



ITC: Demand Forecast & Inventory Management

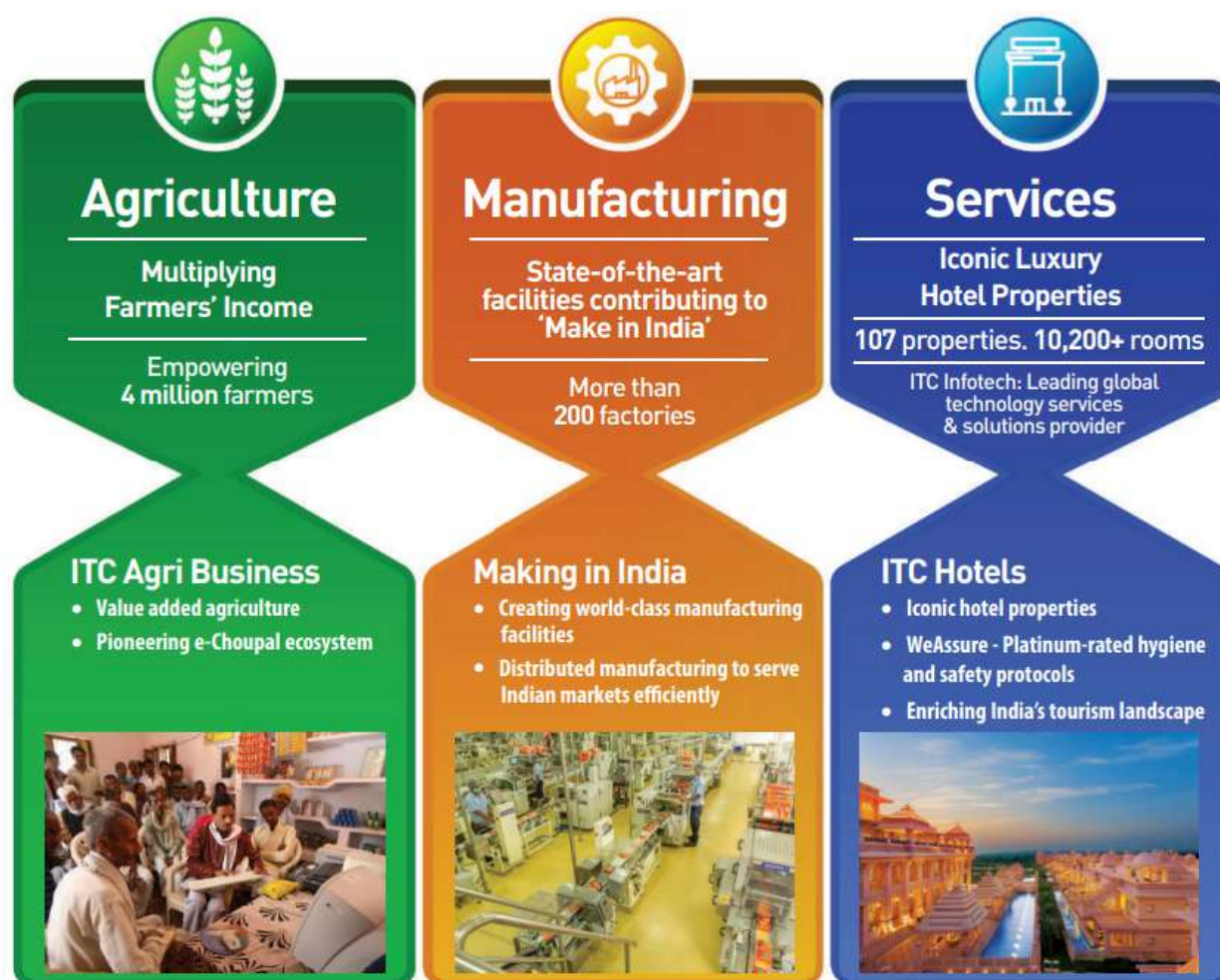
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About ITC

ITC is a diverse conglomerate having activities in Fast Moving Consumer Goods, Hotels, Paperboards and Packaging, Agri-Business, and Information Technology. It is one of India's leading private-sector corporations. With a gross sales value of 74,979 crores and a net profit of 13,032 crores, the company is considered one of India's most valuable corporate firms (as of 31.03.2021). According to a study performed by Fortune India in collaboration with Hay Group, ITC is India's most admired corporation.

Sectors of ITC



Why ITC?

We have selected **ITC** for the analysis, with products ranging from the FMCG industry, personal healthcare, stationery, hotels, etc. It is an established brand that heavily depends on demand forecasting and supply chain management to optimize its profit while maintaining its brand value.

ITC'S BUSINESSES



FMCG Businesses

- FMCG Businesses spanning a range of segments including Branded Packaged Foods, Personal Care Products, Education and Stationery Products, Incense Sticks (Agarbattis), Safety Matches and Cigarettes.
- India's Leading FMCG marketer
- 25+ world-class Indian brands
- Attained Leadership position in several categories



Hotels

- One of India's pre-eminent hospitality chains
- With over 105 properties under 4 brands spread across the country, the Company's Hotels Business is a trailblazer in green hoteliering
- ITC's Premium Luxury Hotels are LEED® Platinum Certified



Paperboards & Packaging

- The Paperboards and Specialty Papers Division is India's largest, most eco-friendly and technologically advanced paper and paperboards business.
- Large-scale afforestation programme covering more than 730,000 acres
- The Packaging and Printing Business provides contemporary and superior packaging solutions utilising its state-of-the-art technologies and processes
- Clear market leader in the Indian Paperboard and Packaging Industry



Agri Business

- ITC is one of India's largest integrated Agri Business enterprises with significant presence across every node of the agri value chain – Crop Development, Procurement, Supply Chain, Processing and Marketing
- Pioneer in rural transformation through ITC e-Choupal, empowering over 4 million farmers across 35,000 villages
- Largest private sector procurer of wheat in India
- Spearheading climate smart agriculture

Methodologies

Dataset

We have used yearly financial reports released by ITC for data collection of sales, profits, P&L statements, and balance sheets for all products, which will help to achieve the goal of comprehensive analysis.

Understanding Demand

With a wide variety of products few of which are seasonal in nature, complex and exhaustive forecasting is required. For this we aim to understand the trend of various products through Simple Moving Average, Linear regression, Weighted

Moving Average, and Exponential smoothing with and without trend. With the possibility of error analysis wherein, we account for qualitative anomalies in the data for non-foreseeable events like COVID'19.

Inventory Management

FMCG products generally have a low shelf life hence, optimizing inventory to avoid losses due to expiration becomes of utmost importance. Although one should also make sure to grab every opportunity of market capture by keeping the inventory to meet the demand. By analyzing their inventory control system to account for seasonal fluctuations and uncertainty of demand.

Aggregate Production Planning


APP (an acronym for aggregate production planning) is a useful tool for operations management. It has to do with determining production, inventory, and personnel levels to meet changing demand during a six-month to one-year planning horizon. We have used 4 different plans and gave a comparison between them in the end.

Results

Demand Forecasting

Sales data collected from yearly financial reports for different sectors of ITC.

Year	FMCG	Hotels	Agri Business	Paperboards, Paper and Packaging	Total
2003	9095.68	349.43	1658.14	1162.86	12266.11
2004	9826.55	450.83	1681.56	1239.87	13198.81
2005	10888.89	627.22	1780.06	1565.31	14861.48
2006	12768.91	849.8	2654.22	1886.22	18159.15



2007	14523.16	985.67	3501.28	2100.06	21110.17
2008	16336.65	1100.2	3868.44	2364.33	23669.62
2009	18129.11	1020.27	3845.98	2821.96	25817.32
2010	20924.71	910.81	3862.14	3233.61	28931.27
2011	17282.22	1067.98	2300.7	2044.74	22695.64
2012	27788	996.3	3507.85	2579.71	34871.86
2013	32991.03	1062.08	5023.01	2733.7	41809.82
2014	37188.46	1121.45	5130.09	3272.62	46712.62
2015	39480.65	1173.55	5672.07	3638.55	49964.82
2016	42067.91	1404.1	4389.34	3851.69	51713.04
2017	44500.55	1329.25	6066.99	3819.01	55715.8
2018	34208.39	1404.1	4551.98	3792.43	43956.9
2019	33200.79	1648.2	6066.99	4305.43	45221.41
2020	36523.12	1911.59	5912.54	4498.98	48846.23
2021	37294.38	659.76	8001.87	4549.83	50505.84

Simple moving average

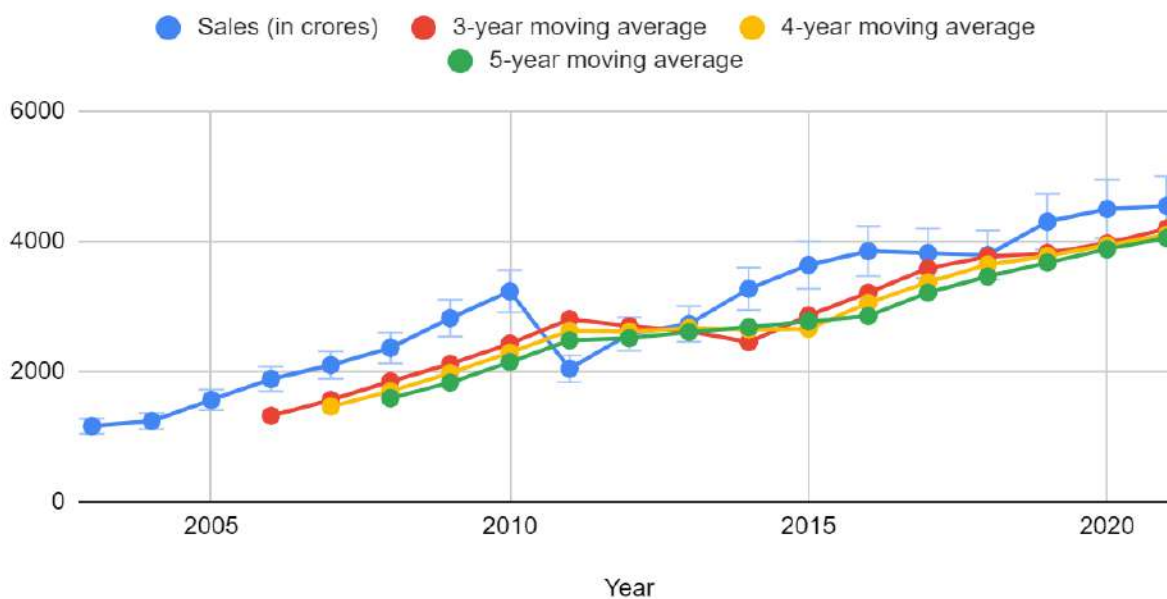
A moving average is a method for calculating a data set's overall trend. The data set in operations management is the company's historical sales volume. This method is particularly good for predicting short-term trends. It's just the average of a number of different time periods.

We have used different time periods of 3,4 and 5 years respectively for different segments of ITC.

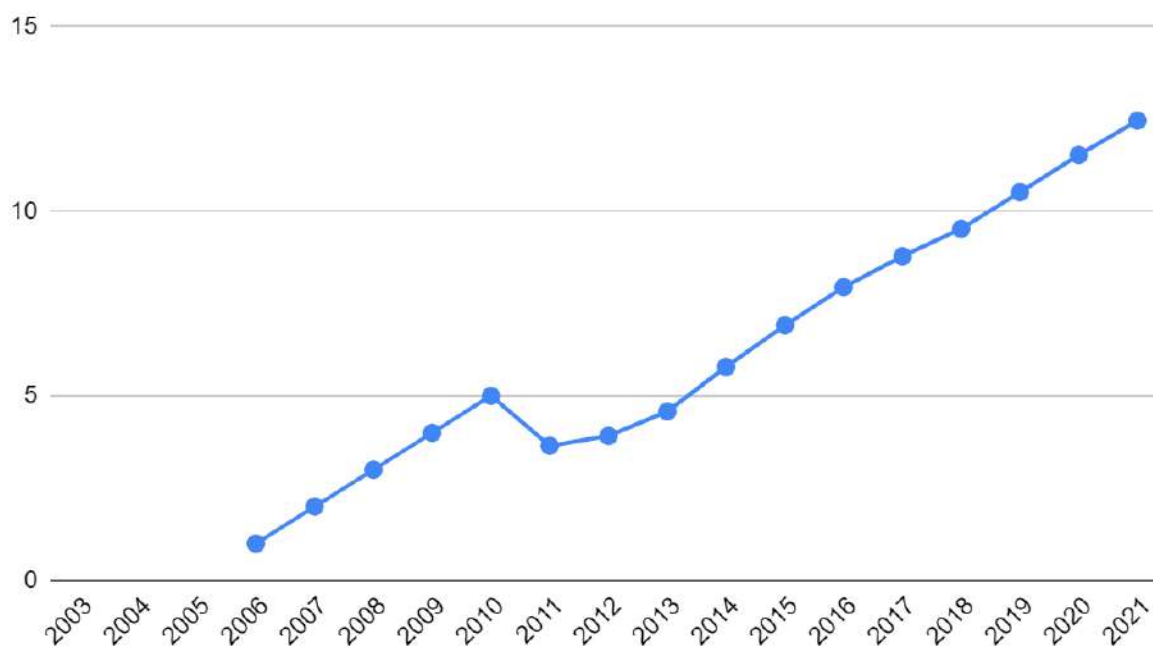
FMCG

Interpretation: As evident between the years 2010 and 2015, the 3-year simple moving average is better able to track the magnitude of the rise and fall in the actual sales when compared to the 4-year and 5-year moving average models.

Sales (in crores), 3-year moving average, 4-year moving average and 5-year moving average



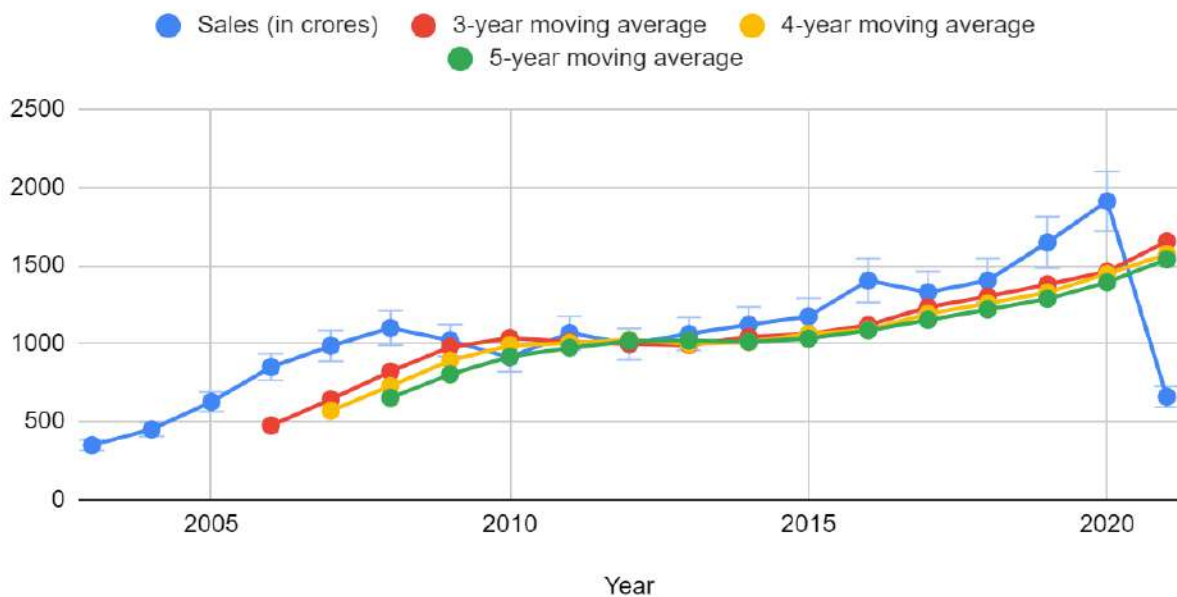
Tracking Signal (3-year simple moving average)



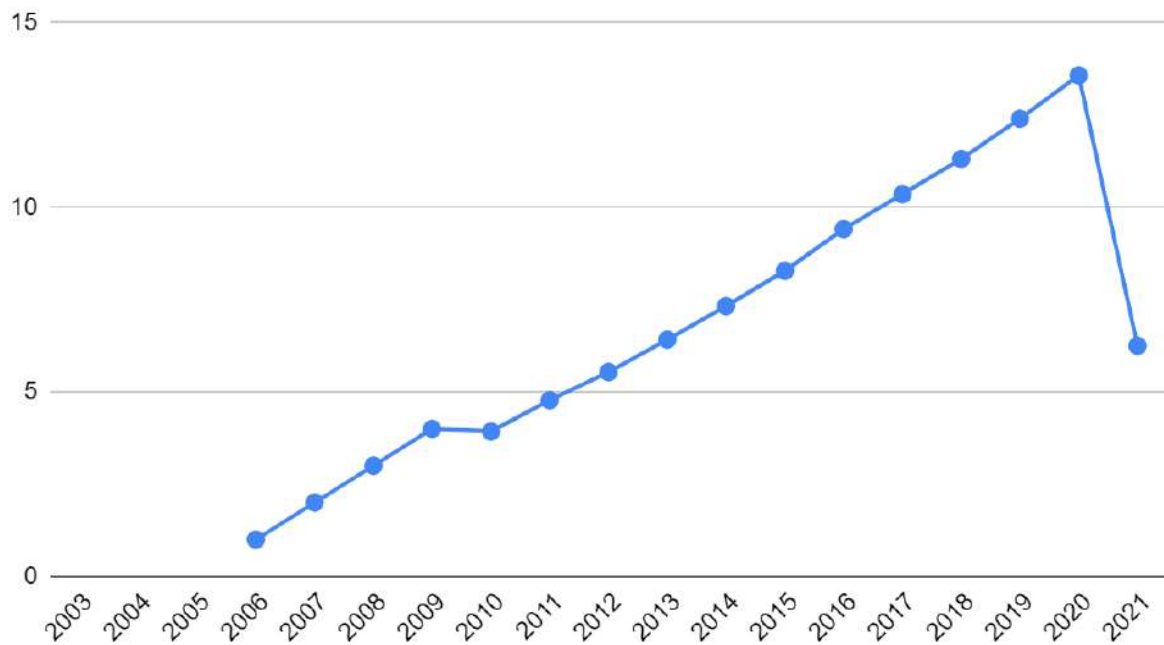
Hotels

Interpretation: Fall in 2021 due to covid explain the decline in the sales generated from the ITC's hotel business which is witness in the years 2020-2021. As evident from the graph, the 3-year moving average is better able to track the deviations in the actual sales as it resembles the sales more closely much better than the 4-year and the 5-year moving averages.

Sales (in crores), 3-year moving average, 4-year moving average and 5-year moving average



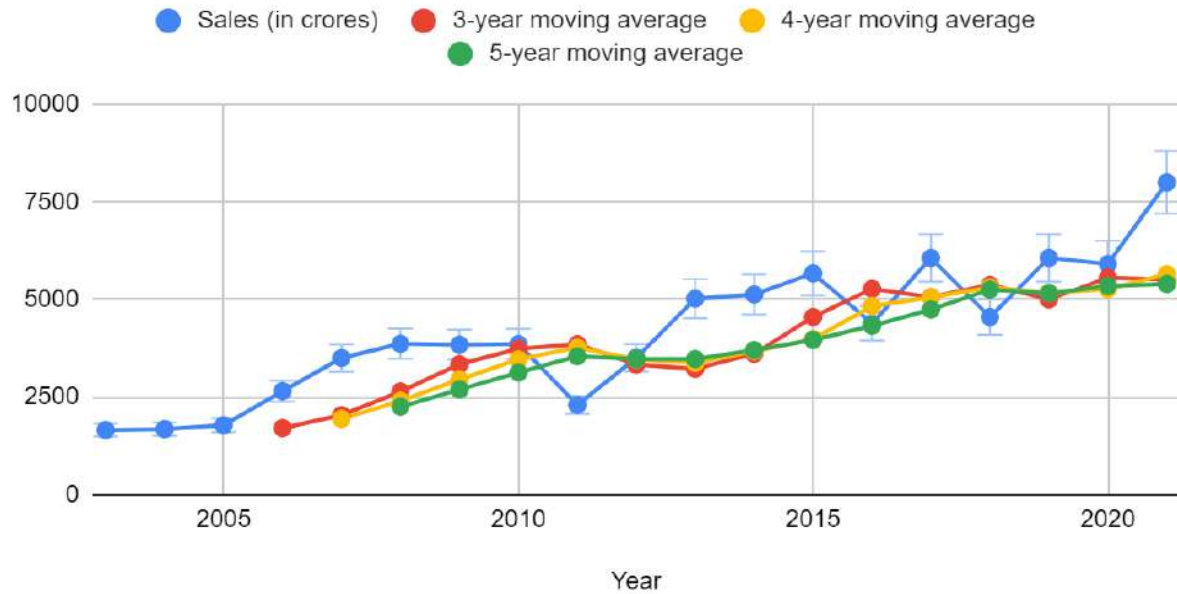
Tracking Signal (3-year simple moving average)



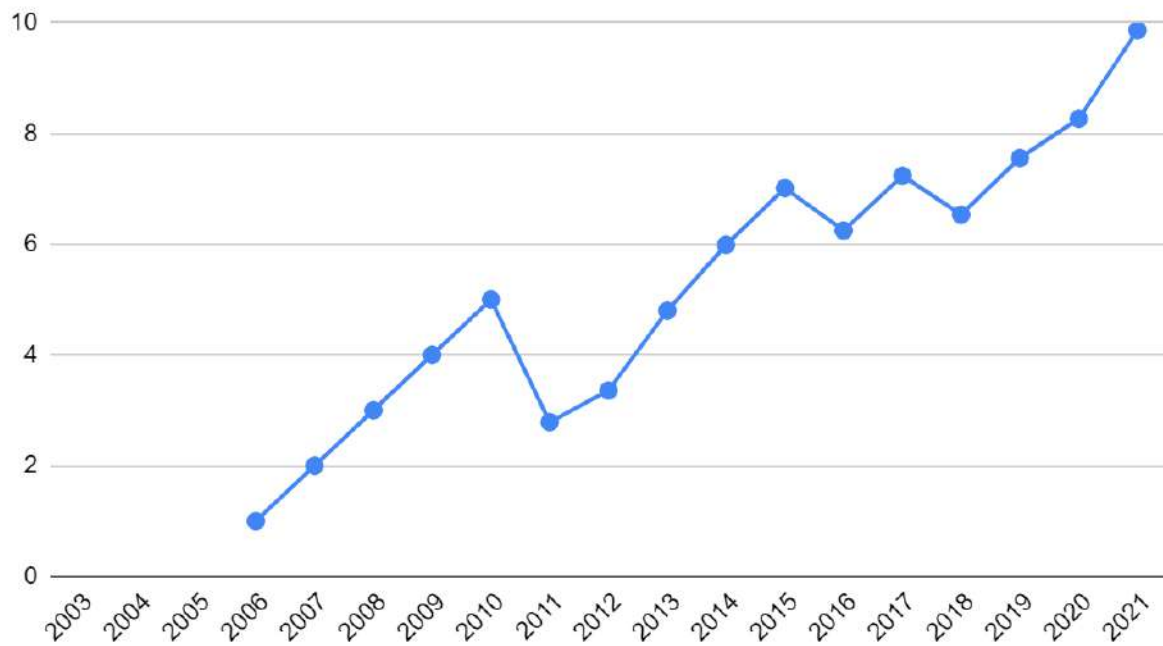
Agri Business

Interpretation: From the graph below we can see that the 3-year moving average performs overall in tracking the deviations in the sales but for the years 2010-2015, the 5-year moving average shows a greater closeness to the magnitude of changes in the actual sales data.

Sales (in crores), 3-year moving average, 4-year moving average and 5-year moving average



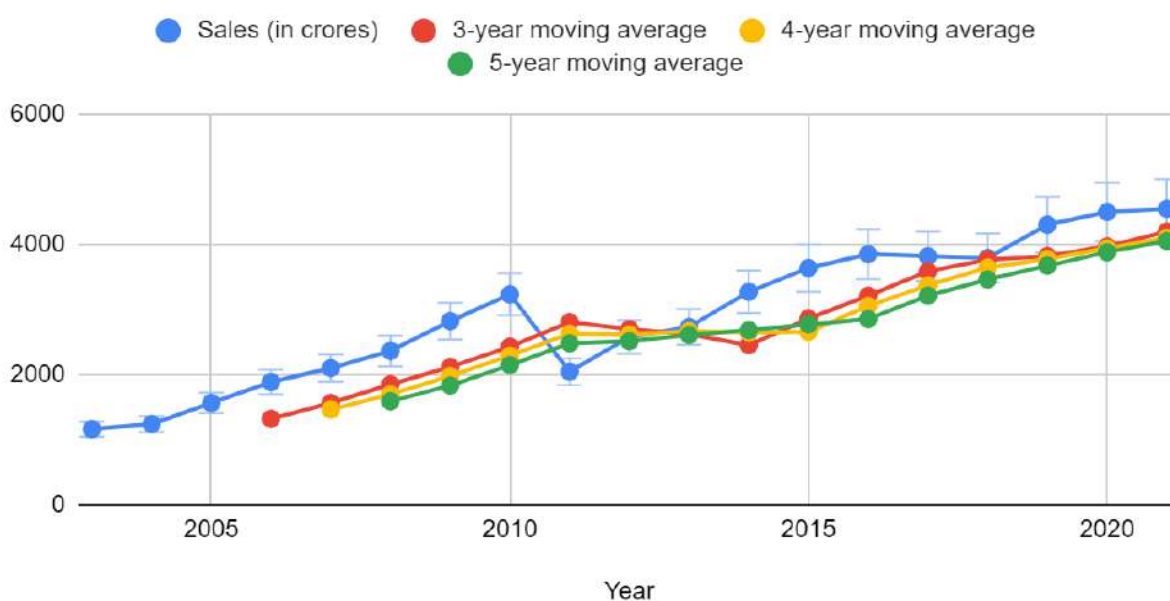
Tracking Signal (3-year simple moving average)



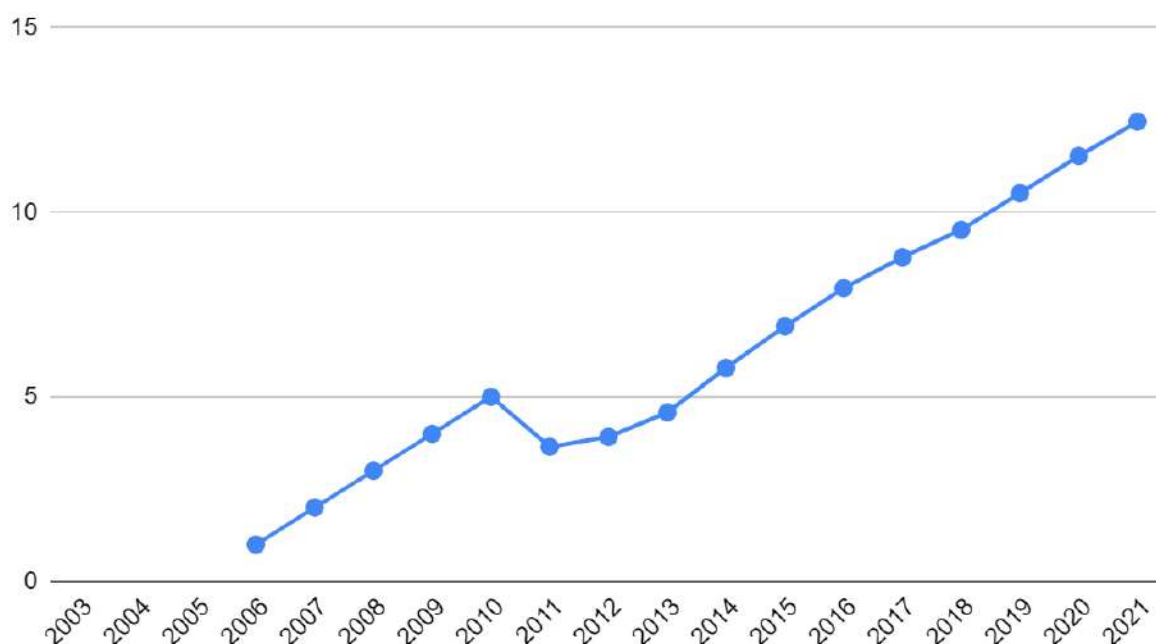
Paperboards, Paper and Packaging

Interpretation: As evident between the years 2010 and 2015, the 3-year and 4-year simple moving average models are better able to track the magnitude of the rise and fall in the actual sales when compared to the 5-year moving average model.

Sales (in crores), 3-year moving average, 4-year moving average and 5-year moving average



Tracking Signal (3-year simple moving average)



Weighted Moving Average

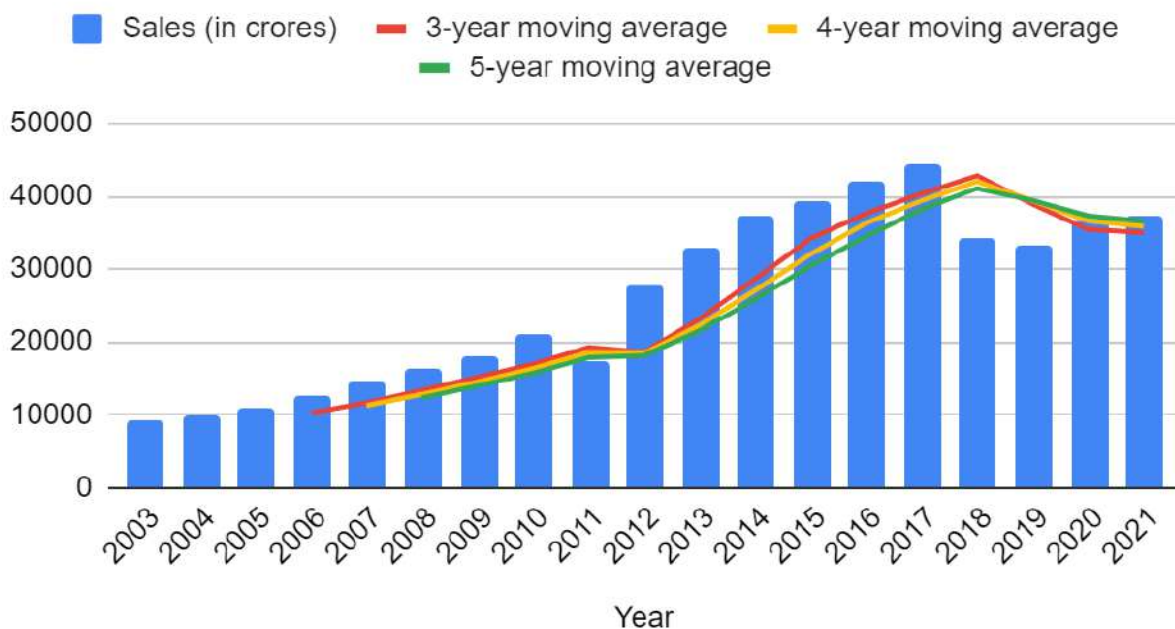
Because more recent data points are more relevant than data points from the distant past, weighted moving averages give them a higher weighting. The total weighting should equal one (or 100 percent). Because the weightings in the simple moving average are evenly distributed, they are not represented in the table above.

We have used different time periods of 3, 4 and 5 years respectively for different segments of ITC. We have given more weightage to recent years' sales trend.

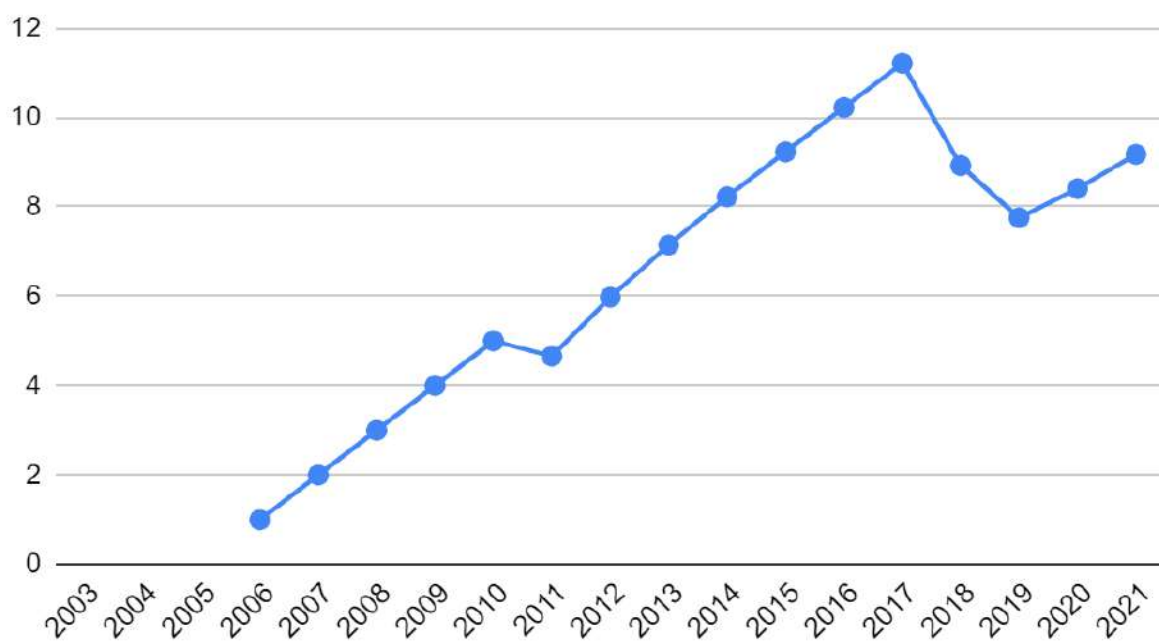
FMCG

Interpretation: As evident from the chart below, the 3-year simple moving average is better able to track the magnitude of the rise and fall in the actual sales when compared to the 4-year and 5-year moving average models.

Weighted Moving Average



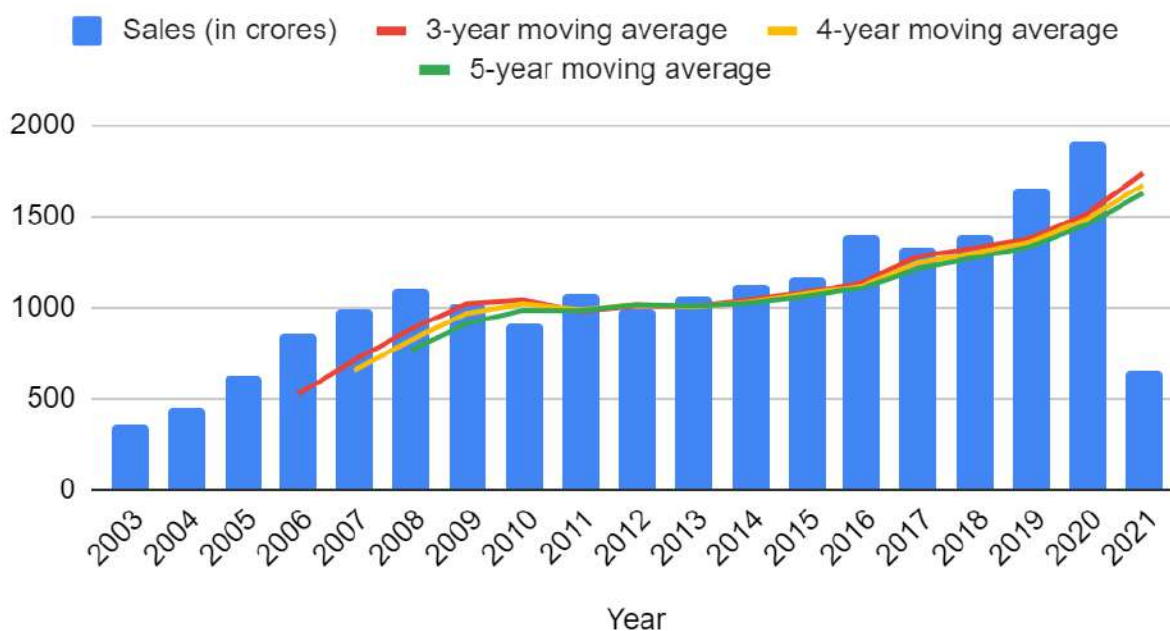
Tracking Signal (3-year weighted moving average)



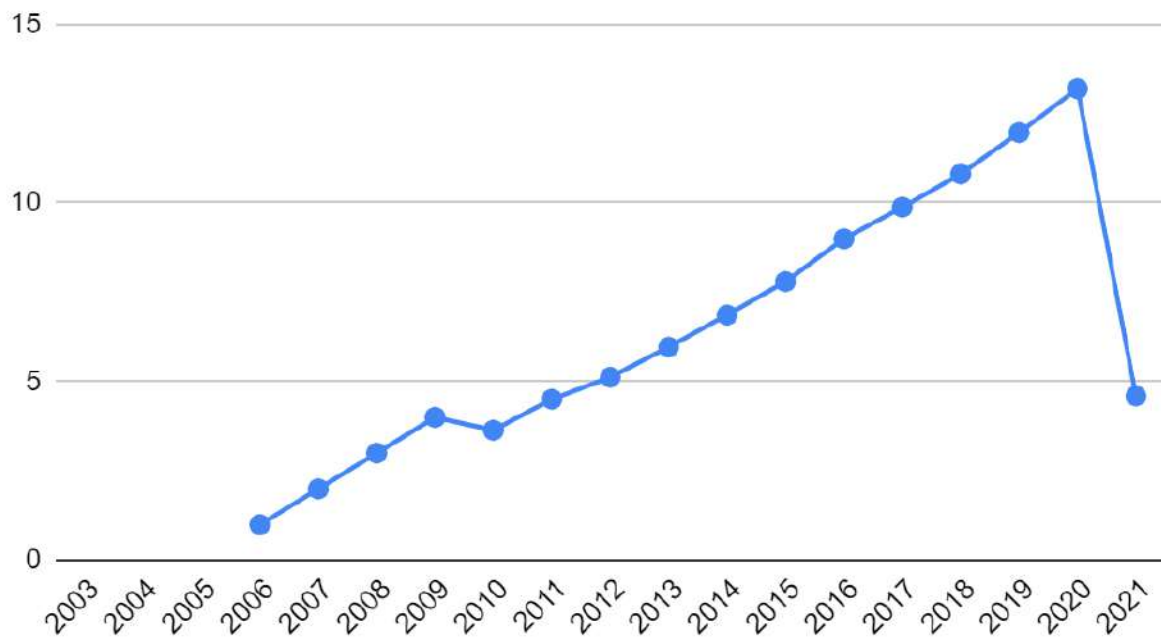
Hotels

Interpretation: Fall in 2021 due to covid explain the decline in the sales generated from the ITC's hotel business which is witness in the years 2020-2021. As evident from the graph, the 3-year moving average is better able to track the deviations in the actual sales as it resembles the sales more closely much better than the 4-year and the 5-year moving averages.

Weighted Moving Average



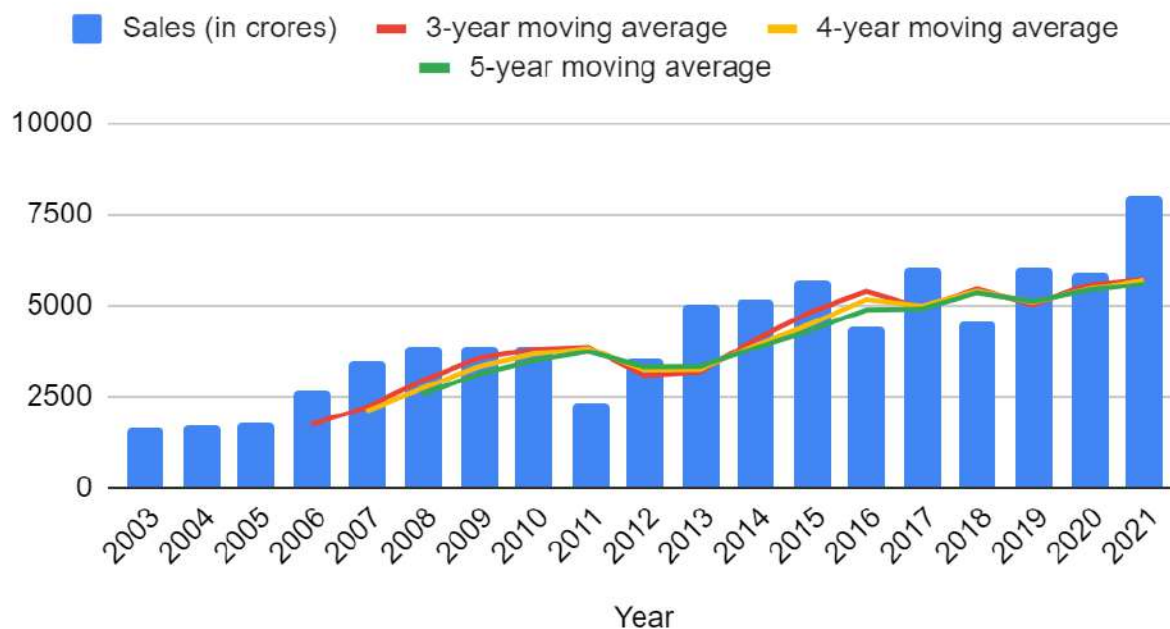
Tracking Signal (3-year weighted moving average)



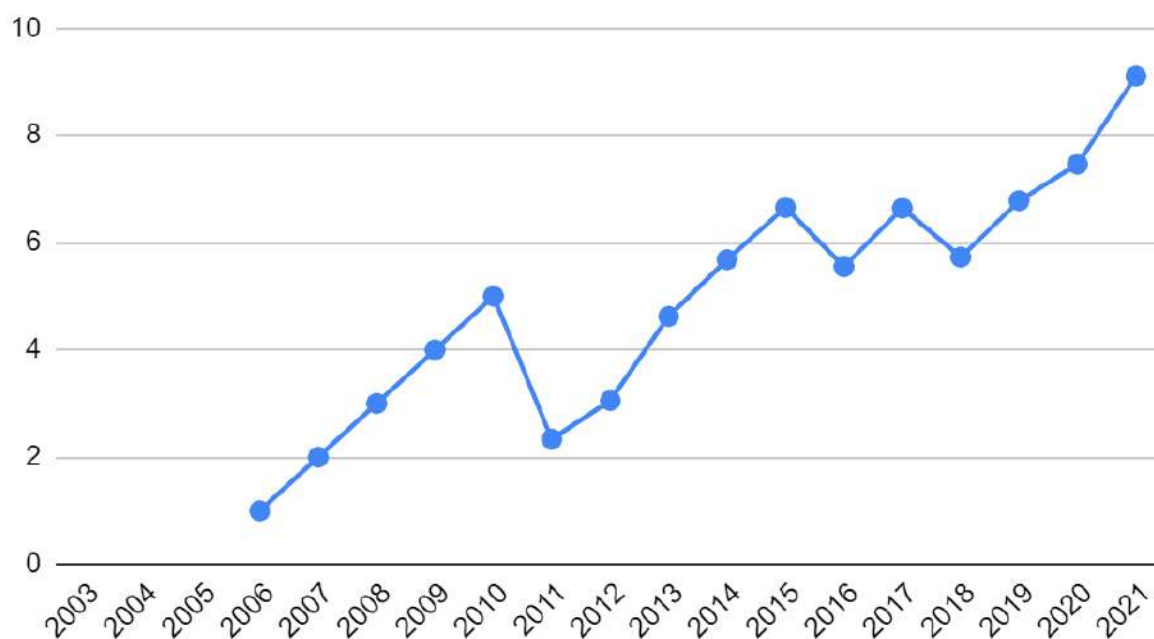
Agri Business

Interpretation: As evident from the graph below, the 3-year simple moving average is better able to track the magnitude of the rise and fall in the actual sales when compared to the 4-year and 5-year moving average models.

Weighted Moving Average



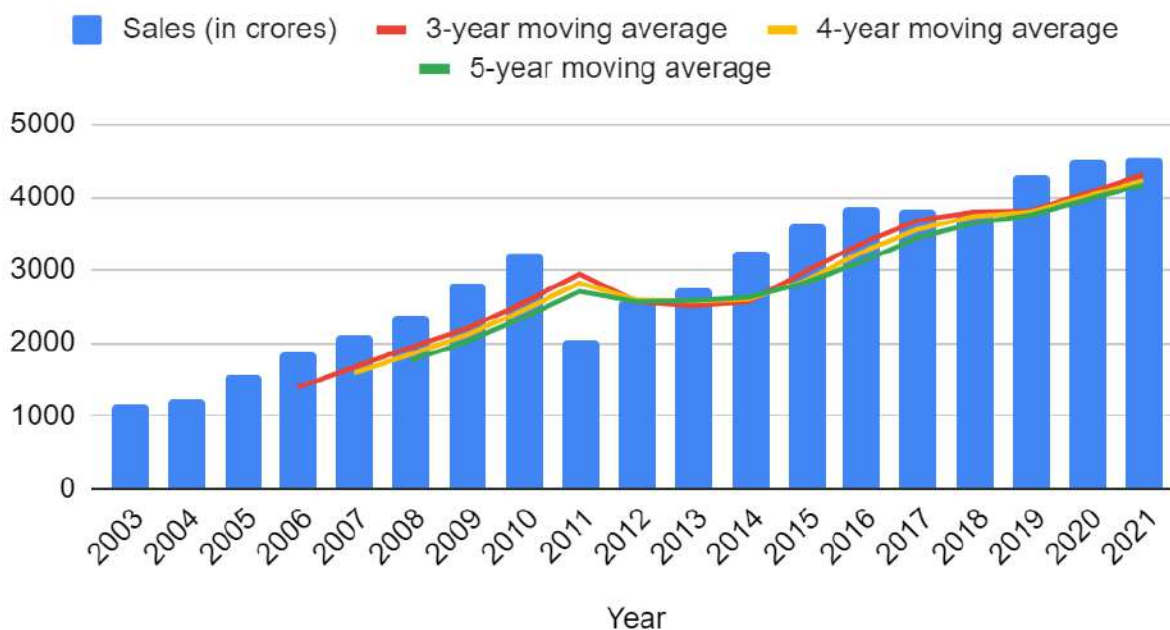
Tracking Signal (3-year weighted moving average)



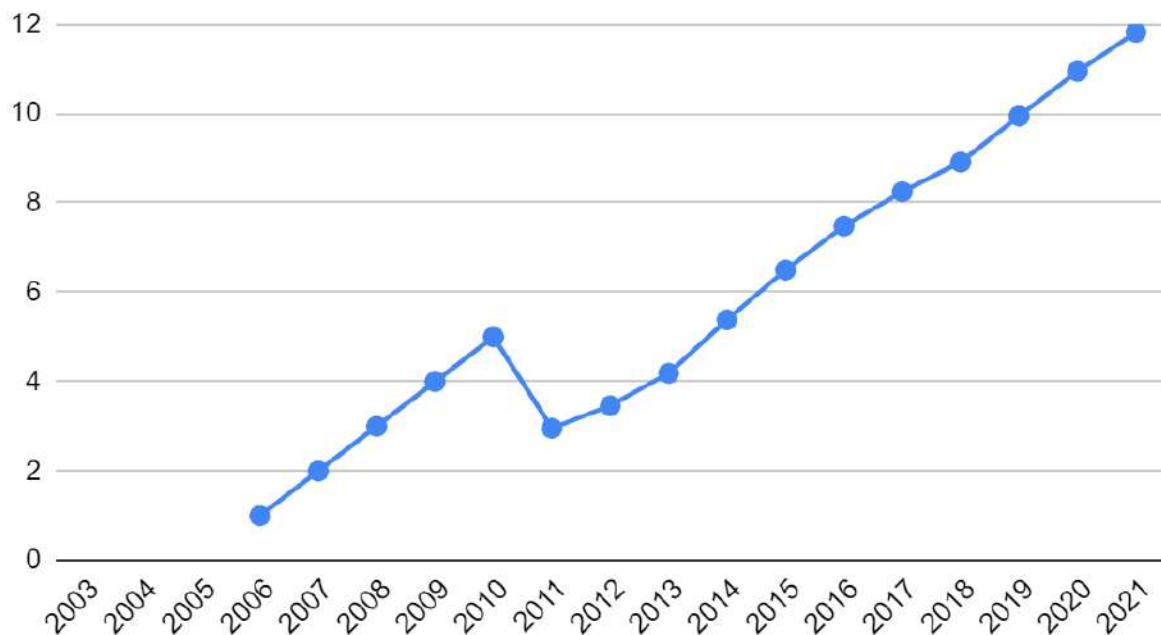
Paperboards, Paper and Packaging

Interpretation: As evident in the chart below, the 3-year simple moving average is better able to track the magnitude of the rise and fall in the actual sales when compared to the 4-year and 5-year moving average models.

Weighted Moving Average



Tracking Signal (3-year weighted moving average)



Exponential Smoothing Without Trend

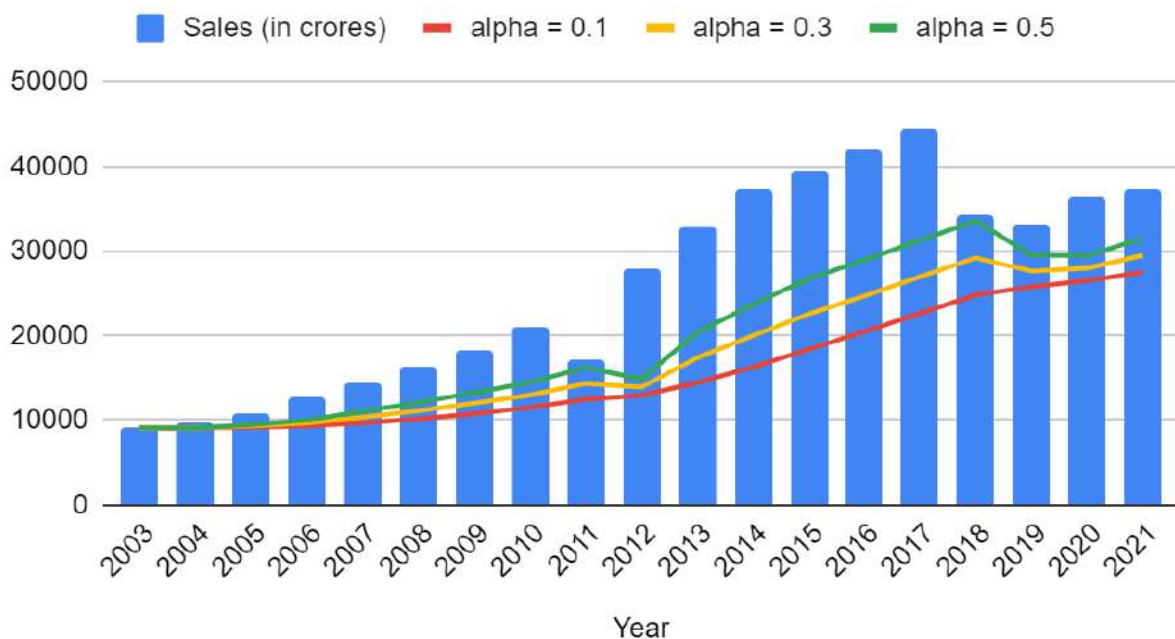
To arrive at fresh estimates, exponential smoothing forecasting systems use constants that allocate weights to current demand and previous projections. Their values have an impact on how sensitive forecasts are to real demand, and hence on forecast error.

We have used 3 different values of alpha as 0.1, 0.3, and 0.5 respectively.

FMCG

Interpretation: As seen in the graph below, the exponential smoothing model with $\alpha=0.5$ is better able to forecast the overall value and the magnitude of changes in the actual sales figure, as compared to the exponential smoothing model with $\alpha = 0.1$ and 0.3 .

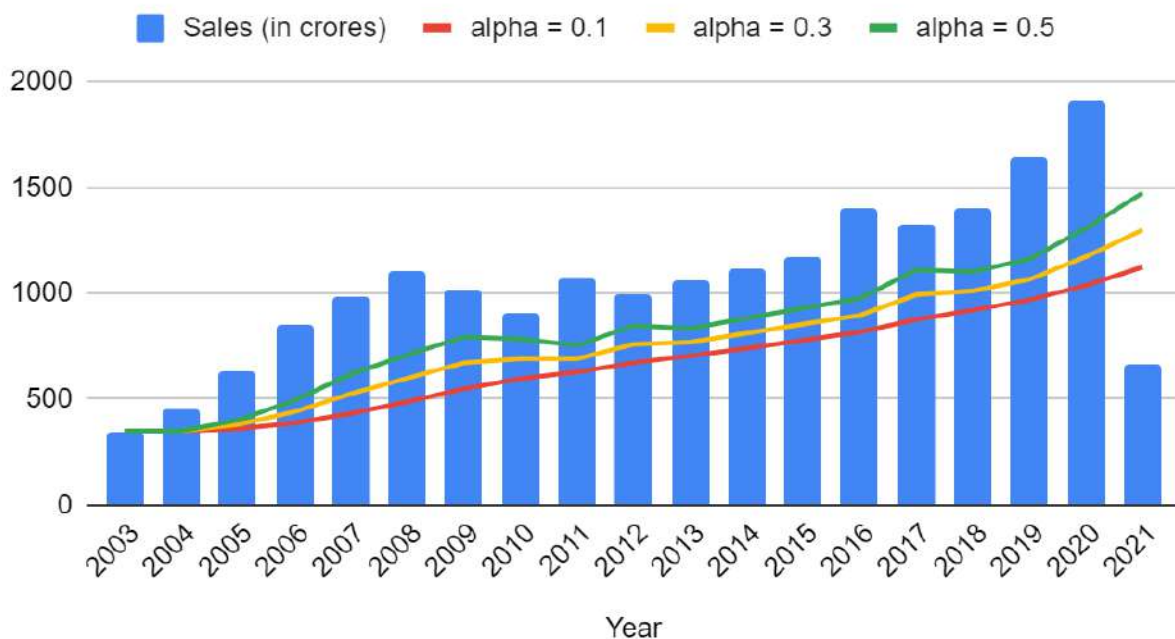
Exponential Smoothing



Hotels

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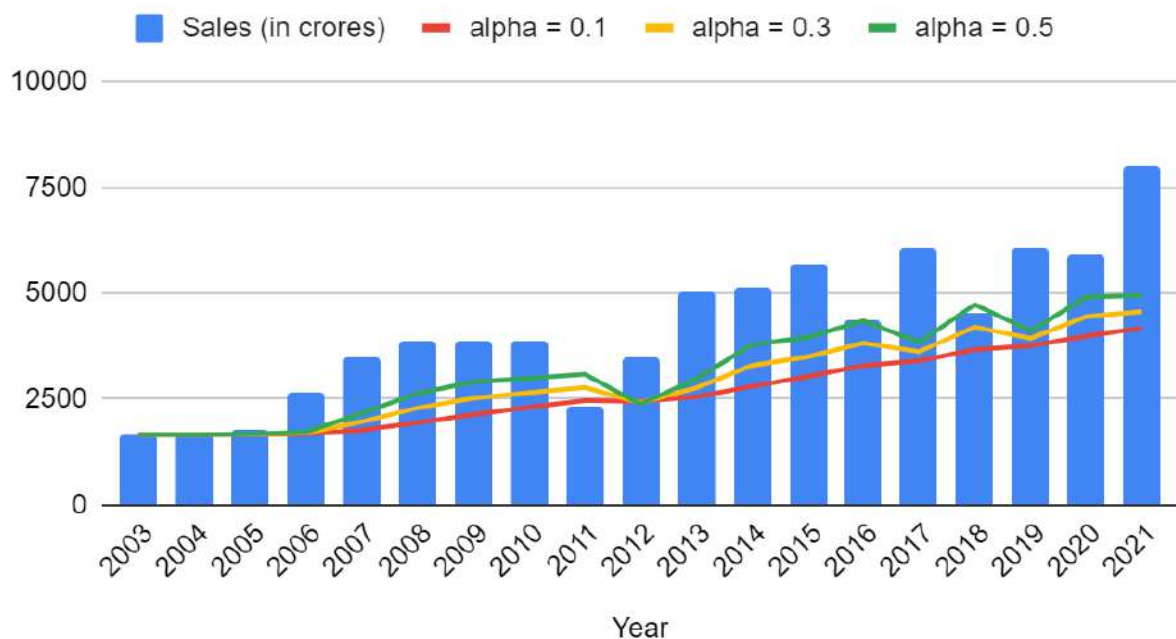
Exponential Smoothing



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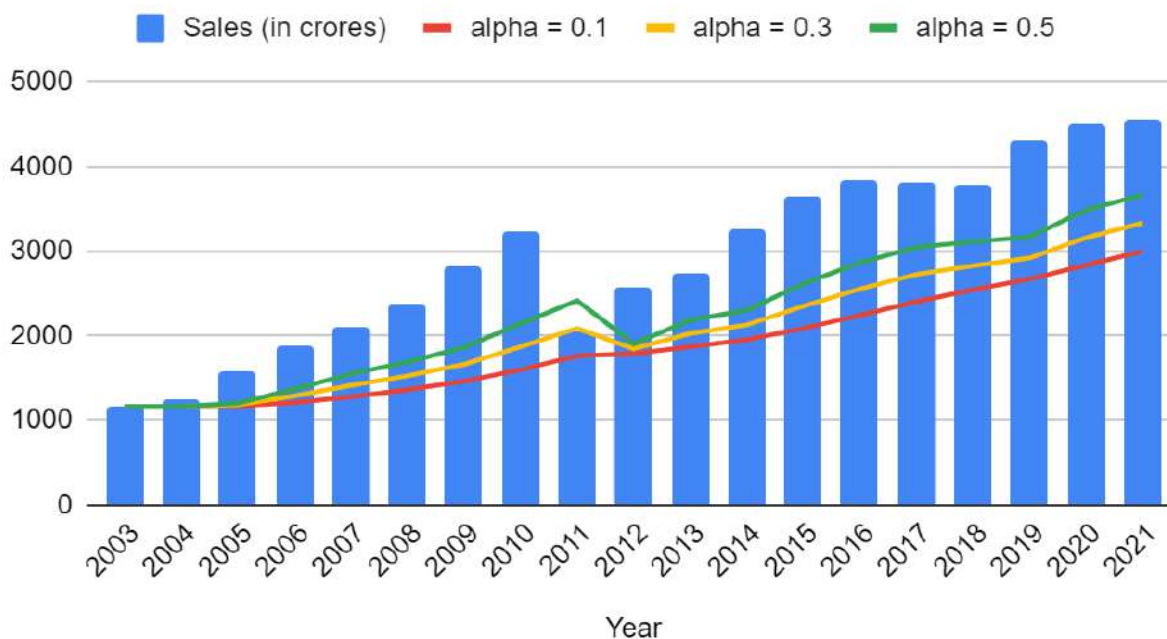
Exponential Smoothing



Paperboards, Paper and Packaging

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Exponential Smoothing



Exponential Smoothing With Trend

Here, the time series exhibits a trend; in addition to the level component, the trend (slope) has to be estimated. The forecast, including the trend for the upcoming period $t+1$, is given by -

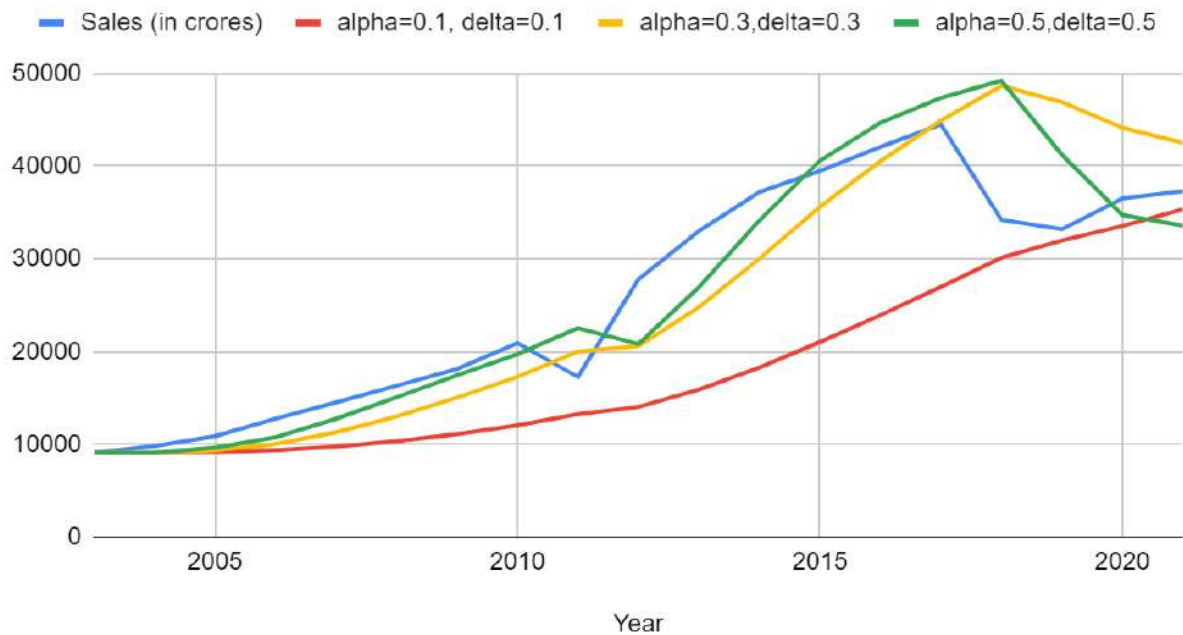
$$F(t+1) = L(t) + T(t)$$

We have used 3 different values of alpha as 0.1, 0.3, and 0.5 respectively.

FMCG

Interpretation: As seen in the graph below, the exponential smoothing with trend model having $\alpha=0.3$ and $\delta=0.3$ is able to capture the actual sales values more effectively for most of the time period until before 2017. Afterwards, the model with $\alpha=0.5$ and $\delta=0.5$ tracks the changes in sales more effectively.

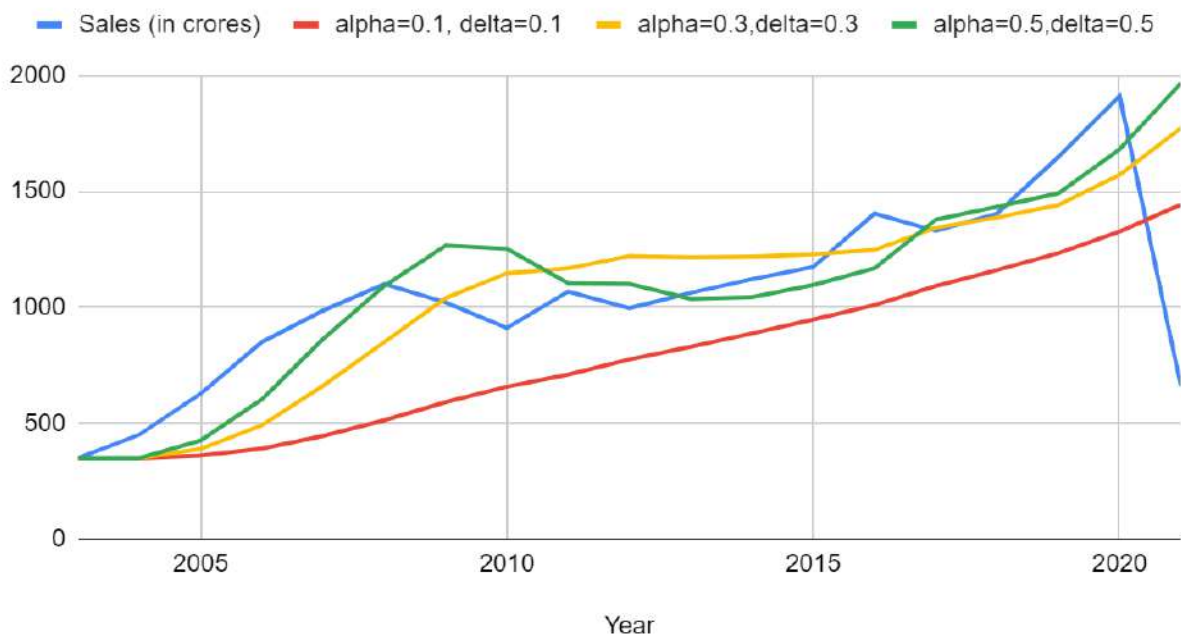
Exponential Smoothing with Trend



Hotels

Interpretation: As seen from the graph below, the exponential smoothing model with $\alpha = 0.5$ and $\delta = 0.5$ shows much closer resemblance to the actual sales data considered than the other α and δ values considered overall.

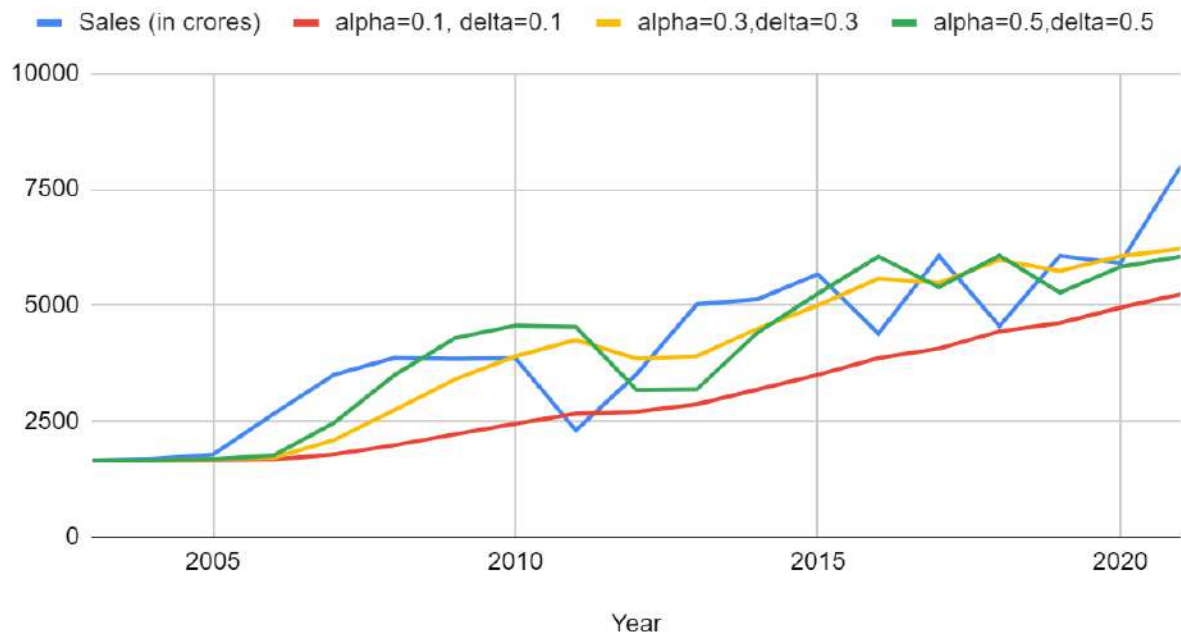
Exponential Smoothing with Trend



Agri Business

Interpretation: In the graph below, the exponential smoothing model with alpha value = 0.3 and delta = 0.3 is much more effectively able to capture the actual sales data with trends than the other alpha and delta value models considered.

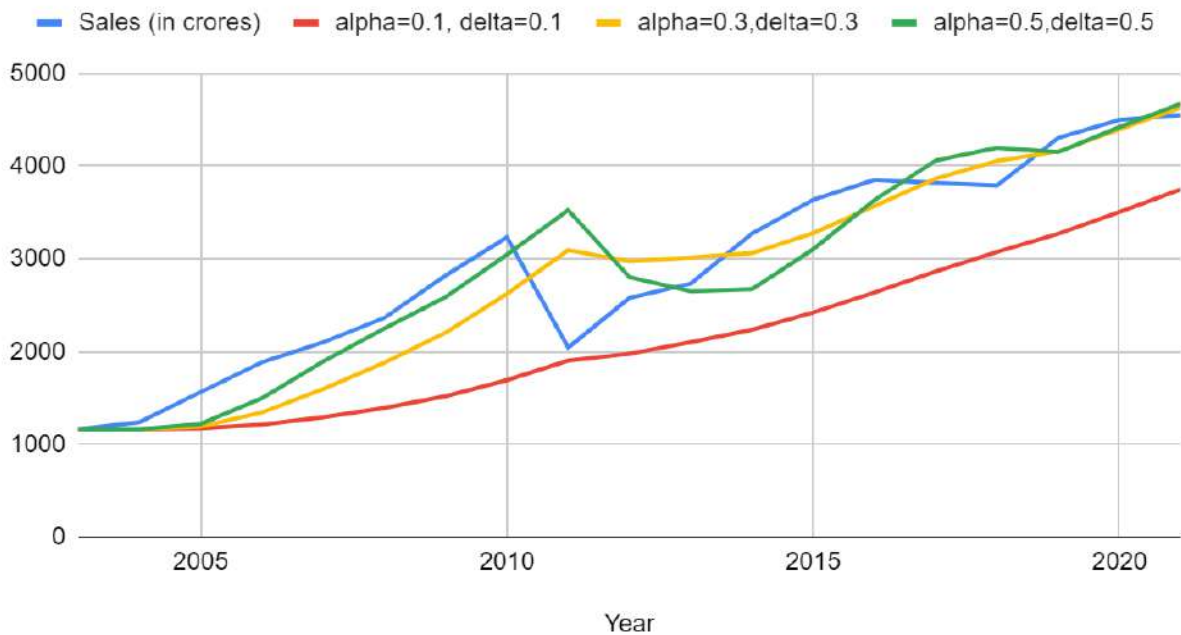
Exponential Smoothing with Trend



Paperboards, Paper and Packaging

Interpretation: As evident for the chart below, the exponential smoothing with trend model having the values of $\alpha = 0.5$ and $\delta = 0.5$ outperforms the other models when capturing the changes in the actual sales figure.

Exponential Smoothing with Trend



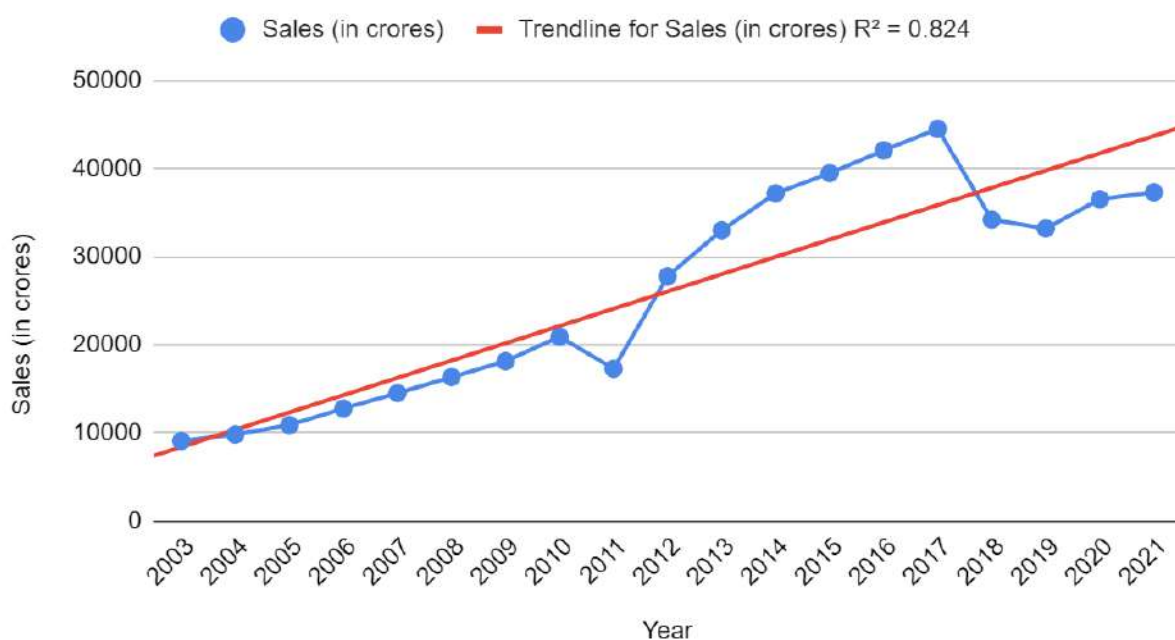
Linear Regression

Regression is a technique for determining the functional connection between two or more correlated variables, usually using data that has already been collected. For given values of the independent variable, the dependent variable is predicted. Linear regression is a type of regression in which the connection between the variables is assumed to be explained by a straight line.

FMCG

Interpretation: Since the R^2 score value is 0.824 which is close to 1, it implies that the sales data of FMCG can be captured using linear regression.

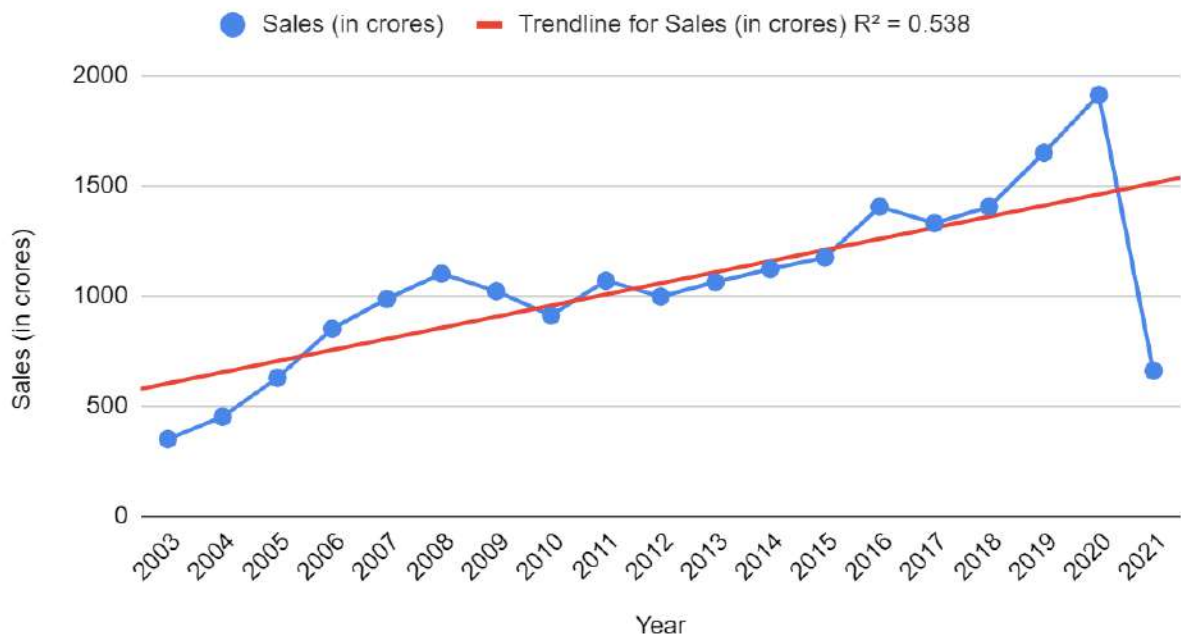
Sales (in crores) vs. Year



Hotels

Interpretation: As the R2 score value is 0.538, it suggests that the sales data of Hotels cannot be captured using a Linear Regression model due to adverse effect of covid on sales causing a steep change.

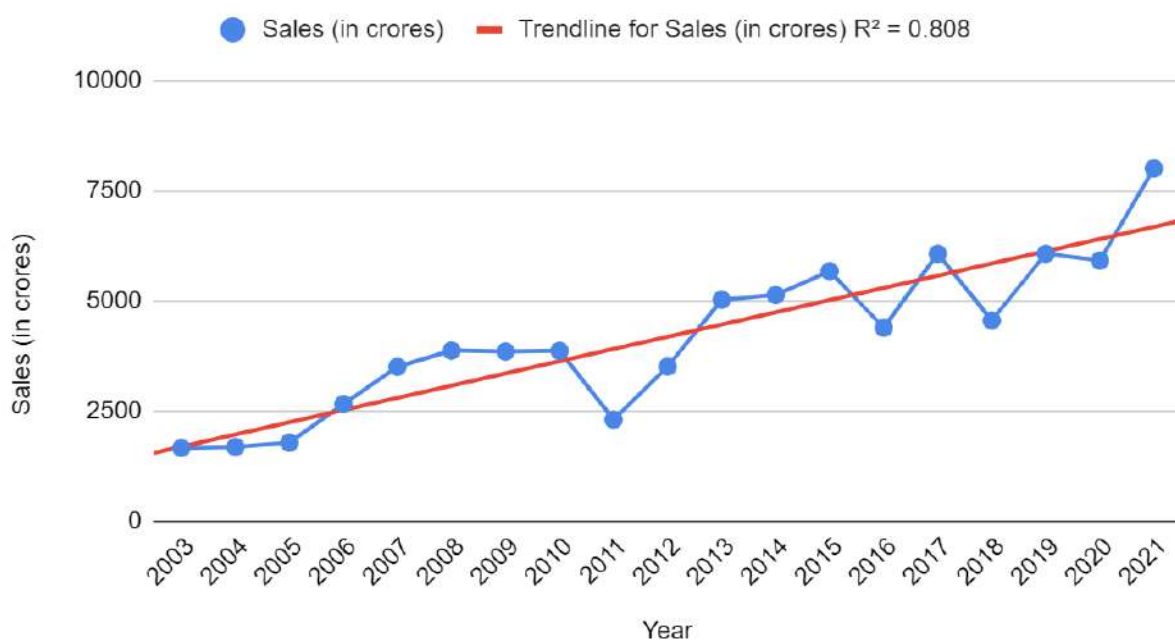
Sales (in crores) vs. Year



Agri Business

Interpretation: Since the R^2 score value is 0.808, it implies that the sales data of the Agri Business can be captured using linear regression.

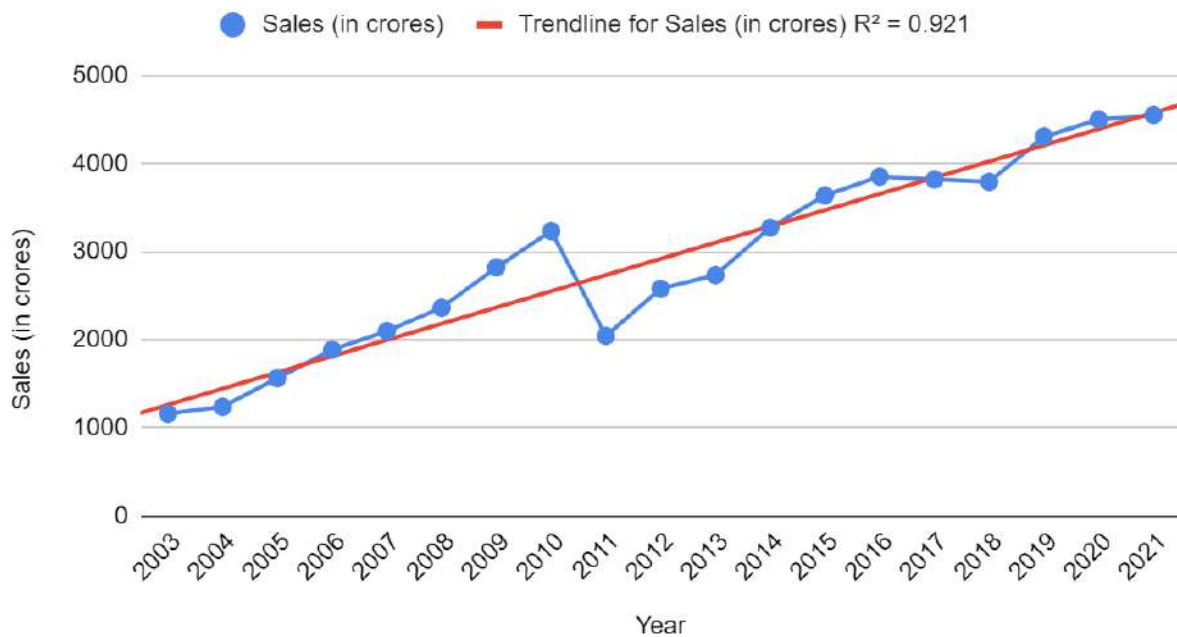
Sales (in crores) vs. Year



Paperboards, Paper and Packaging

Interpretation: As the R2 score value is 0.921, it suggests that the sales data of Paperboards, Paper and Packaging can be captured using a Linear Regression model.

Sales (in crores) vs. Year



Inventory Management

Inventory management plays a critical role in micromanaging orders such that the production matches the demand so that there is minimum wastage, also while making sure that underordering cost is minimum.

We were unable to find exhaustive data which was confidential in case of ITC about all orders and their quantity so we assumed the following -

- Material Required according to the sector of production.
- Ordering cost per order.
- Holding cost for FMCG was assumed to be 0.4 because this industry requires more maintenance of the product. Similarly holding cost for Agri-Business is assumed to be 0.3 and for Paperboards, Paper and Packaging industry it is assumed to be 0.1

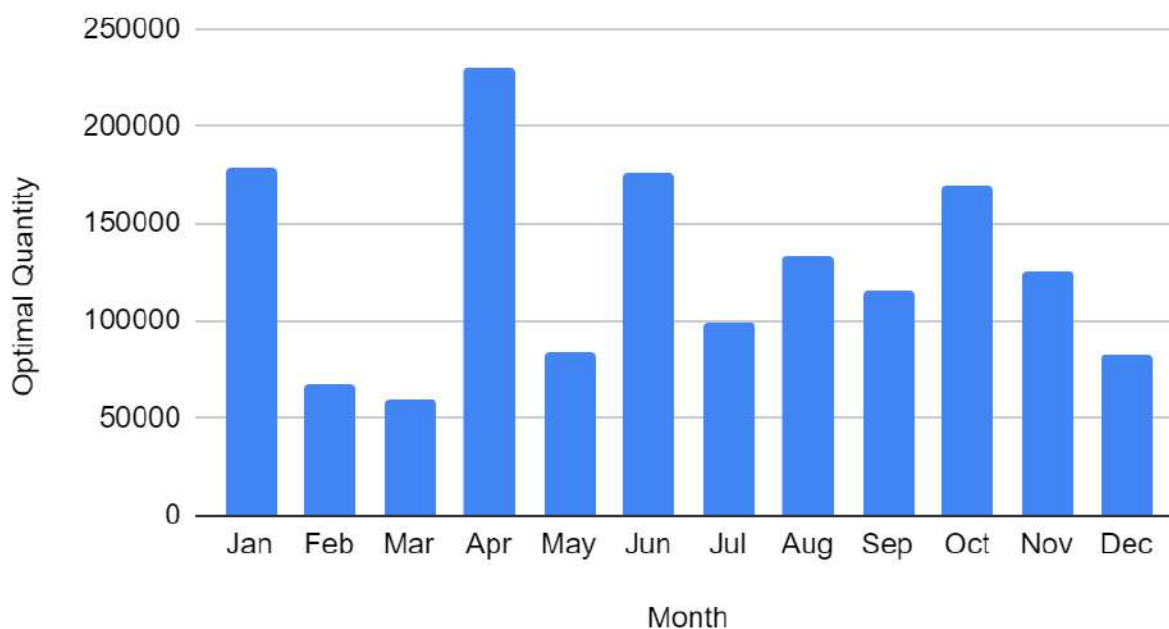
We analyzed the inventory data of 2021 for three sectors which are FMCG, Agri-Business, and Paperboards, Paper and Packaging respectively. We use the fixed order quantity model to determine the optimal quantity by -

$$\text{Optimal Quantity} = \sqrt{\frac{(2 * \text{Material Req}) * (\text{Ordering cost per order})}{(\text{holding cost}) * (\text{Purchase price per unit})}}$$

FMCG

		FMCG 2021			
Month	Material Required	Ordering Cost Per Order	Holding Cost	Purchase Price Per Unit	Optimal Quantity
Jan	189493333.3	500	0.4	15	177713.8774
Feb	204719791.7	350	0.4	79	67341.90444
Mar	226851875	300	0.4	95	59848.74026
Apr	266018958.3	910	0.4	23	229402.462
May	302565833.3	460	0.4	98	84267.6383
Jun	340346875	800	0.4	44	175899.4741
Jul	377689791.7	510	0.4	98	99134.46695
Aug	435931458.3	480	0.4	59	133164.5789
Sep	360046250	350	0.4	47	115784.1846
Oct	578916666.7	780	0.4	79	169054.519
Nov	687313125	440	0.4	96	125502.6923
Dec	774759583.3	100	0.4	57	82438.68446

Optimal Quantity vs. Month

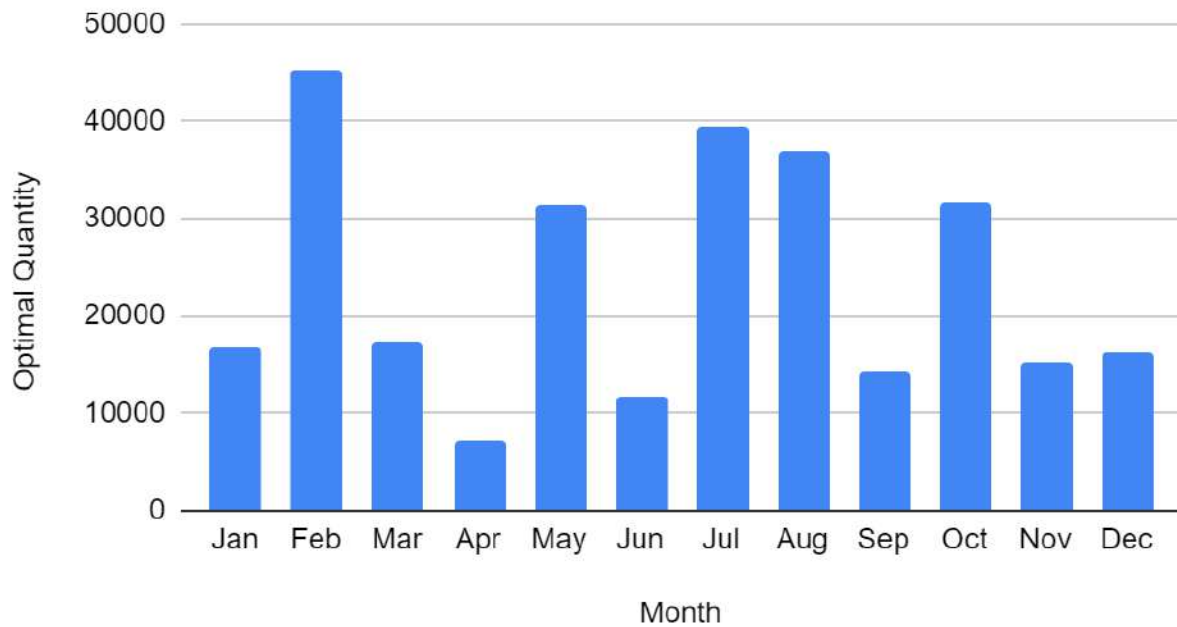


Agri Business

		Agri Business 2021			
Month	Material Required	Ordering Cost Per Order	Holding Cost	Purchase Price Per Unit	Optimal Quantity
Jan	2010702	5733	0.3	273	16777.91048
Feb	7889274	6493	0.3	167	45220.70785
Mar	8244212	2178	0.3	402	17256.18775
Apr	1353622	1970	0.3	342	7209.79859
May	4621970	5605	0.3	175	31414.9748
Jun	8269761	1450	0.3	588	11659.93657
Jul	5487105	7323	0.3	173	39350.24778
Aug	8177187	9399	0.3	378	36817.24268
Sep	2007173	5878	0.3	392	14165.06367
Oct	9513233	8215	0.3	520	31653.41337
Nov	7874409	1458	0.3	326	15322.63007

Dec	9628405	3980	0.3	956	16347.22858
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Optimal Quantity vs. Month

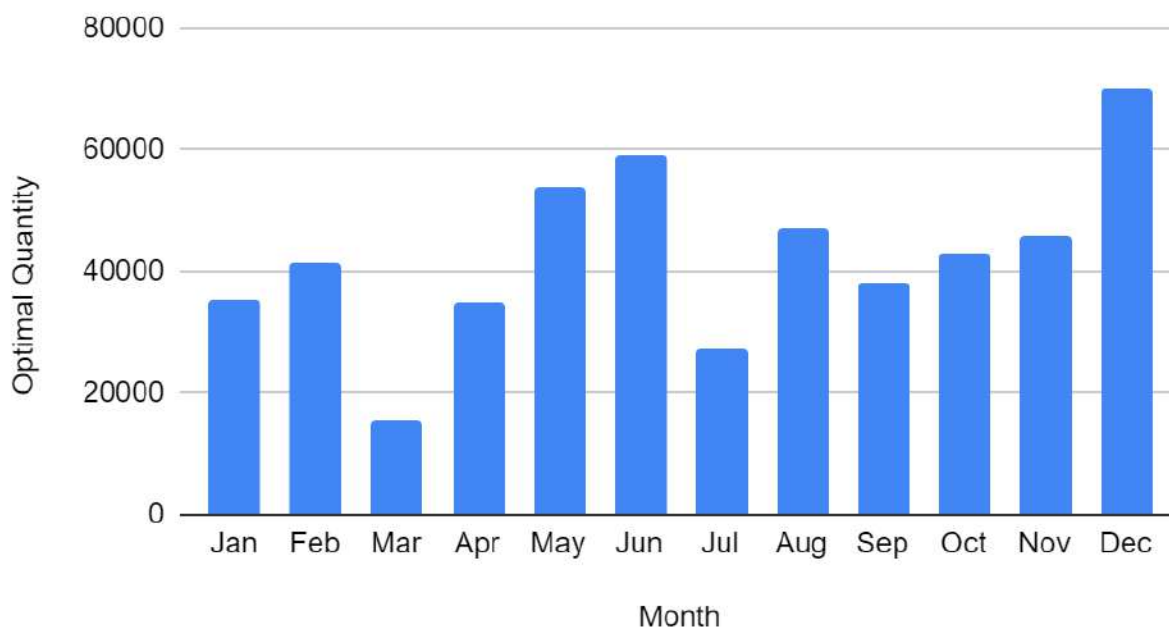


Paperboards, Paper and Packaging

Paperboards, Paper and Packaging 2021					
Month	Material Required	Ordering Cost Per Order	Holding Cost	Purchase Price Per Unit	Optimal Quantity
Jan	97384652	104	0.1	163	35251.94823
Feb	17062095	715	0.1	142	41451.47838
Mar	15169636	144	0.1	180	15579.28676
Apr	15510072	692	0.1	177	34824.77497
May	54523518	451	0.1	171	53628.68506
Jun	58926390	357	0.1	120	59212.50041
Jul	30037398	183	0.1	149	27163.05187
Aug	15652324	910	0.1	130	46811.59429

Sep	15661148	616	0.1	133	38088.2773
Oct	50517993	342	0.1	187	42986.32242
Nov	45804150	395	0.1	174	45602.78179
Dec	80738824	411	0.1	136	69856.6354

Optimal Quantity vs. Month



Aggregate Production Planning

The APP is involved with determining intermediate-term production rates by product group or other broad categories (3 to 18 months).

The aggregate production plan's main goal is to determine the best mix of production rate, labor, and inventory on hand.

Assumptions:

Working hours	8/day
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Labor hours required	10/unit
Inventory Holding Cost	2/unit/month
Straight time cost	10/hour
Worker Hiring Cost	250/worker
Layoff Cost	200/worker
Marginal Cost of Stockout	5/unit/month
Marginal Cost of Subcontracting	125/unit/month
Overtime Cost	15/hour

We have used 4 different Production Plans as follows:

Plan 1

Produce to exact monthly production requirement using a regular eight-hour day by varying workforce size.

Months	Opening Stock	Demand	Safety Stock (25% of demand)	Production Requirement	No. of working days	Working hours	No. of workers	Production Cost	Hiring Cost	Layoff Cost	Total Cost
Jan' 21	242.36	909.68	227.42	895	22	176	51	89474	0	0	89474
Feb '21	0	982.55	245.6375	1228	18	144	85	122818.75	8613.324653	0	131432.0747
Mar' 21	0	1088.89	272.2225	1361	21	168	81	136111.25	0	854.4394841	136965.6895
April' 21	0	1278.91	319.7275	1599	20	160	100	159863.75	4724.06064	0	164587.8106
May' 21	0	1423.16	355.79	1779	21	168	106	177895	1493.759301	0	179388.7593
June' 21	0	1636.65	409.1625	2046	20	160	128	204581.25	5493.350074	0	210074.6001
July' 21	0	1829.11	457.2775	2286	22	176	130	228638.75	511.274858	0	229150.0249
Aug' 21	0	2094.71	523.6775	2618	19	152	172	261838.75	10588.48871	0	272427.2387
Sept' 21	0	1782.22	445.555	2228	21	168	133	222777.5	0	7931.336153	230708.8362
Oct' 21	0	788	197	985	20	160	62	98500	0	14208.63095	112708.631

Nov' 21	0	1391.03	347.7575	1739	21	168	103	173878.75	10484.18899	0	184362.939
Dec' 21	0	988.46	247.115	1236	22	176	70	123557.5	0	6659.22619	130216.7262
Total								1999935.25	41908.44722	29653.63278	2071497.33

Plan 2

Produce to meet expected average demand over the next twelve months by maintaining a constant workforce & varying the inventory.

Months	Opening Stock	Demand	Safety Stock (25% of demand)	Production Requirement	No. of working days	Working hours	No. of workers	Production	Closing Stock	Production Cost	Inventory Holding Cost	Shortage Cost	Total Cost
Jan' 21	242.36	909.68	227.42	895	22	176	102	1795	900	179520	1800.92	0	181320.92
Feb '21	900	982.55	245.6375	328	18	144	102	1469	1141	146880	2282.145	0	149162.145
Mar' 21	1141	1088.89	272.2225	220	21	168	102	1714	1494	171360	2987.12	0	174347.12
April' 21	1494	1278.91	319.7275	105	20	160	102	1632	1527	163200	3053.845	0	166253.845
May' 21	1527	1423.16	355.79	252	21	168	102	1714	1462	171360	2923.145	0	174283.145
June' 21	1462	1636.65	409.1625	584	20	160	102	1632	1048	163200	2095.52	0	165295.52
July' 21	1048	1829.11	457.2775	1239	22	176	102	1795	557	179520	1113.145	0	180633.145
Aug' 21	557	2094.71	523.6775	2062	19	152	102	1550	-511	155040	0	0	155040
Sept' 21	-511	1782.22	445.555	2739	21	168	102	1714	-1026	171360	0	2900.175	174260.175
Oct' 21	-1026	788	197	2011	20	160	102	1632	-379	163200	0	907.95	164107.95
Nov' 21	-379	1391.03	347.7575	2117	21	168	102	1714	-404	171360	0	280.1	171640.1
Dec' 21	-404	988.46	247.115	1639	22	176	102	1795	156	179520	311.695	0	179831.695
Total		16193.37	4048.3425	14191	247	1976				2015520	16567.535	4088.225	2036175.76
Averag		1349.44	337.361	1183	20.5833	164.666							

e		75	875		3333	6667						
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Plan 3

Produce to meet the minimum expected demand using a constant workforce on a regular time. Use sub-contracting to meet additional output requirements.

Months	Opening Stock	Demand	Safety Stock (25% of demand)	Production Requirement	No. of working days	Working hours	No. of workers	Production	Units subcontracted	Production Cost	Subcontracting Cost	Total Cost
Jan' 21	242.36	909.68	227.42	895	22	176	34	598	296	59840	37042.5	96882.5
Feb '21	227.42	982.55	245.6375	1001	18	144	34	490	511	48960	63895.9375	112855.9375
Mar' 21	245.6375	1088.89	272.2225	1115	21	168	34	571	544	57120	68034.375	125154.375
April' 21	272.2225	1278.91	319.7275	1326	20	160	34	544	782	54400	97801.875	152201.875
May' 21	319.7275	1423.16	355.79	1459	21	168	34	571	888	57120	111002.8125	168122.8125
June' 21	355.79	1636.65	409.1625	1690	20	160	34	544	1146	54400	143252.8125	197652.8125
July' 21	409.1625	1829.11	457.2775	1877	22	176	34	598	1279	59840	159853.125	219693.125
Aug' 21	457.2775	2094.71	523.6775	2161	19	152	34	517	1644	51680	205538.75	257218.75
Sept' 21	523.6775	1782.22	445.555	1704	21	168	34	571	1133	57120	141612.1875	198732.1875
Oct' 21	445.555	788	197	539	20	160	34	544	0	54400	0	54400
Nov' 21	197	1391.03	347.7575	1542	21	168	34	571	971	57120	121323.4375	178443.4375
Dec' 21	347.7575	988.46	247.115	888	22	176	34	598	289	59840	36177.1875	96017.1875
Total										671840	1185535	1857375

Plan 4

Produce to meet expected demand for all but the first two months using a constant workforce (60 no. of workers) and use overtime to meet additional output requirements

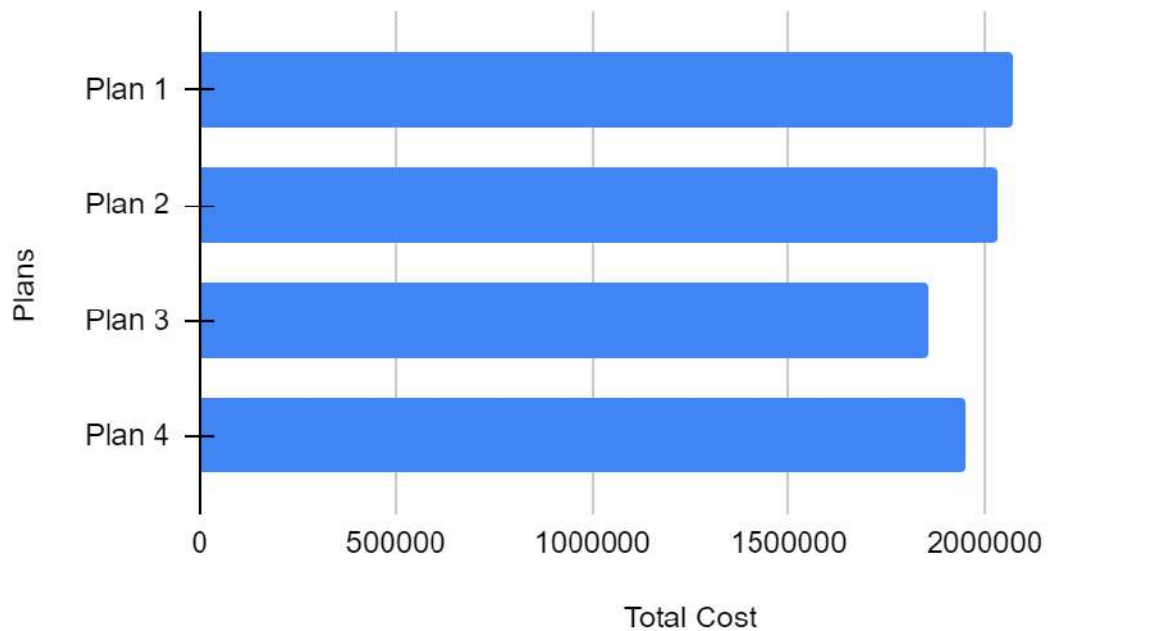
Months	Opening Stock	Demand	Safety Stock (25% of demand)	Production Requirement	No. of working days	Working hours	No. of workers	Production	Units overtime	Units excess	Production Cost	Overtime Cost	Inventory Holding Cost	Total Cost
Jan' 21	242.36	909.68	227.42	895	22	176	60	1056	0	161	105600	0	322.52	105922.52
Feb' 21	227.42	982.55	245.6375	1001	18	144	60	864	137	0	86400	20515.125	0	106915.125
Mar' 21	245.6375	1088.89	272.2225	1115	21	168	60	1008	107	0	100800	16121.25	0	116921.25
April' 21	272.2225	1278.91	319.7275	1326	20	160	60	960	366	0	96000	54962.25	0	150962.25
May' 21	319.7275	1423.16	355.79	1459	21	168	60	1008	451	0	100800	67683.375	0	168483.375
June' 21	355.79	1636.65	409.1625	1690	20	160	60	960	730	0	96000	109503.375	0	205503.375
July' 21	409.1625	1829.11	457.2775	1877	22	176	60	1056	821	0	105600	123183.75	0	228783.75
Aug' 21	457.2775	2094.71	523.6775	2161	19	152	60	912	1249	0	91200	187366.5	0	278566.5
Sept' 21	523.6775	1782.22	445.555	1704	21	168	60	1008	696	0	100800	104414.625	0	205214.625
Oct' 21	445.555	788	197	539	20	160	60	960	0	421	96000	0	841.11	96841.11
Nov' 21	197	1391.03	347.7575	1542	21	168	60	1008	534	0	100800	80068.125	0	180868.125
Dec' 21	347.7575	988.46	247.115	888	22	176	60	1056	0	168	105600	0	336.365	105936.365
Total											1185600	763818.375	1499.995	1950918.37

Comparison

Cost	Plan 1	Plan 2	Plan 3	Plan 4
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Hiring	41908.44722	0	0	0
Layoff	29653.63278	0	0	0
Excess Inventory	0	16567.535	0	1499.995
Shortage Inventory	0	4088.225	0	0
Subcontract	0	0	1185535	0
Overtime	0	0	0	763818.375
Straight Time	1999935.25	2015520	671840	1185600
Total	2071497.33	2036175.76	1857375	1950918.37

Total Cost vs. Plan



Inference: If we go according to cost, then plan 3 is more efficient, and it also makes sense for ITC, since the diversity of workforce ranges from daily wage worker to top tier managers, it's important to keep a minimum threshold of workers and then flexibly change according to the requirement for all small scale works in a factory and agri business.



Conclusion

Having a Gross Sales Value of 74,979 crores and a Net Profit of 13,032 crores, ITC is one of India's leading private sector firms, with operations in FMCG, Hotels, Packaging, Paperboards & Specialty Papers, Agri & IT.

With a plethora of materials and products, it becomes really important to have an optimal inventory management system along with an efficient demand forecast of each region along different seasons to reduce wastage while also ensuring that the market demand is met.

With this project, we got a real life experience of how difficult and intriguing it is to manage the operations of a large scale company. We also got various insights of how theoretical knowledge can be applied in the actual world.

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