecast.

The simplest of the exponentially smoothing methods is naturally called simple exponential smoothing (SES). This method is suitable for forecasting data with no clear trend or seasonal pattern. Exponential smoothing is a rule of thumb technique for smoothing time series data using the exponential window function. Whereas in the simple moving average the past observations are weighted equally, exponential functions are used to assign exponentially decreasing weights over time. It is an easily learned and easily applied procedure for making some determination based on prior assumptions by the user, such as seasonality. Exponential smoothing is often used for analysis of time-series data.

4.5 Mean Absolute Deviation

MAD (mean absolute deviation) for forecasts shows the deviation of forecasted demand from actual demand. This is the mean deviation per period in absolute terms between a number of period forecasts and the corresponding period demand. Mean Absolute Deviation (MAD) is used as a measurement of accuracy for your forecasted data. MAD plays an important role in understanding how accurate and reliable your forecasts are. By seeing how successful or unsuccessful your most recent forecast was, you are able to minimise forecasting error and create a more reliable and accurate prediction next time round.

MAD = Actual Values – Forecast Values

This sum will give you the variance for each period, offering a clearer understanding of the margins between your predictions and your realities.

4.6 Mean Absolute Percentage Error

The mean absolute percentage error (MAPE), also known as mean absolute percentage deviation (MAPD), is a measure of prediction accuracy of a forecasting method in statistics, for example in trend estimation, also used as a loss function for regression problems in machine learning. The MAPE is also sometimes reported as a percentage, which is the above equation multiplied by 100. The absolute value in this calculation is summed for every forecasted point in time and divided by the number of fitted points n. Multiplying by 100% makes it a percentage error.

The mean absolute percentage error (MAPE) is a statistical measure of how accurate a forecast system is. It measures this accuracy as a percentage, and can be calculated as the average absolute percent error for each time period minus actual values divided by actual values. Where At is the actual value and Ft is the forecast value, this is given by:

$$\mathrm{M} = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|$$

The mean absolute percentage error (MAPE) is the most common measure used to forecast error, and works best if there are no extremes to the data (and no zeros).

4.7 Trend Analysis

Trend analysis is the widespread practice of collecting information and attempting to spot a pattern. In some fields of study, the term "trend analysis" has more formally defined meanings. Although trend analysis is often used to predict future events, it could be used to estimate uncertain events in the past, such as how many ancient kings probably ruled between two dates, based on data such as the average years which other known kings reigned.

In statistics, trend analysis often refers to techniques for extracting an underlying pattern of behavior in a time series which would otherwise be partly or nearly completely hidden by noise. If the trend can be assumed to be linear, trend analysis can be undertaken within a formal regression analysis, as described in Trend estimation. Trend analysis offers a measurable and verifiable method for businesses to project future outcomes. It can be used for failure analysis and as an early warning indicator of impending problems. Where accurate historical information exists and valid relationships between variables can be established, trend analysis is a precise tool for anticipating events. Trend analysis is used to forecast market trends, sales growth, inventory levels and interest rates

4.8 Implementation

I have analyzed the forecast for all products of my organization. It is needed to analyze forecast for our demand planning and put forecast in system. After analyzing forecast based on weighted moving average, simple moving average and exponential smoothing, we are able to take decision which forecast should be put in system either affiliate forecast or statistical forecast. Then we can determine the next couple of months forecast which helps to proper demand planning. That’s why this forecast analysis is very important and it helps a lot for our demand planning.

I have given the weighted moving average, simple moving average, trend analysis and exponential smoothing forecast analysis in below as figure.

Product SL	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	4WMA Forecast				
	Actual Sales	Actual Sales	Actual Sales	Actual Sales	Actual Sales	Actual Sales	Jun-20	Jul-20	Aug-20	Mean Absolute Deviation (MAD)	Mean Absolute Percentage Error (MAPE)
1	3510	848	3898	777	5260	1143	2001	3202	2580	2659	121%
3	595	506	525	280	70	355	430	268	272	224	270%
4	138	143	456	92	44	56	216	151	100	133	280%
7	124.2	183.2	139.2	109.1	153.8	1375	134	140	632	627	51%
11	453	116	7	13	598	315	76	256	309	291	53%
12	654	1104	563	361	1271	791	600	840	826	360	29%
13	3101	3177	3531	2116	2640	2383	2851	2715	2522	271	11%
14	8808	21161	8348	8511	10726	7939	11022	10629	8930	1493	18%
15	3846	4483	1653	3816	4119	3468	3304	3571	3551	459	11%
16	4666	2688	5234	3378	6146	2894	3926	4787	4200	2057	51%
17	216	512	133	464	68	163	350	244	192	181	232%
18	6935	6514	5915	4999	7565	4220	5770	6360	5549	1967	37%
19	22649	2957	16911	9981	23870	7461	11922	16220	13833	10354	84%
20	3048	2974	2096	2769	3493	3077	2636	2945	3042	495	14%
21	2252	1646	1537	2201	2619	1835	1896	2180	2114	534	23%
22	3072	4079	3828	3540	3300	2411	3687	3556	3045	766	30%
23	504	436	286	282	429	167	336	357	281	141	68%
24	1333	1850	423	1381	808	1333	1183	1007	1094	350	35%
25	120	781	496	439	689	182	493	585	417	300	125%
26	284	188	331	284	573	495	279	399	460	195	35%
27	3564	4208	6518	3112	6031	2659	4398	5070	4147	2022	59%
29	4368	4546	5818	2170	1364	1962	3959	2815	2210	1724	117%
30	763	768	296	512	870	847	524	638	732	278	32%
31	220	704	144	568	321	849	433	398	564	282	44%
32	5710	4411	2299	4164	4158	2715	3809	3813	3396	724	24%
33	9	189	20	47	223	154	64	126	140	94	45%
34	384	677	450	244	538	578	406	446	486	132	24%
35	5693	6257	85	10402	4046	552	6007	5382	3524	3395	462%

Figure 4.1: Weighted Moving Average Analysis

Product SL	Avg. Forecast (Jan to Jul)	Avg. Sales (Jan to Jul)	Forecast Error (Jan to July)	Avg. Forecast (Aug to Dec)	Mean Absolute Percentage Error (MAPE)	Mean Absolute Deviation (MAD)
1	400	379	5%	500	32%	98
2	43	31	39%	50	64%	16
3	2200	2770	21%	2500	10%	581
4	825	834	1%	350	58%	61
5	375	308	22%	600	95%	130
6	173	162	6%	180	11%	156
7	258	114	126%	280	146%	164
8	165	135	22%	180	33%	30
9	10	184	95%	20	89%	184
11	9	9	1%	10	10%	211
13	213	233	9%	250	7%	523
14	750	747	0%	800	7%	1037
15	2825	2668	6%	3000	12%	1546
16	9125	8881	3%	10500	18%	2902
17	3750	3264	15%	4000	23%	150
18	3375	4413	24%	5000	13%	2065
19	250	207	21%	258	24%	165
20	6000	5675	6%	7000	23%	2075
21	210	45	367%	300	567%	513
22	12750	14556	12%	9500	35%	762
23	3125	2859	9%	3500	22%	1480
24	2750	2048	34%	2500	22%	459
25	4750	3270	45%	4500	38%	42
26	1875	1471	27%	2000	36%	284
27	150	120	25%	150	25%	1043
28	575	291	98%	500	72%	161
29	1875	986	90%	2000	103%	204
30	350	452	22%	825	83%	1501
31	625	421	49%	500	19%	3757
32	3750	4580	18%	4000	13%	404
33	6500	2829	130%	4125	46%	190
34	800	631	27%	950	50%	1077
35	660	471	40%	755	60%	113

Figure 4.2: Simple Moving Average Analysis

Product SL	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20		Exponencial Forecast						
	Actual Sales	Actual Sales	Actual Sales	Actual Sales	Actual Sales	Actual Sales	Avg. Sales (Apr to July	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Mean Absolute Deviation (MAD)	Mean Absolute Percentage Error (MAPE)
1	3510	848	3898	777	5260	1143	2770	2978	1458	3274	1674	4437	1030	49%
3	595	506	525	280	70	355	308	577	510	476	238	127	201	176%
4	138	143	456	92	44	56	162	139	206	383	82	46	199	253%
7	124.2	183.2	139.2	109.1	153.8	1375	444	136	174	133	118	398	337	42%
11	453	116	7	13	598	315	233	386	94	8	130	541	309	1548%
12	654	1104	563	361	1271	791	747	744	996	523	543	1175	453	75%
13	3101	3177	3531	2116	2640	2383	2668	3116	3248	3248	2221	2589	579	24%
14	8808	21161	8348	8511	10726	7939	8881	11279	18598	8381	8954	10169	4095	47%
15	3846	4483	1653	3816	4119	3468	3264	3973	3917	2086	3877	3989	1216	51%
16	4666	2688	5234	3378	6146	2894	4413	4270	3197	4863	3932	5496	866	20%
17	216	512	133	464	68	163	207	275	436	199	385	87	131	110%
18	6935	6514	5915	4999	7565	4220	5675	6851	6394	5732	5512	6896	1364	25%
19	22649	2957	16911	9981	23870	7461	14556	18711	5748	15525	12759	20588	4919	40%
20	3048	2974	2096	2769	3493	3077	2859	3033	2798	2231	2914	3410	598	22%
21	2252	1646	1537	2201	2619	1835	2048	2131	1624	1670	2285	2462	642	31%
22	3072	4079	3828	3540	3300	2411	3270	3273	4029	3770	3492	3122	649	22%
23	504	436	286	282	429	167	291	490	406	285	311	377	154	59%
24	1333	1850	423	1381	808	1333	986	1436	1565	615	1266	913	364	70%
25	120	781	496	439	689	182	452	252	724	485	489	588	260	78%
26	284	188	331	284	573	495	421	265	217	322	342	557	135	30%
27	3564	4208	6518	3112	6031	2659	4580	3693	4670	5837	3696	5357	1404	34%
29	4368	4546	5818	2170	1364	1962	2829	4404	4800	5088	2009	1484	1954	105%
30	763	768	296	512	870	847	631	764	674	339	584	865	356	70%
31	220	704	144	568	321	849	471	317	592	229	519	427	155	48%
32	5710	4411	2299	4164	4158	2715	3334	5450	3989	2672	4163	3869	1565	58%
33	9	189	20	47	223	154	111	45	155	25	82	209	101	123%
34	384	677	450	244	538	578	453	443	632	409	303	546	200	58%
35	5693	6257	85	10402	4046	552	3771	5806	5023	2148	9131	3347	5394	2096%

Figure 4.3: Exponential Smoothing Forecast Analysis

	Marketing Forecast		Exponencial Forecast			4WMA Forecast			
Product SL	Mean Absolute Percentage Error (MAPE)	Mean Absolute Deviation (MAD)	Mean Absolute Deviation (MAD)	Mean Absolute Percentage Error (MAPE)	Forecast in Aug 2020	Mean Absolute Deviation (MAD)	Mean Absolute Percentage Error (MAPE)	Forecast in Aug 2020	Trend Seasonal Impact in Aug 2020
1	32%	98	1030	49%	***4437***	2659	121%	***2580***	0.99
2	64%	16	201	176%	***127***	224	270%	***272***	0.98
3	10%	581	199	253%	***46***	133	280%	***100***	1.01
4	58%	61	337	42%	***398***	627	51%	***632***	0.99
5	95%	130	309	1548%	***541***	291	53%	***309***	1.01
6	11%	156	453	75%	***1175***	360	29%	***826***	1.08
7	146%	164	579	24%	***2589***	271	11%	***2522***	1.01
8	33%	30	4095	47%	***10169***	1493	18%	***8930***	1.04
9	89%	184	1216	51%	***3989***	459	11%	***3551***	0.97
11	10%	211	866	20%	***5496***	2057	51%	***4200***	1.01
13	7%	523	131	110%	***87***	181	232%	***192***	0.99
14	7%	1037	1364	25%	***6896***	1967	37%	***5549***	1.00
15	12%	1546	4919	40%	***20588***	10354	84%	***13833***	1.07
16	18%	2902	598	22%	***3410***	495	14%	***3042***	0.90
17	23%	150	642	31%	***2462***	534	23%	***2114***	1.04
18	13%	2065	649	22%	***3122***	766	30%	***3045***	1.00
19	24%	165	154	59%	***377***	141	68%	***281***	0.99
20	23%	2075	364	70%	***913***	350	35%	***1094***	1.04
21	567%	513	260	78%	***588***	300	125%	***417***	1.00
22	35%	762	135	30%	***557***	195	35%	***460***	1.02
23	22%	1480	1404	34%	***5357***	2022	59%	***4147***	0.97
24	22%	459	1954	105%	***1484***	1724	117%	***2210***	0.98
25	38%	42	356	70%	***865***	278	32%	***732***	0.99
26	36%	284	155	48%	***427***	282	44%	***564***	0.99
27	25%	1043	1565	58%	***3869***	724	24%	***3396***	1.05
28	72%	161	101	123%	***209***	94	45%	***140***	1.02
29	103%	204	200	58%	***546***	132	24%	***486***	1.03
30	83%	1501	5394	2096%	***3347***	3395	462%	***3524***	1.01
31	19%	3757	3665	23%	***14337***	4034	28%	***17367***	0.98
32	13%	404	1167	35%	***5537***	2439	67%	***3705***	0.97
33	46%	190	1964	39%	***7839***	3833	79%	***4994***	1.04
34	50%	1077	1794	141%	***3297***	1940	166%	***2042***	1.00
35	60%	113	83	26%	***265***	14	5%	***285***	1.04

Figure 4.4: Particular Month Forecast analysis with all Forecasting Tool

In last figure, we can see that I have got the August 2020 forecast based on given all forecast analysis tool including error analysis and trend analysis which gives better forecast.

References

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[2] J. Heizer and B. Render, " Operations Management" 2014

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