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10 February 2015

TIM 125 Midterm Examination

Problem 1: Planning

Step 1: Intent of the product

Project is to complete an accurate, high-quality midterm examination for submission on Tuesday 10 February 2015.

Step 2: Determine the subtasks and activities.

1. Complete midterm problem #2
    - 1a: read the Specialty Packaging Corporation Case Study
    - 1b: analyze SPC's business and state what their competitive strategy should be
    - 1c: considering their competitive strategy, identify a supply chain strategy which best aligns to this competitive strategy
    - 1d: identify SPC's position in the zone of strategic fit
    - 1e: identify what SPC's high-level SC strategy should be for each of the SC drivers.

2. Complete midterm problem #3
    - 2a: download corrected demand data from course website
    - 2b: input this data into a new Excel workbook
    - 2c: forecast both the demand for black and clear plastic, including error analysis using:
        - -static forecasting,
        - -moving average
        - -simple exponential smoothing
        - -Holt's method
        - -Winter's method
    - 2d: based on error metrics, identify which forecasting method is best for both clear and black plastic
    - 2e: state the demand forecast for each quarter of 2007 for both black and clear plastic

3. Complete midterm problem #4
    - 3a: identify and state why SPC should have a cycle inventory
    - 3b: given the numbers presented in the question, calculate the values a-g
    - 3c: create a diagram showing clear plastic inventory as a function of time to illustrate these values.
    - 3d: read section in text on Short-Term Discounting

3e: identify the optimal order quantity and how much the forward buy on polystyrene be if the supplier offers a promotional discount of 25% per unit at the beginning of the year.

4. Complete midterm problem #5
   - 4a: do some brief studying on safety inventory
   - 4b: determine if SPC should have a safety inventory and why
   - 4c: give a recommendation for how much safety inventory SPC should have

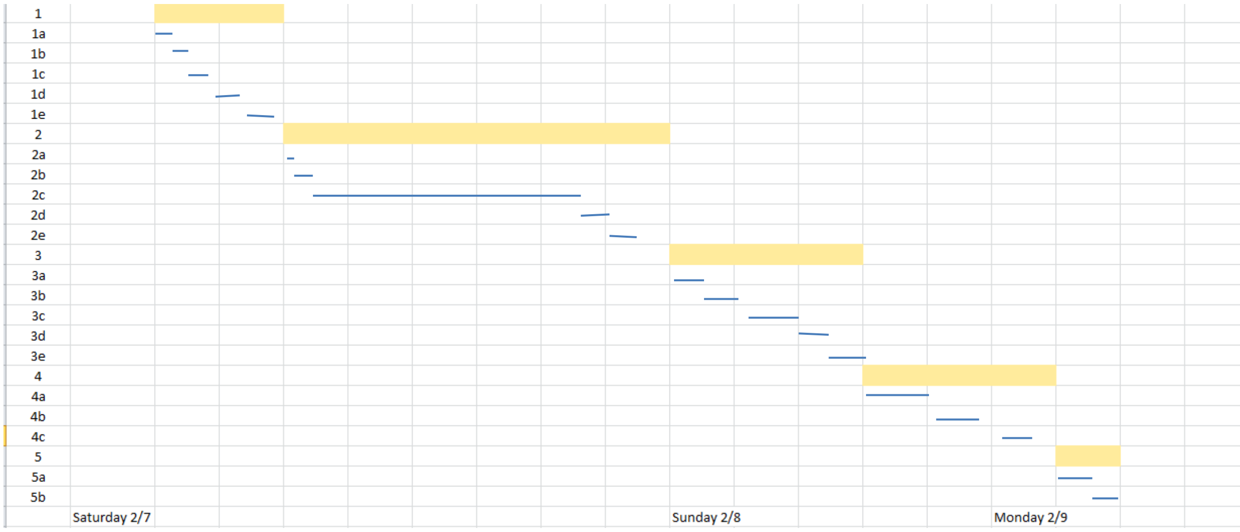
5. Complete midterm problem #6
   - 5a: compare my plan with its execution. Indicate reasons for the difference between the plan and its execution
   - 5b: create a fourth column; it will contain what was done well and what I would now have done differently.

Step 3: Create a design/development activity matrix

Design and Development Activity Matrix

	1	1a	1b	1c	1d	1e	2	2a	2b	2c	2d	2e	3	3a	3b	3c	3d	3e	4	4a	4b	4c	5	5a	5b
1	1																								
1a		1a																							
1b		x	1b																						
1c		x	x	1c																					
1d		x	x	x	1d																				
1e		x	x	x	x	1e																			
2							2																		
2a								2a																	
2b								x	2b																
2c								x	x	2c															
2d								x	x	x	2d														
2e								x	x	x	x	2e													
3													3												
3a													x	3a											
3b													x	x	3b										
3c													x	x	x	3c									
3d													x	x	x	x	3d								
3e													x	x	x	x	x	3e							
4																			4						
4a																				4a					
4b																				x	4b				
4c																				x	x	4c			
5																							5		
5a																								5a	
5b																								x	5b

Step 4: Create a time-phased schedule of tasks

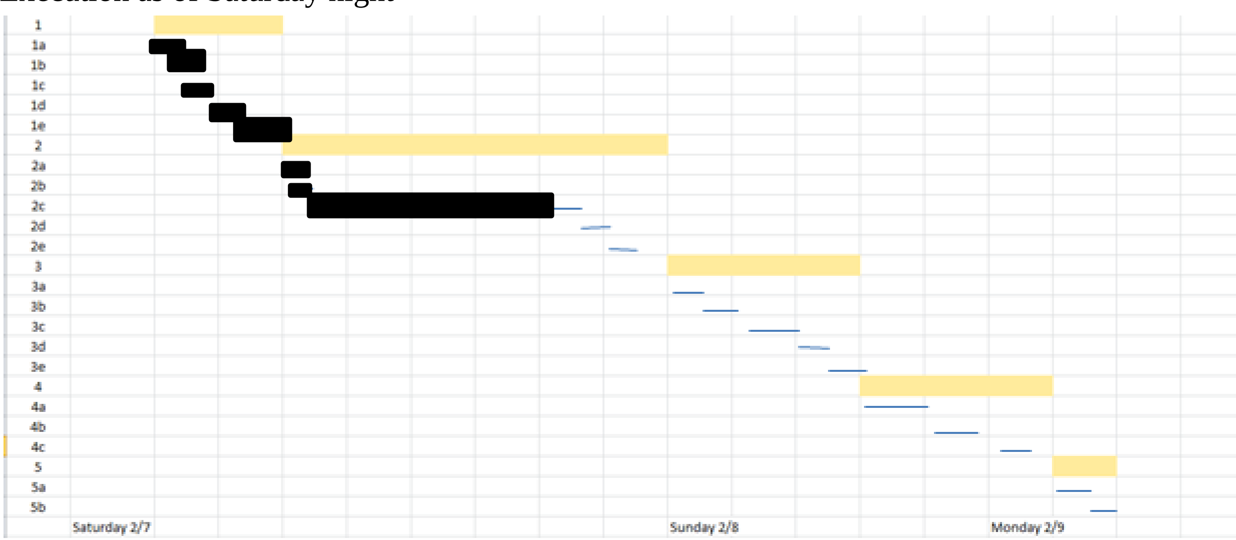


Step 5: Identify the critical path

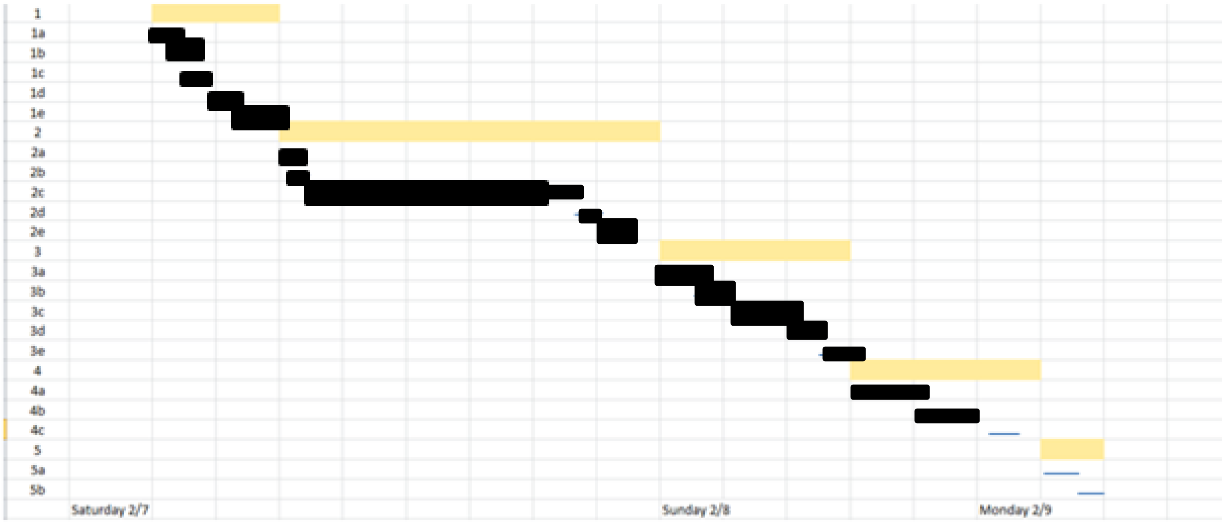
As seen in the above figure “Design and Development Activity Matrix”, each subtask of every problem are sequential, and the problems themselves are sequential. Therefore I must execute all tasks and subtasks in sequential order.

Tracking Progress with Project Plan

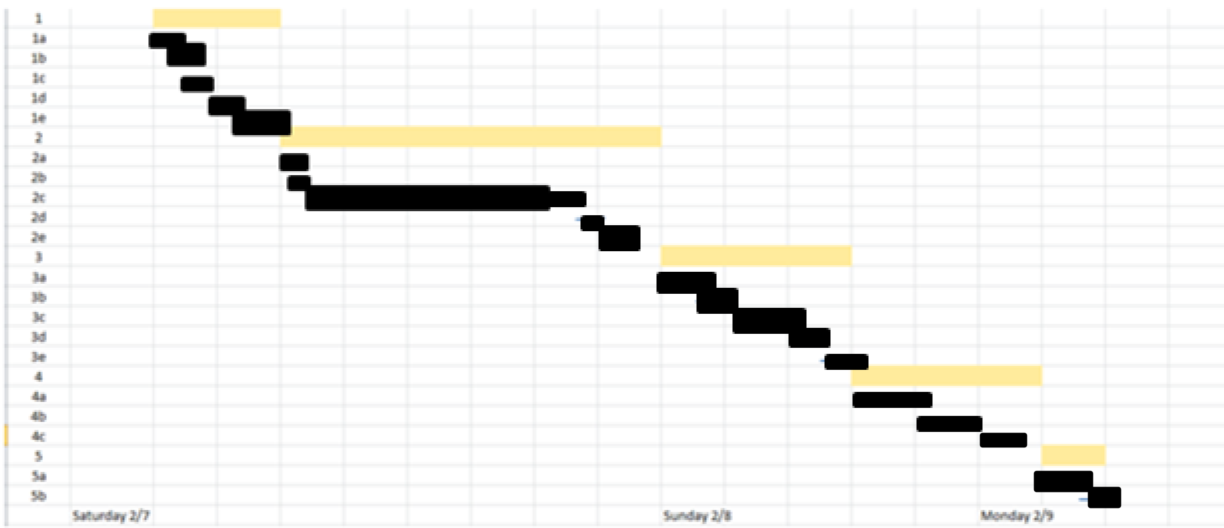
Execution as of Saturday night



Execution as of Sunday night



Execution as of Monday afternoon



Problem 2: Supply Chain Strategy for SPC

Structured Problem Solving

Step 1: Define the Problem

What should SPC's competitive strategy be? What should SPC's supply chain strategy be to align with its competitive strategy? Where does SPC lie in the zone of strategic fit between IDU and responsiveness? What should SPC's high-level SC strategy be for each of the supply chain drivers?

Step 2: Plan

- read the Specialty Packaging Corporation Case Study
- analyze SPC's business and state what their competitive strategy should be considering their competitive strategy, identify a supply chain strategy which best aligns to this competitive strategy
- identify SPC's position in the zone of strategic fit
- identify what SPC's high-level SC strategy should be for each of the SC drivers

Step 3: Execute

Design of a Supply Chain Network for SPC

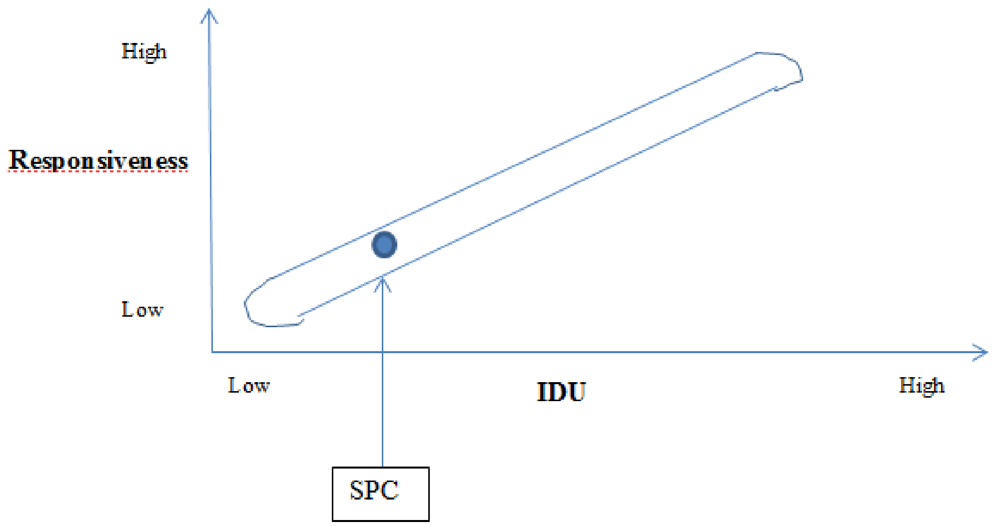
Table 2.1: Design of SC Network

Design or create the competitive strategy for the company	Customer needs: high-quality plastic containers for food storage, reliable delivery Product variety: Differentiated strategy, target entire food industry(restaurants, supermarkets, caterer, etc.) with a particular product line for each market segment
Design the SC Strategy to be aligned with the competitive strategy	How responsive should the SC be? Supply chain should be slightly responsive since the product is established and demand is well understood. How efficient should SC be? Supply chain should be highly efficient so as to help maximize the SC profitability.

Design the SC configuration to meet desired performance objectives	Key Drivers: Inventory- raw materials: Polystyrene resin pellets; work-in-progress: Polystyrene sheet Facilities-storage, manufacturing Transportation-rail and trailers Information- data and analysis linking the chain

Specialty Packing Corporation's positioning in the Zone of Strategic Fit:

Figure 2.1: Zone of Strategic Fit



As seen in Figure 2.1 above, SPC lies in the lower section of IDU and Responsiveness in the Zone of Strategic Fit. This is due to their product being mature and thus relatively low demand uncertainty (note that a level of uncertainty exists, due in part to the seasonality of demand and SPC's past ineffective demand forecasting). This in turn brings down responsiveness as SBC is able to focus on making their supply chain more efficient.

SC Strategy for Each of the SC Drivers

1. Facilities

- Single storage facility for both resin pellets and Polystyrene sheets
- Single manufacturing facility
- Manufacturing and storage facility should be in close proximity to avoid unnecessary transportation costs. Do not need to be close to the customer (possibly even overseas)

2. Transportation

-If facilities are located overseas, ship product by boat (SC does not need to be highly responsive)

-Once product gets to U.S. ship by truck.

3. Inventory

-Cycle inventory: need to build inventory of plastic sheets to meet future demand since extruders produce limited output.

- Hold very little amount of safety inventory since product is mature and there IDU is low.

4. Information

-Connect suppliers and distributors with SPC to better exchange information and yield a more profitable supply chain.

Step 4: Check work

After re-reading the case study, my assumptions about the product and company are valid. Also I have carefully read and understood SPC's manufacturing process to aid in my design of their strategy for the supply chain as a whole and for each of the key drivers. All figures and tables are labeled and explained and all information is presented clearly.

Step 5: Learn and Generalize

A company must understand both its product and the market in order to successfully design an effective supply chain. As a product matures, the market demand is better understood and thus the IDU goes down with time. This means the firm must design their supply chain to be less responsive and more efficient so as to properly maximize the supply chain profitability.

Problem 3: Demand Forecasting for SPC

Structured Problem Solving

Step 1: Define the problem

Which forecasting method should Julie Williams use for black plastic? Which forecasting method should she use for clear plastic? What is the demand forecast for each quarter of 2007 for black plastic and fore clear plastic?

Step 2: Plan

- download corrected demand data from course website
- input this data into a new Excel workbook
- forecast both the demand for black and clear plastic, including error analysis using:
    - -static forecasting
    - -moving average

-simple exponential smoothing
-Holt's method
-Winter's method

- based on error metrics, identify which forecasting method is best for both clear and black plastic
- state the demand forecast for each quarter of 2007 for both black and clear plastic

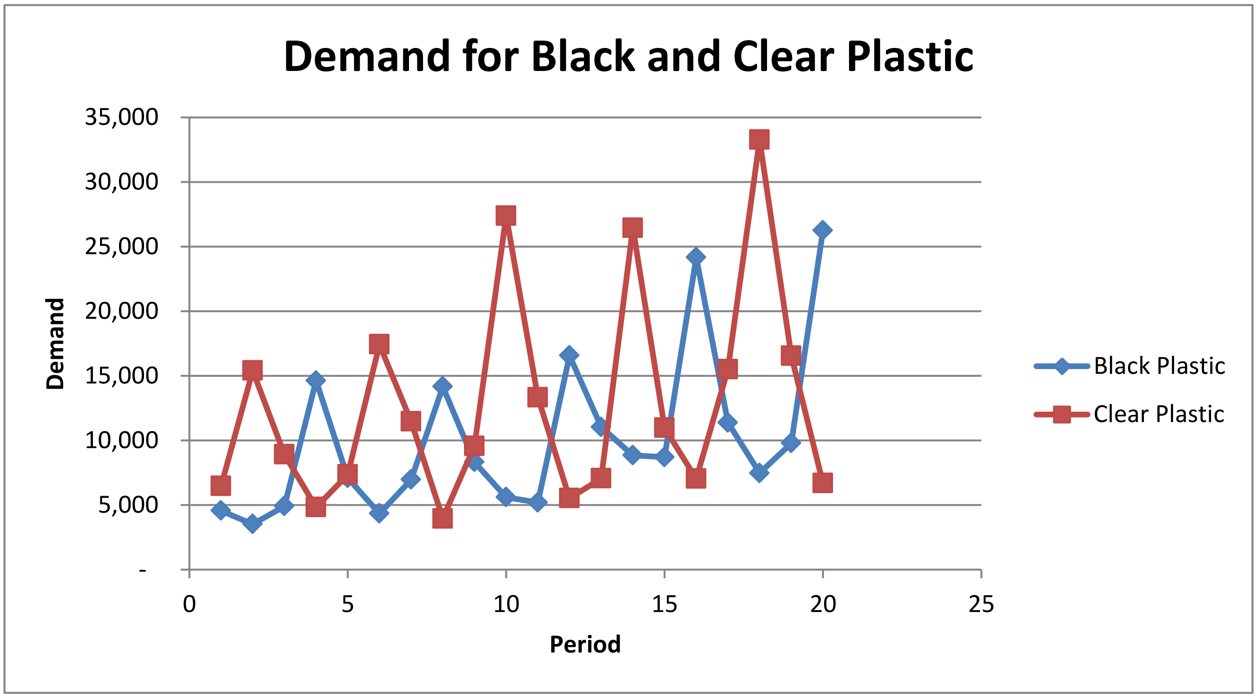
Step 3: Execute

Static Forecasting

Step 1: First, we must de-seasonalize the given data

Plotting the data gives us:

Figure 3.1: Demand for Black and Clear Plastic



Observe from Figure 3.1 above, that both the data for black and clear plastic has seasonality, and in each case the periodicity, p, is equal to 4. So we now de-seasonalize the data.

Since p=4, we need 4 data points to average the data. We achieve this with the following general equation:

Equation 1:

(De-seasonalized Demand)$_t$ = ($D_{t-p/2}$ + $D_{t+p/2}$ + 2[sum from i=t-(p/2-1) to t+(p/2-1) of D_i]) / 2p

We apply this value to periods 3-18 and insert into column 5.

Step 2: Regress de-seasonalized data from Step 1

Now we must regress the de-seasonalized data. The intercept of the line of best fit will be our level, L, and the slope of the line will be our trend, T. Apply the equation

$$D_t \text{ bar} = L + Tt \qquad (2)$$

And put data into column 6. The result is level, L = 5247 and trend, T = 455.

Step 3: Estimate the seasonal factor for each time period t

$$(\text{Seasonal Factor})_t = (\text{Demand})_t \,/\, (\text{Regressed De-seasonalized Data})_t \qquad (3)$$

We place these seasonal factors into column 7 of the spreadsheet.

Step 4: Calculate the average seasonal factor, S_t, averaged over number of cycles, n, of available data. For p = 4,

$$S_1 = [(\text{Seasonal Factor})_1 + (\text{Seasonal Factor})_5 + (\text{Seasonal Factor})_9 + \ldots\ ] / n \qquad (4)$$

And so on….

We place average seasonal factor in column 8 of spreadsheet

Step 5: Forecasting (bring back the seasonal effects)

$$\text{Forecast, } F = (\text{seasonal factor}) * (\text{regressed de-seasonalized data}) \qquad (5)$$

$$F_{t+l} = (S_{t+l})[L + (t+l)T] \qquad (6)$$

In equation (6) above, t is the present time and l is the number of periods in the future. We will apply this forecast to periods 21-24 which represent all four quarters of 2007.

Now we plot both our forecasted demand and historical demand for both Black and Clear plastic to visually see how accurate our forecast is:

Figure 3.2

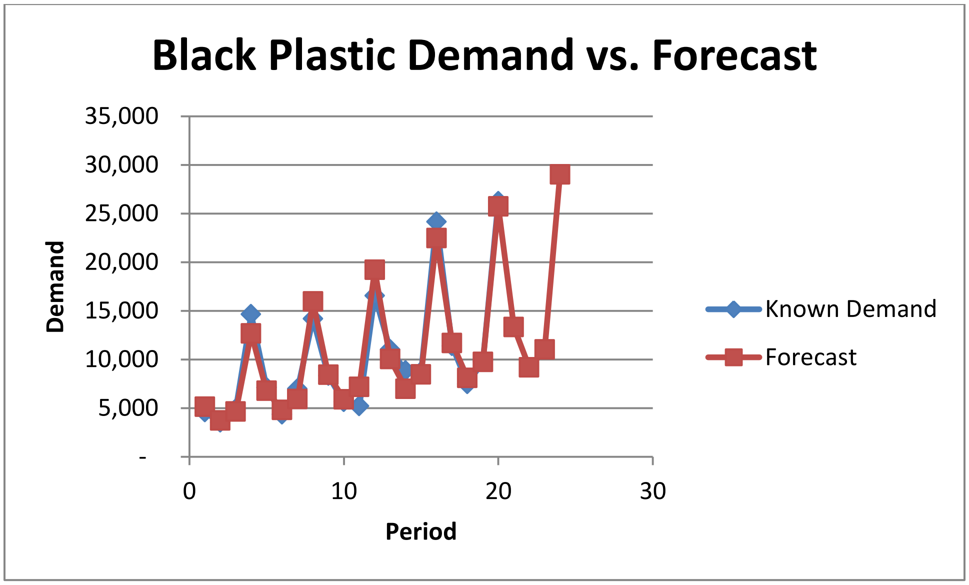
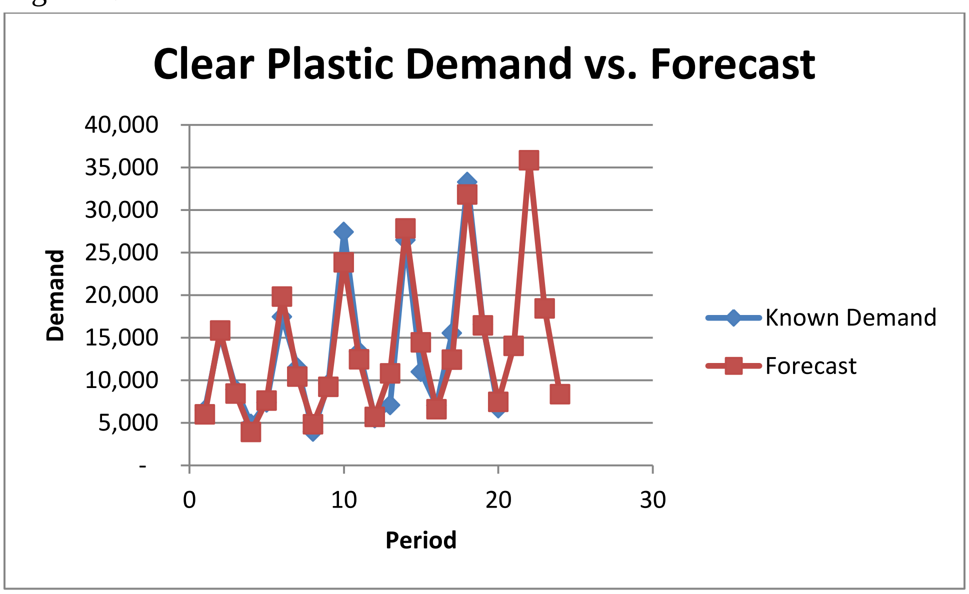


Figure 3.3



Visually, we can see that our static forecast for both black and clear plastic seems to be somewhat accurate.

Now we must include an analysis of the forecast error. We define

F_t to be the forecast of demand at time t and

D_t to be the actual demand at time t

The forecast error, $E_t = F_t - D_t$ (1)

Below we illustrate the equations for all of the following error metrics which are used in each method of forecasting:

1. Mean square error (MSE)
2. Absolute error (A_t)
3. Mean Absolute Deviation (MAD)
4. % Error
5. Mean Absolute Percent Error (MAPE)
6. Bias
7. Tracking Signal (TS)

$$(MSE)_n = \frac{1}{n}\left[\sum_{i=1}^{n} E_i^2\right] \longrightarrow (2)$$

$$A_t = |E_t| \underset{(1)}{=} |F_t - D_t| \longrightarrow (3)$$

$$(MAD)_n = \frac{1}{n}\left[\sum_{i=1}^{n} A_i\right] \longrightarrow (4)$$

$$\%\ Error = \left(\frac{E_i}{D_i}\right) 100 \longrightarrow (5)$$

$$MAPE_n(\%) = \frac{1}{n}\left[\sum_{i=1}^{n} \frac{|E_i|}{D_i}\right] \times 100 \longrightarrow (6)$$

$$(Bias)_n = \sum_{i=1}^{n} E_i \longrightarrow (7)$$

$$(TS)_n = \frac{(Bias)_n}{(MAD)_n} \longrightarrow (8)$$

We now apply these error metrics to our spreadsheets for both black and clear plastic below.

Table 3.1: Static Forecasting for Black Plastic

Year	Quarter	Period	Black Plastic Demand ('000 lb)	De-seasonalized Demand	regressed De-seasonalized Demand	Seasonal Factor	Average Seasonal Factor	Re-seasonalized Demand	Error E_t	Absolute Error A_t	$Bias_t$	Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	TS_t
2002	I	1	4,567		5702	0.800947	0.9001298	5132.539976	566	566	566	319,835	566	12.38	12	1
	II	2	3,530		6157	0.573331	0.6015416	3703.691551	174	174	739	175,002	370	4.92	9	2
	III	3	4,909	7224.5	6612	0.742438	0.7004668	4631.486163	-278	278	462	142,339	339	5.65	8	1
	IV	4	14,627	7641.875	7067	2.069761	1.7938991	12677.48466	-1,950	1,950	-1,488	1,056,907	742	13.33	9	-2
2003	I	5	7,097	8000.625	7522	0.943499		6770.776166	-326	326	-1,814	866,810	658	4.60	8	-3
	II	6	4,339	8200.875	7977	0.543939		4798.49724	459	459	-1,355	757,531	625	10.59	9	-2
	III	7	6,970	8296.625	8432	0.826613		5906.335651	-1,064	1,064	-2,418	810,939	688	15.26	10	-4
	IV	8	14,168	8608.875	8887	1.594239		15942.38095	1,774	1,774	-644	1,103,125	824	12.52	10	-1
2004	I	9	8,322	8546.75	9342	0.890816		8409.012356	87	87	-557	981,397	742	1.05	9	-1
	II	10	5,612	8624.875	9797	0.572828		5893.302928	281	281	-275	891,170	696	5.01	9	0
	III	11	5,200	9263.5	10252	0.507218		7181.185139	1,981	1,981	1,706	1,166,981	813	38.10	11	2
	IV	12	16,563	10006.875	10707	1.546932		19207.27724	2,644	2,644	4,350	1,652,416	965	15.96	12	5
2005	I	13	11,036	10850.375	11162	0.988712		10047.24855	-989	989	3,361	1,600,510	967	8.96	11	3
	II	14	8,845	12239.375	11617	0.761384		6988.108616	-1,857	1,857	1,504	1,732,477	1,031	20.99	12	1
	III	15	8,715	13232.125	12072	0.721918		8456.034627	-259	259	1,245	1,621,449	979	2.97	11	1
	IV	16	24,160	13103.875	12527	1.928634		22472.17353	-1,688	1,688	-442	1,698,156	1,024	6.99	11	0
2006	I	17	11,381	13065.875	12982	0.876675		11685.48474	304	304	-138	1,603,718	981	2.68	11	0
	II	18	7,474	13461	13437	0.556225		8082.914305	609	609	471	1,535,221	961	8.15	11	0
	III	19	9,782		13892	0.704146		9730.884116	-51	51	420	1,454,558	913	0.52	10	0
	IV	20	26,254		14347	1.82993		25737.06982	-517	517	-97	1,395,191	893	1.97	10	0
2007	I	21			14802			13323.72093								
	II	22			15257			9177.719993								
	III	23			15712			11005.7336								
	IV	24			16167			29001.96611								

Table 3.2: Static Forecasting for Clear Plastic

Year	Quarter	Period	Clear Plastic Demand ('000 lb)	De-seasonalized Demand	regressed De-seasonalized Demand	Seasonal Factor	Average Seasonal Factor	Re-seasonalized Demand	Error E_t	Absolute Error A_t	$Bias_t$	Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	TS_t
2002	I	1	6,478		7821	0.83	0.763532337	5971.586406	-506	506	-506	256,455	506	7.82	8	-1
	II	2	15,403		8349	1.84	1.894501496	15817.19299	414	414	-92	214,005	460	2.69	5	0
	III	3	8,918	9019.625	8877	1.00	0.948592559	8420.65615	-497	497	-590	225,120	473	5.58	5	-1
	IV	4	4,837	9384.125	9405	0.51	0.417315867	3924.855733	-912	912	-1,502	376,842	583	18.86	9	-3
2003	I	5	7,363	9957.125	9933	0.74		7584.166702	221	221	-1,281	311,257	510	3.00	8	-3
	II	6	17,434	10167.5	10461	1.67		19818.38015	2,384	2,384	1,104	1,206,925	823	13.68	9	1
	III	7	11,471	10335.25	10989	1.04		10424.08364	-1,047	1,047	57	1,191,084	855	9.13	9	0
	IV	8	3,967	11857	11517	0.34		4806.226846	839	839	896	1,130,236	853	21.16	10	1
2004	I	9	9,575	13335.5	12045	0.79		9196.746997	-378	378	518	1,020,551	800	3.95	10	1
	II	10	27,396	13764.125	12573	2.18		23819.56731	-3,576	3,576	-3,059	2,197,583	1,078	13.05	10	-3
	III	11	13,337	13646.375	13101	1.02		12427.51112	-909	909	-3,968	2,073,000	1,062	6.82	10	-4
	IV	12	5,530	13215.625	13629	0.41		5687.597958	158	158	-3,810	1,902,320	987	2.85	9	-4
2005	I	13	7,070	12802	14157	0.50		10809.32729	3,739	3,739	-71	2,831,570	1,199	52.89	12	0
	II	14	26,455	12694.75	14685	1.80		27820.75447	1,366	1,366	1,295	2,762,550	1,211	5.16	12	1
	III	15	10,969	13939.375	15213	0.72		14430.93861	3,462	3,462	4,757	3,377,381	1,361	31.56	13	3
	IV	16	7,040	15846.875	15741	0.45		6568.96907	-471	471	4,286	3,180,161	1,305	6.69	13	3
2006	I	17	15,517	17396.5	16269	0.95		12421.90759	-3,095	3,095	1,190	3,556,599	1,410	19.95	13	1
	II	18	33,268	18051	16797	1.98		31821.94163	-1,446	1,446	-256	3,475,181	1,412	4.35	13	0
	III	19	16,553		17325	0.96		16434.36609	-119	119	-374	3,293,018	1,344	0.72	12	0
	IV	20	6,692		17853	0.37		7450.340182	758	758	384	3,157,121	1,315	11.33	12	0
2007	I	21			18381			14034.48788								
	II	22			18909			35823.12879								
	III	23			19437			18437.79358								
	IV	24			19965			8331.711294								

4-point Moving Average

We will now perform Adaptive forecasting for both black and clear plastic. Our first method will be a four point moving average in which we assume the data has level only.

Step 1: Forecast level, L_t

If N=4, the estimate of level for an N-point average is given by

$$L_t = [D_t + D_{t-1} + D_{t-2} + \ldots + D_{t-(N-1)}] / N$$

Since data is assumed to have level only, forecast of demand at t+1 is:

$F_{t+1} = L_t$; $F_{t+2} = L_t$

Step 2: Adapt the forecast

Once the actual demand at (t+1) is known, we can now estimate L_{t+1} as

$$L_{t+1} = [D_{t+1} + D_t + \ldots + D_{t-(N-2)}] / N$$

We now apply this method to forecast demand for both black and clear plastic.

Figure 3.4: Demand vs. Forecast for Black Plastic using Moving Average

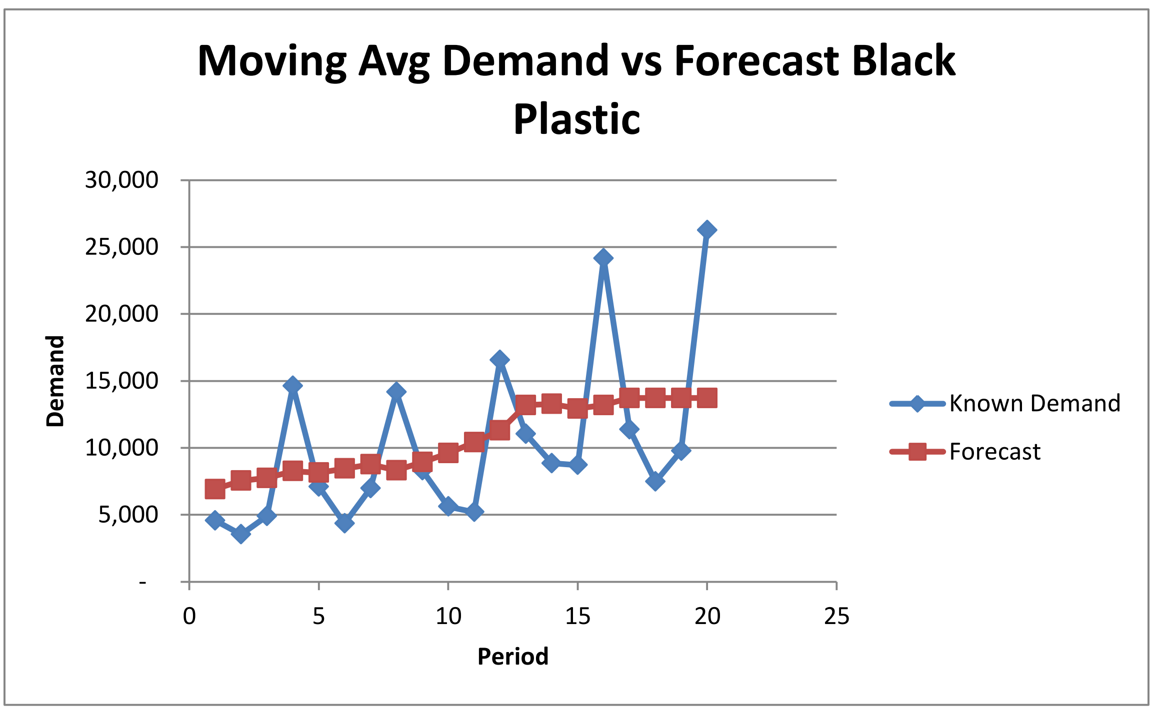


Figure 3.5: Demand vs. Forecast for Clear Plastic using Moving Average

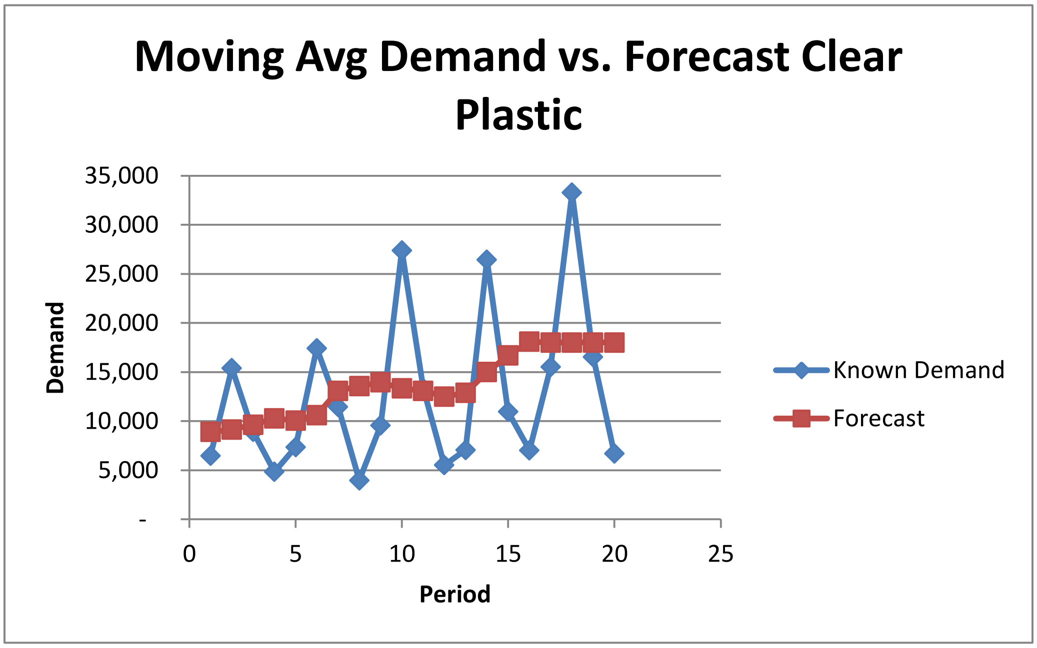


Table 3.3: Forecast for Black Plastic using 4-point Moving Average

Year	Month	Period, t	Black Plastic Demand, D_t	Level L_t	Forecast F_t	Error E_t	Absolute Error A_t	$Bias_t$	Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	TS_t
2002	I	1	4,567										
	II	2	3,530										
	III	3	4,909										
	IV	4	14,627	6,908									
2003	I	5	7,097	7,541	6,908	-188.75	188.75	-188.75	7125.31	188.75	2.66	2.66	-1.00
	II	6	4,339	7,743	7,541	3201.75	3201.75	3013.00	1714471.60	1695.25	73.79	38.22	1.78
	III	7	6,970	8,258	7,743	773.00	773.00	3786.00	1554908.38	1387.83	11.09	29.18	2.73
	IV	8	14,168	8,144	8,258	-5909.75	5909.75	-2123.75	5726187.96	2518.31	41.71	32.31	-0.84
2004	I	9	8,322	8,450	8,144	-178.50	178.50	-2302.25	5093485.10	2050.35	2.14	26.28	-1.12
	II	10	5,612	8,768	8,450	2837.75	2837.75	535.50	5389419.10	2181.58	50.57	30.33	0.25
	III	11	5,200	8,326	8,768	3568.00	3568.00	4103.50	6056801.36	2379.64	68.62	35.80	1.72
	IV	12	16,563	8,924	8,326	-8237.50	8237.50	-4134.00	11206768.44	3111.88	49.73	37.54	-1.33
2005	I	13	11,036	9,603	8,924	-2111.75	2111.75	-6245.75	10687746.87	3000.75	19.14	35.49	-2.08
	II	14	8,845	10,411	9,603	757.75	757.75	-5488.00	9965349.60	2776.45	8.57	32.80	-1.98
	III	15	8,715	11,290	10,411	1696.00	1696.00	-3792.00	9492754.03	2678.23	19.46	31.59	-1.42
	IV	16	24,160	13,189	11,290	-12870.25	12870.25	-16662.25	19252165.34	3527.56	53.27	33.40	-4.72
2006	I	17	11,381	13,275	13,189	1808.00	1808.00	-14854.25	18311971.14	3395.29	15.89	32.05	-4.37
	II	18	7,474	12,933	13,275	5801.25	5801.25	-9053.00	19164333.94	3567.14	77.62	35.30	-2.54
	III	19	9,782	13,199	12,933	3150.50	3150.50	-5902.50	18678087.43	3539.37	32.21	35.10	-1.67
	IV	20	26,254	13,723	13,199	-13054.75	13054.75	-18957.25	26265507.94	4134.08	49.72	36.01	-4.59
2007	I	21			13,723								
	II	22			13,723								
	III	23			13,723								
	IV	24			13,723								

Table 3.4: Forecast for Clear Plastic using 4-point Moving Average

Year	Month	Period, t	Clear Plastic Demand, D_t	Level L_t	Forecast F_t	Error E_t	Absolute Error A_t	$Bias_t$	Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	TS_t
2002	I	1	6,478										
	II	2	15,403										
	III	3	8,918										
	IV	4	4,837	8,909									
2003	I	5	7,363	9,130	8,909	1546.00	1546.00	1546.00	478023.20	1546.00	21.00	21.00	1.00
	II	6	17,434	9,638	9,130	-8303.75	8303.75	-6757.75	11890396.68	4924.88	47.63	34.31	-1.37
	III	7	11,471	10,276	9,638	-1833.00	1833.00	-8590.75	10671752.72	3894.25	15.98	28.20	-2.21
	IV	8	3,967	10,059	10,276	6309.25	6309.25	-2281.50	14313613.08	4498.00	159.04	60.91	-0.51
2004	I	9	9,575	10,612	10,059	483.75	483.75	-1797.75	12749213.19	3695.15	5.05	49.74	-0.49
	II	10	27,396	13,102	10,612	-16784.25	16784.25	-18582.00	39645396.68	5876.67	61.27	51.66	-3.16
	III	11	13,337	13,569	13,102	-234.75	234.75	-18816.75	36046279.48	5070.68	1.76	44.53	-3.71
	IV	12	5,530	13,960	13,569	8038.75	8038.75	-10778.00	38427547.99	5441.69	145.37	57.14	-1.98
2005	I	13	7,070	13,333	13,960	6889.50	6889.50	-3888.50	39122752.78	5602.56	97.45	61.62	-0.69
	II	14	26,455	13,098	13,333	-13121.75	13121.75	-17010.25	48626864.94	6354.48	49.60	60.41	-2.68
	III	15	10,969	12,506	13,098	2129.00	2129.00	-14881.25	45687250.01	5970.34	19.41	56.69	-2.49
	IV	16	7,040	12,884	12,506	5466.00	5466.00	-9415.25	44699119.14	5928.31	77.64	58.43	-1.59
2006	I	17	15,517	14,995	12,884	-2633.50	2633.50	-12048.75	42477719.32	5674.87	16.97	55.24	-2.12
	II	18	33,268	16,699	14,995	-18272.75	18272.75	-30321.50	58667478.94	6574.71	54.93	55.22	-4.61
	III	19	16,553	18,095	16,699	145.50	145.50	-30176.00	55580831.12	6146.10	0.88	51.60	-4.91
	IV	20	6,692	18,008	18,095	11402.50	11402.50	-18773.50	59302639.88	6474.63	170.39	59.02	-2.90
2007	I	21			18,008								
	II	22			18008								
	III	23			18008								
	IV	24			18008								

As we can see visually in figures 3.4 and 3.5 as well as from the high error metrics MAPE and MAD in tables 3.3 and 3.4, using the moving average method of demand forecasting is not an appropriate approach for this data set.

Simple Exponential Smoothing

We will now perform adaptive forecasting using the method of simple exponential smoothing. We will use a smoothing constant, $\alpha = 0.05$, to smooth the forecast of the level, L.

Step 1: Initialize level

L_0 = average of all demand points, D_i (1)

Step 2: Initial Forecast

$F_1 = L_0$; $F_2 = L_0$ … (2)

Step 3: Compute the forecast error

$E_1 = F_1 - D_1 = (L_0 - D_1)$ (3)

Step 4: Modification, adapt the level based on forecast error

If $E_1 > 0$, $F_1 > D_1$ and thus we are over predicting the demand. Therefore to improve the forecast, we should (from eq.(3)) reduce the level.

$L_1 = L_0 - \alpha E_1$ (4)

Combining equations (3) and (4) we get

$$L_1 = \alpha D_1 + (1-\alpha)L_0 \qquad (5)$$

Forecast $F_2 = L_1$

Our general equations are:

$$F_{t+1} = L_t \qquad (6)$$

$$L_{t+1} = \alpha D_{t+1} + (1-\alpha)L_t \qquad (7)$$

The demand forecast, F_{t+l} , = L_{t+1} ($l = 2,3,4\ldots$)

After applying equations (1) through (7) into our spreadsheet we arrive at the following:

Table 3.5: Forecast for Black Plastic using Simple Exponential Smoothing

Year	Month	Period, *t*	Black Plastic Demand, D_t	Level L_t	Forecast F_t	Error E_t	Absolute Error A_t	$Bias_t$	Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	TS_t
		0		10,178									
2002	I	1	4,567	9,897	10,178	5,611	5,611	5,611	31,478,271	5,611	122.85	122.85	1.00
	II	2	3,530	9,579	9,897	6,367	6,367	11,978	36,008,623	5,989	180.37	151.61	2.00
	III	3	4,909	9,345	9,579	4,670	4,670	16,647	31,274,359	5,549	95.12	132.78	3.00
	IV	4	14,627	9,609	9,345	-5,282	5,282	11,365	30,430,154	5,482	36.11	108.61	2.07
2003	I	5	7,097	9,484	9,609	2,512	2,512	13,878	25,606,432	4,888	35.40	93.97	2.84
	II	6	4,339	9,226	9,484	5,145	5,145	19,022	25,749,956	4,931	118.57	98.07	3.86
	III	7	6,970	9,114	9,226	2,256	2,256	21,279	22,798,745	4,549	32.37	88.68	4.68
	IV	8	14,168	9,366	9,114	-5,054	5,054	16,224	23,142,260	4,612	35.67	82.06	3.52
2004	I	9	8,322	9,314	9,366	1,044	1,044	17,269	20,692,078	4,216	12.55	74.34	4.10
	II	10	5,612	9,129	9,314	3,702	3,702	20,971	19,993,434	4,164	65.97	73.50	5.04
	III	11	5,200	8,933	9,129	3,929	3,929	24,900	19,579,221	4,143	75.56	73.69	6.01
	IV	12	16,563	9,314	8,933	-7,630	7,630	17,269	22,799,592	4,434	46.07	71.38	3.90
2005	I	13	11,036	9,400	9,314	-1,722	1,722	15,548	21,273,855	4,225	15.60	67.09	3.68
	II	14	8,845	9,372	9,400	555	555	16,103	19,776,309	3,963	6.28	62.75	4.06
	III	15	8,715	9,340	9,372	657	657	16,760	18,486,702	3,742	7.54	59.07	4.48
	IV	16	24,160	10,081	9,340	-14,820	14,820	1,940	31,059,150	4,435	61.34	59.21	0.44
2006	I	17	11,381	10,146	10,081	-1,300	1,300	639	29,331,619	4,250	11.43	56.40	0.15
	II	18	7,474	10,012	10,146	2,672	2,672	3,311	28,098,606	4,163	35.75	55.25	0.80
	III	19	9,782	10,001	10,012	230	230	3,541	26,622,517	3,956	2.35	52.47	0.90
	IV	20	26,254	10,813	10,001	-16,253	16,253	-12,713	38,500,188	4,571	61.91	52.94	-2.78
2007	I	21			10,813								
	II	22			10,813								
	III	23			10,813								
	IV	24			10,813								

Figure 3.6: Forecast vs. Demand Black Plastic, Simple Exponential Smoothing

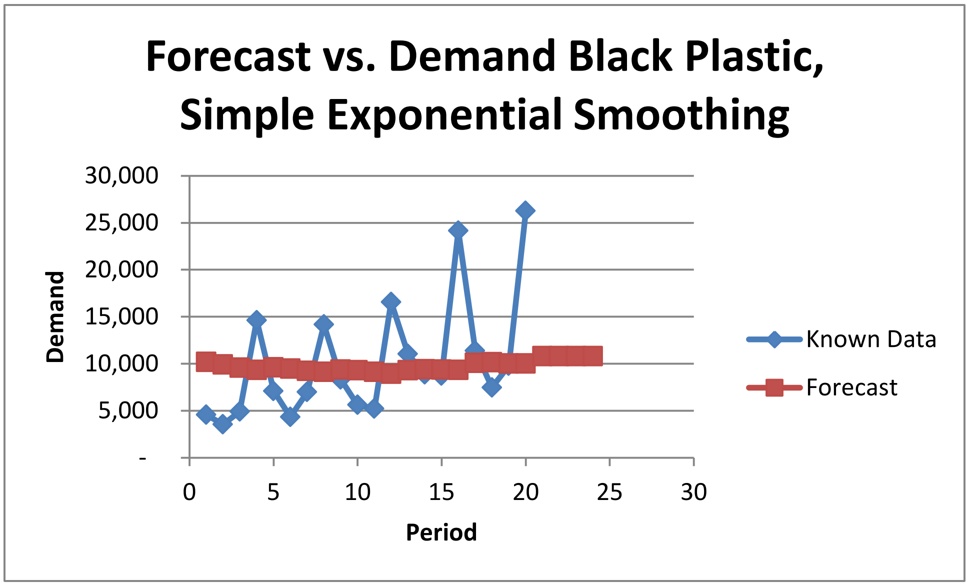
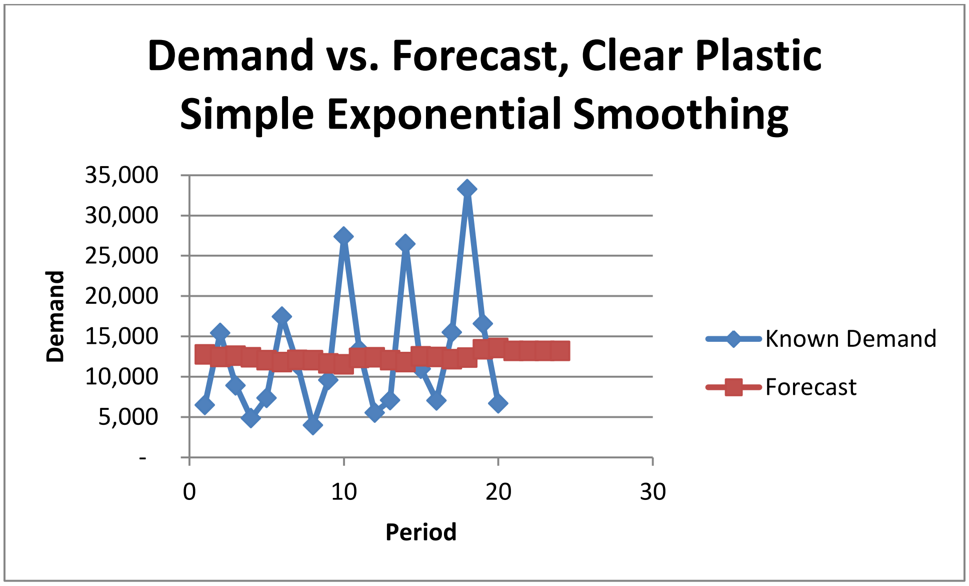


Table 3.6: Forecast for Clear Plastic using Simple Exponential Smoothing

Year	Month	Period, t	Clear Plastic Demand, D_t	Level L_t	Forecast F_t	Error E_t	Absolute Error A_t	$Bias_t$	Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	TS_t
		0		12,764									
2002	I	1	6,478	12,449	12,764	6,286	6285.65	6,286	39,509,396	6,286	97	97	1
	II	2	15,403	12,597	12,449	-2,954	2953.633	3,332	24,116,670	4,620	19	58	1
	III	3	8,918	12,413	12,597	3,679	3679.049	7,011	20,589,581	4,306	41	52	2
	IV	4	4,837	12,034	12,413	7,576	7576.097	14,587	29,791,496	5,124	157	79	3
2003	I	5	7,363	11,801	12,034	4,671	4671.292	19,258	28,197,390	5,033	63	76	4
	II	6	17,434	12,082	11,801	-5,633	5633.273	13,625	28,786,786	5,133	32	68	3
	III	7	11,471	12,052	12,082	611	611.3909	14,237	24,727,787	4,487	5	59	3
	IV	8	3,967	11,648	12,052	8,085	8084.821	22,321	29,807,356	4,937	204	77	5
2004	I	9	9,575	11,544	11,648	2,073	2072.58	24,394	26,972,715	4,619	22	71	5
	II	10	27,396	12,337	11,544	-15,852	15852.05	8,542	49,404,189	5,742	58	70	1
	III	11	13,337	12,387	12,337	-1,000	1000.446	7,541	45,003,889	5,311	8	64	1
	IV	12	5,530	12,044	12,387	6,857	6856.576	14,398	45,171,285	5,440	124	69	3
2005	I	13	7,070	11,795	12,044	4,974	4973.747	19,372	43,599,506	5,404	70	69	4
	II	14	26,455	12,528	11,795	-14,660	14659.94	4,712	55,836,244	6,065	55	68	1
	III	15	10,969	12,450	12,528	1,559	1559.057	6,271	52,275,872	5,765	14	65	1
	IV	16	7,040	12,180	12,450	5,410	5410.104	11,681	50,837,957	5,742	77	65	2
2006	I	17	15,517	12,346	12,180	-3,337	3337.401	8,344	48,502,679	5,601	22	63	1
	II	18	33,268	13,393	12,346	-20,922	20921.53	-12,578	70,125,334	6,452	63	63	-2
	III	19	16,553	13,551	13,393	-3,160	3160.455	-15,738	66,960,236	6,279	19	61	-3
	IV	20	6,692	13,208	13,551	6,859	6858.568	-8,880	65,964,222	6,308	102	63	-1
2007	I	21			13,208								
	II	22			13,208								
	III	23			13,208								
	IV	24			13,208								

Figure 3.7: Demand vs. Forecast, Clear Plastic using Simple Exponential Smoothing



As is clear from our plots we can visually see that simple exponential smoothing is not an accurate forecasting method for this data. This is confirmed by the large error metrics MAPE and MAD in tables 3.5 and 3.6.

Holt's Model

We now forecast demand using Level and Trend corrected exponential smoothing. The assumption is that the data has level, L, and trend, T, only.

Process:

Step 1: Regress the given data to compute the initial values of the level, L_0, and initial trend T_0.

$$\text{Forecast, } F_1 = L_0 + T_0 \tag{1}$$

Step 2: Adapt

Use two smoothing constants, α=0.05 andβ=0.05, to smooth respectively level and trend.

$$L_1 = \alpha D_1 + (1-\alpha)[L_0 + T_0] \tag{2}$$
$$T_1 = \beta[L_1 – L_0] + (1-\beta)T_0 \tag{3}$$

$$\text{Forecast } F_2 = L_1 + T_1 \tag{4}$$

Step 3: Forecast

$$F_{t+1} = L_t + T_t \tag{5}$$
$$L_{t+1} = \alpha D_{t+1} + (1-\alpha)[L_t + T_t] \tag{6}$$
$$T_{t+1} = \beta[L_{t+1} – L_t] + (1-\beta)T_t \tag{7}$$

After applying equations (1) through (7) into our spreadsheet we arrive at the following:

Table 3.7: Demand Forecast for Black Plastic using Holt's Method

Year	Month	Period, t	Black Plastic Demand, D_t	Level L_t	Trend T_t	Forecast F_t	Error E_t	Absolute Error A_t	$Bias_t$	Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	TS_t
		0		4150.179	574.0353									
2002	I	1	4,567	4716.354	573.6423	4724.214	157	157	157	24,716	157	3	3	1
	II	2	3,530	5201.996	569.2423	5289.996	1,760	1,760	1,917	1,561,151	959	50	27	2
	III	3	4,909	5728.126	567.0867	5771.238	862	862	2,779	1,288,586	926	18	24	3
	IV	4	14,627	6711.803	587.9162	6295.213	-8,332	8,332	-5,552	18,321,107	2,778	57	32	-2
2003	I	5	7,097	7289.583	587.4094	7299.719	203	203	-5,350	14,665,105	2,263	3	26	-2
	II	6	4,339	7700.093	578.5644	7876.992	3,538	3,538	-1,812	14,307,152	2,475	82	35	-1
	III	7	6,970	8213.224	575.2928	8278.657	1,309	1,309	-503	12,507,928	2,309	19	33	0
	IV	8	14,168	9057.491	588.7415	8788.517	-5,379	5,379	-5,882	14,561,792	2,693	38	34	-2
2004	I	9	8,322	9580.021	585.4309	9646.233	1,324	1,324	-4,558	13,138,658	2,540	16	32	-2
	II	10	5,612	9937.779	574.0473	10165.45	4,553	4,553	-5	13,898,185	2,742	81	37	0
	III	11	5,200	10246.24	560.7677	10511.83	5,312	5,312	5,307	15,199,759	2,975	102	43	2
	IV	12	16,563	11094.8	575.1577	10807	-5,756	5,756	-449	16,694,071	3,207	35	42	0
2005	I	13	11,036	11638.26	573.5728	11669.96	634	634	185	15,440,828	3,009	6	39	0
	II	14	8,845	12043.49	565.1557	12211.84	3,367	3,367	3,552	15,147,595	3,035	38	39	1
	III	15	8,715	12413.97	555.4216	12608.65	3,894	3,894	7,446	15,148,456	3,092	45	39	2
	IV	16	24,160	13528.92	583.3981	12969.39	-11,191	11,191	-3,745	22,028,540	3,598	46	40	-1
2006	I	17	11,381	13975.75	576.5698	14112.32	2,731	2,731	-1,014	21,171,572	3,547	24	39	0
	II	18	7,474	14198.4	558.874	14552.32	7,078	7,078	6,065	22,778,853	3,743	95	42	2
	III	19	9,782	14508.51	546.4358	14757.28	4,975	4,975	11,040	22,882,776	3,808	51	42	3
	IV	20	26,254	15614.9	574.4334	15054.95	-11,199	11,199	-159	28,009,573	4,178	43	42	0
2007	I	21				16189.34								
	II	22				16189								
	III	23				16189								
	IV	24				16189								

Figure 3.8: Demand vs. Forecast for Black Plastic using Holt's Method

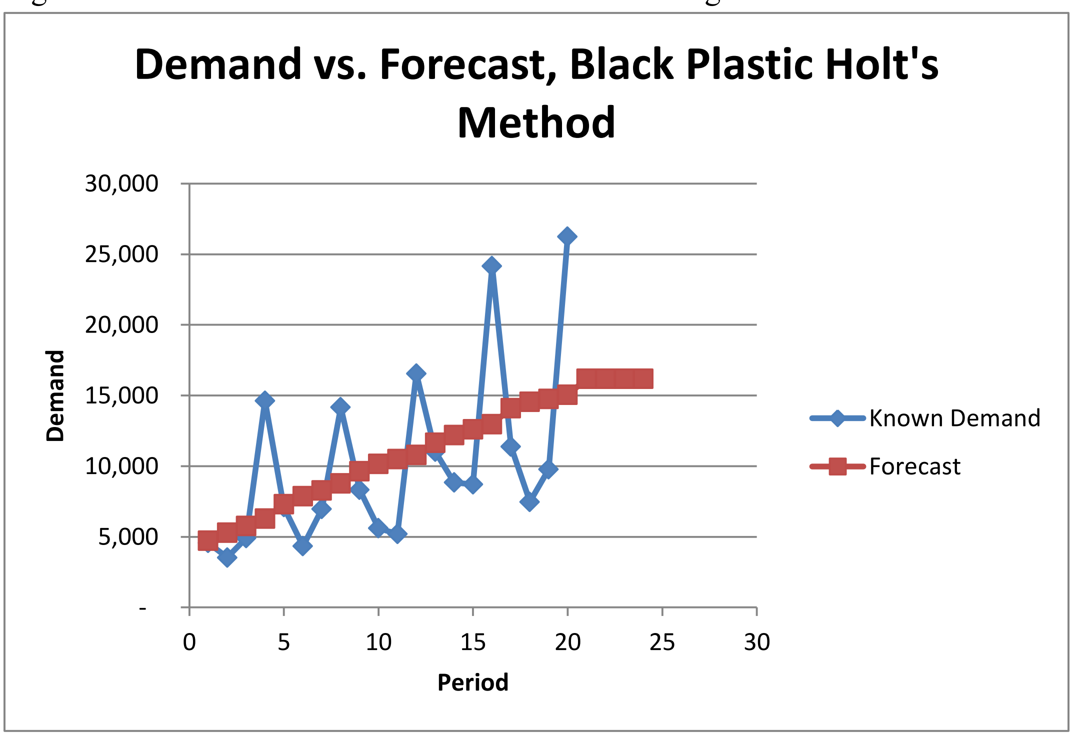
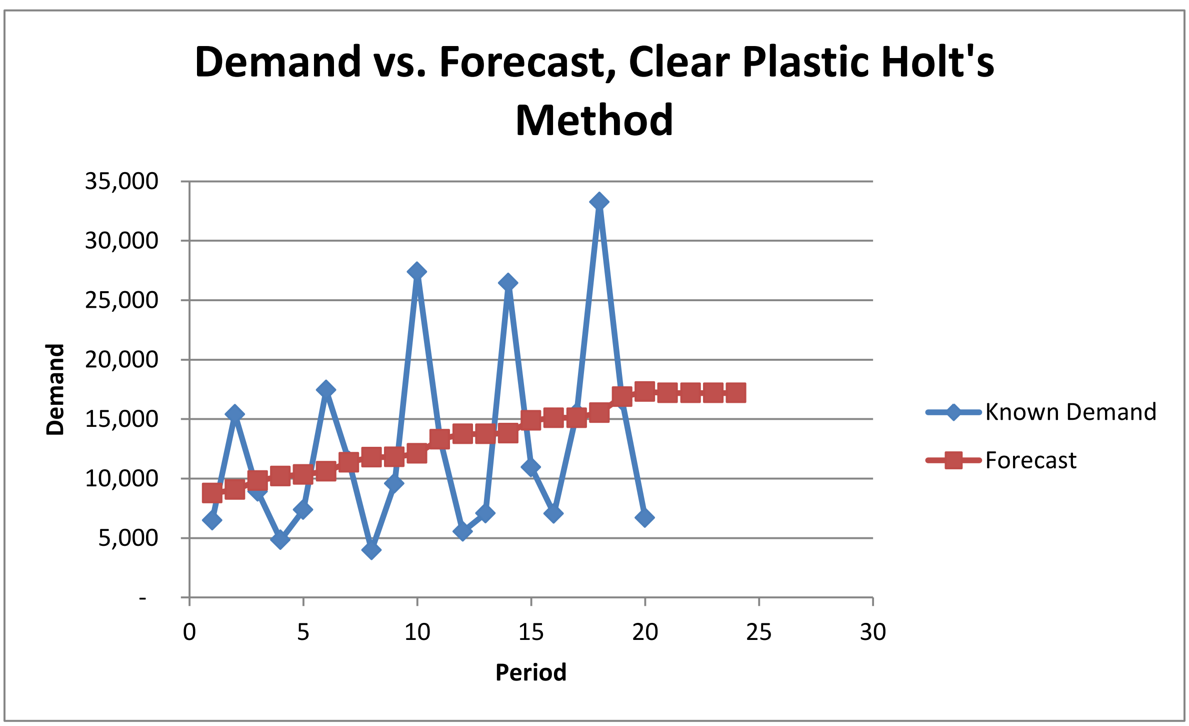


Table 3.8: Demand Forecast for Clear Plastic using Holt's Method

Year	Month	Period, t	Clear Plastic Demand, D_t	Level L_t	Trend T_t	Forecast F_t	Error E_t	Absolute Error A_t	$Bias_t$	Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	TS_t
		0		8341.2	421.1857									
2002	I	1	6,478	8648.166	415.4748	8762.386	2,284	2,284	2,284	5,218,418	2,284	35	35	1
	II	2	15,403	9380.609	431.3231	9063.641	-6,339	6,339	-4,055	22,702,944	4,312	41	38	-1
	III	3	8,918	9767.236	429.0883	9811.932	894	894	-3,161	15,401,668	3,173	10	29	-1
	IV	4	4,837	9928.358	415.69	10196.32	5,359	5,359	2,198	18,731,839	3,719	111	49	1
2003	I	5	7,363	10195	408.2374	10344.05	2,981	2,981	5,179	16,762,801	3,572	40	48	1
	II	6	17,434	10944.77	425.3143	10603.23	-6,831	6,831	-1,651	21,745,564	4,115	39	46	0
	III	7	11,471	11375.13	425.5666	11370.09	-101	101	-1,752	18,640,510	3,541	1	40	0
	IV	8	3,967	11409.01	405.9823	11800.7	7,834	7,834	6,081	23,981,298	4,078	197	59	1
2004	I	9	9,575	11703	400.3824	11815	2,240	2,240	8,321	21,874,218	3,874	23	55	2
	II	10	27,396	12868.01	438.6139	12103.38	-15,293	15,293	-6,971	43,073,226	5,016	56	55	-1
	III	11	13,337	13308.14	438.6899	13306.62	-30	30	-7,002	39,157,562	4,562	0	50	-2
	IV	12	5,530	13335.99	418.1478	13746.83	8,217	8,217	1,215	41,520,792	4,867	149	59	0
2005	I	13	7,070	13419.93	401.4374	13754.14	6,684	6,684	7,899	41,763,631	5,007	95	61	2
	II	14	26,455	14453.05	433.0215	13821.37	-12,634	12,634	-4,734	50,181,132	5,552	48	60	-1
	III	15	10,969	14690.22	423.2288	14886.07	3,917	3,917	-817	47,858,620	5,443	36	59	0
	IV	16	7,040	14709.77	403.0452	15113.45	8,073	8,073	7,256	48,941,240	5,607	115	62	1
2006	I	17	15,517	15133.03	404.0557	15112.82	-404	404	6,852	46,071,953	5,301	3	59	1
	II	18	33,268	16423.63	448.383	15537.08	-17,731	17,731	-10,879	60,978,254	5,991	53	58	-2
	III	19	16,553	16856.06	447.5854	16872.01	319	319	-10,560	57,774,229	5,693	2	55	-2
	IV	20	6,692	16773.07	421.0563	17303.65	10,612	10,612	52	60,515,871	5,939	159	61	0
2007	I	21				17194.12								
	II	22				17194.12								
	III	23				17194.12								
	IV	24				17194.12								

Figure 3.9: Demand vs. Forecast for Black Plastic using Holt's Method



As we can see from Figures 3.8 and 3.9 above, the forecast does not very accurately represent actual demand. The high % error, MAPE, and MAD in Tables 3.7 and 3.8 confirm that this is not an accurate forecasting method for this data set.

Winter's Model

We now forecast demand using Level, Trend, and seasonality corrected exponential smoothing. Our assumption is that the data has Level, L, Trend, T, and seasonality, S.

Process:

Step 1: We find initial level, trend, and seasonality using the static forecasting method. Running a regression between de-seasonalized demand and time we obtain (rounding to nearest whole number):

Black Plastic:

$L_0 = 5247$

$T_0 = 455$

Clear Plastic:

$L_0 = 7293$

$T_0 = 528$

The initial seasonality (S_1 through S_4) is obtained from the average seasonal factor (obtained in Static Forecasting)

	Black Plastic	Clear Plastic	
Step 2: Initial Forecast $F_1 = (L_0 + T_0)(S_1) =$	5132.54	5971.586	(1)

3. Adaptation

Let α=0.05, β=0.05, γ=0.05

$$L_{t+1} = \alpha(D_{t+1}/S_{t+1}) + (1-\alpha)(L_t + T_t) \quad (2)$$

$$T_{t+1} = \beta(L_{t+1} - L_t) + (1 - \beta)T_t \quad (3)$$

$$S_{t+p+1} = \gamma(D_{t+1}/L_{t+1}) + (1 - \gamma)S_{t+1} \quad (4)$$

Applying equations (1) through (4) to our spreadsheet yields:

Table 3.9: Demand Forecasting for Black Plastic using Winter's Model

Year	Month	Period, t	Black Plastic Demand, D_t	Level L_t	Trend T_t	Seasonal Factor S_t	Forecast F_t	Error E_t	Absolute Error A_t	$Bias_t$	Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	TS_t
		0		5247	455										
2002	I	1	4,567	5670.586	453.4293	0.90013	5,133	566	566	566	319,835	566	12	12	1
	II	2	3,530	6111.227	452.7899	0.601542	3,684	154	154	719	171,753	360	4	8	2
	III	3	4,909	6586.225	453.9003	0.700467	4,598	-311	311	408	146,768	344	6	8	1
	IV	4	14,627	7095.807	456.6844	1.793899	12,629	-1,998	1,998	-1,589	1,107,803	757	14	9	-2
2003	I	5	7,097	7571.173	457.6185	0.90	6,762	-335	335	-1,924	908,628	673	5	8	-3
	II	6	4,339	7988.727	455.6152	0.60	4,820	481	481	-1,443	795,758	641	11	9	-2
	III	7	6,970	8518.062	459.3012	0.70	5,934	-1,036	1,036	-2,479	835,427	697	15	10	-4
	IV	8	14,168	8920.467	456.4564	1.81	16,225	2,057	2,057	-422	1,259,667	867	15	10	0
2004	I	9	8,322	9371.703	456.1954	0.90	8,416	94	94	-329	1,120,680	781	1	9	0
	II	10	5,612	9806.138	455.1074	0.60	5,872	260	260	-69	1,015,373	729	5	9	0
	III	11	5,200	10115.16	447.8032	0.71	7,270	2,070	2,070	2,001	1,312,592	851	40	12	2
	IV	12	16,563	10495.84	444.4471	1.80	18,974	2,411	2,411	4,413	1,687,812	981	15	12	4
2005	I	13	11,036	11008.43	447.8539	0.90	9,814	-1,222	1,222	3,190	1,672,920	1,000	11	12	3
	II	14	8,845	11625.21	456.3006	0.60	6,831	-2,014	2,014	1,176	1,843,289	1,072	23	13	1
	III	15	8,715	12101.04	457.2767	0.70	8,442	-273	273	903	1,725,365	1,019	3	12	1
	IV	16	24,160	12606.99	459.7107	1.79	22,422	-1,738	1,738	-835	1,806,382	1,064	7	12	-1
2006	I	17	11,381	13044.04	458.5776	0.90	11,790	409	409	-426	1,709,963	1,025	4	11	0
	II	18	7,474	13445.73	455.7331	0.60	8,162	688	688	261	1,641,243	1,006	9	11	0
	III	19	9,782	13905.26	455.9232	0.70	9,729	-53	53	208	1,555,011	956	1	11	0
	IV	20	26,254	14375.68	456.6478	1.79	25,735	-519	519	-311	1,490,747	934	2	10	0
2007	I	21				0.90	13,361								
	II	22				0.60	8,929.47								
	III	23				0.70	10,382.93								
	IV	24				1.79	26,604.35								

Figure 3.10: Demand vs. Forecast of Black Plastic using Winter's Model

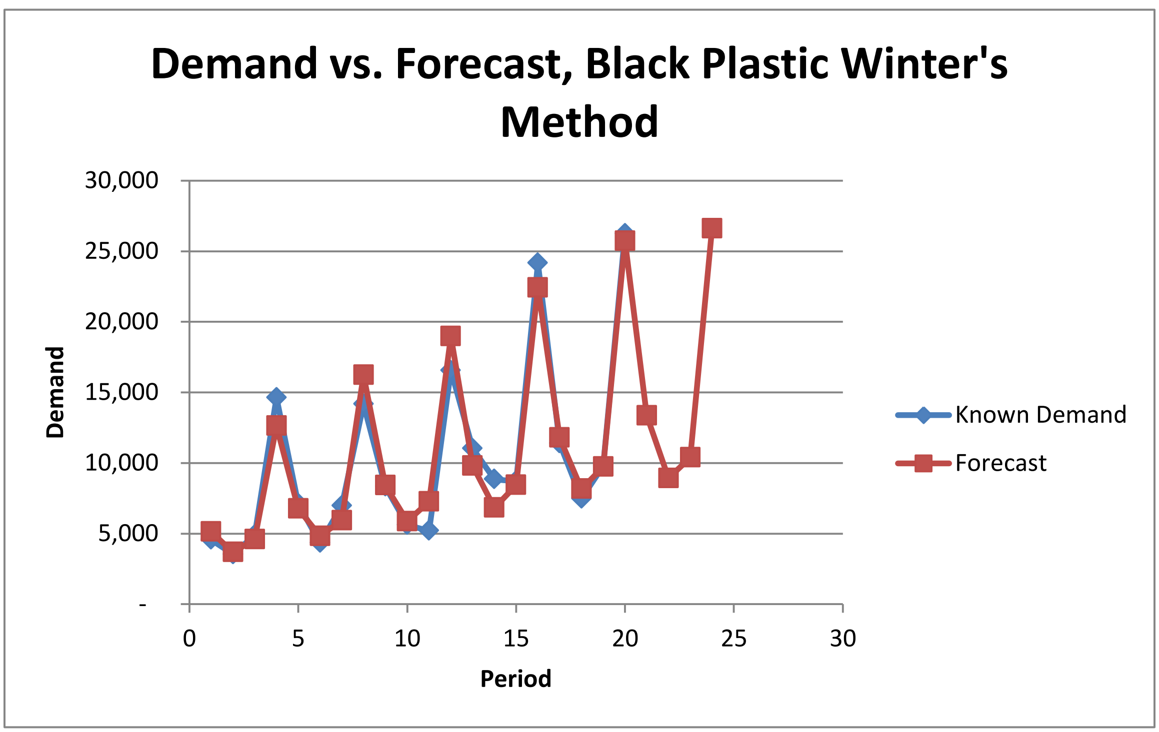
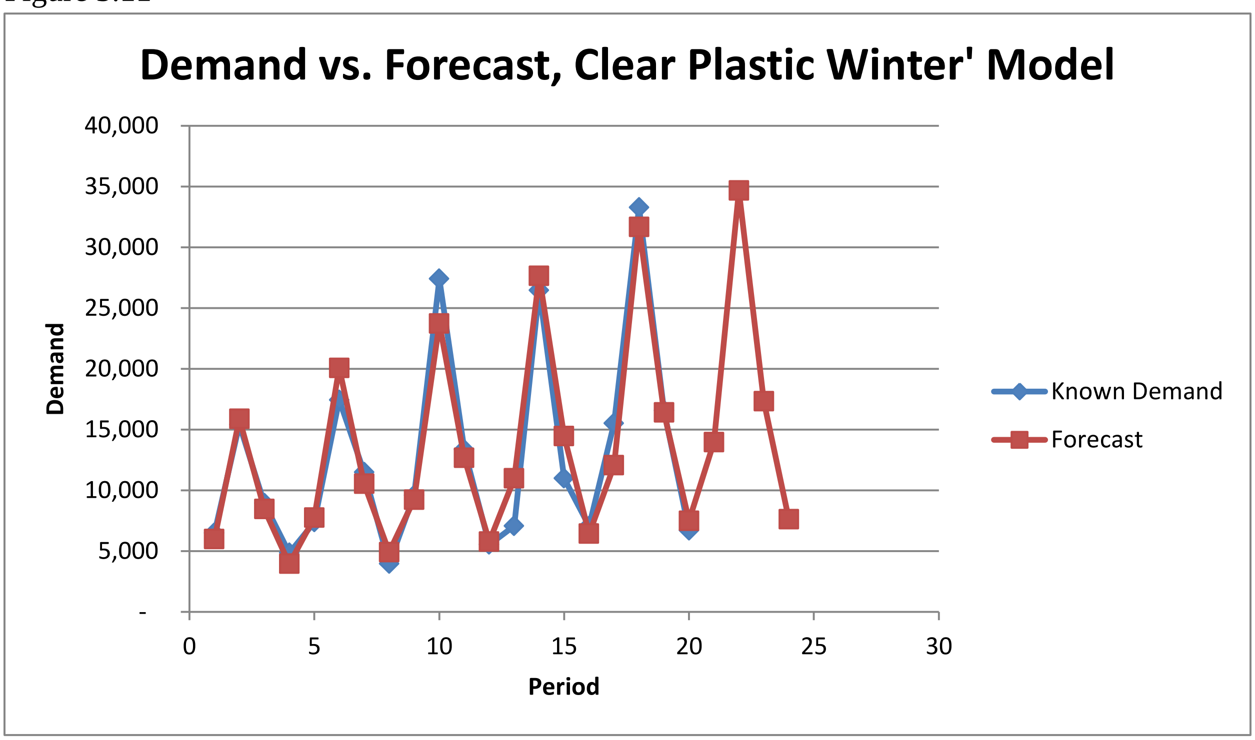


Table 3.10: Demand Forecasting for Clear Plastic using Winter's Model

Year	Month	Period, t	Clear Plastic Demand, D_t	Level L_t	Trend T_t	Seasonal Factor S_t	Forecast F_t	Error E_t	Absolute Error A_t	$Bias_t$	Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	TS_t
		0		7293	528										
2002	I	1	6,478	7854.163	529.6581	0.763532	5971.5864	-506	506	-506	256,455	506	8	8	-1
	II	2	15,403	8371.148	529.0245	1.894501	15883.161	480	480	-26	243,505	493	3	5	0
	III	3	8,918	8925.229	530.2773	0.948593	8442.6376	-475	475	-502	237,660	487	5	5	-1
	IV	4	4,837	9562.268	535.6154	0.417316	3945.9328	-891	891	-1,393	376,745	588	18	9	-2
2003	I	5	7,363	10073.23	534.3827	0.77	7740.9869	378	378	-1,015	329,971	546	5	8	-2
	II	6	17,434	10538.02	530.9029	1.89	20067.237	2,633	2,633	1,619	1,430,631	894	15	9	2
	III	7	11,471	11118.5	533.3818	0.95	10527.897	-943	943	675	1,353,319	901	8	9	1
	IV	8	3,967	11539.6	527.7676	0.42	4914.0888	947	947	1,623	1,296,276	907	24	11	2
2004	I	9	9,575	12089.97	528.8978	0.76	9229.2717	-346	346	1,277	1,165,526	844	4	10	2
	II	10	27,396	12716.57	533.7832	1.88	23722.298	-3,674	3,674	-2,397	2,398,583	1,127	13	10	-2
	III	11	13,337	13286	535.5654	0.96	12656.098	-681	681	-3,078	2,222,678	1,087	5	10	-3
	IV	12	5,530	13792.22	534.098	0.42	5775.2543	245	245	-2,833	2,042,467	1,017	4	9	-3
2005	I	13	7,070	14071.39	521.3515	0.77	10976.407	3,906	3,906	1,074	3,059,201	1,239	55	13	1
	II	14	26,455	14561.63	519.796	1.89	27633.244	1,178	1,178	2,252	2,939,848	1,235	4	12	2
	III	15	10,969	14900.09	510.7295	0.96	14441.757	3,473	3,473	5,725	3,547,861	1,384	32	14	4
	IV	16	7,040	15484.41	514.4088	0.42	6426.2989	-614	614	5,111	3,349,659	1,336	9	13	4
2006	I	17	15,517	16229.24	525.9301	0.75	12046.858	-3,470	3,470	1,641	3,860,966	1,461	22	14	1
	II	18	33,268	16797.62	528.0524	1.89	31663.701	-1,604	1,604	37	3,789,456	1,469	5	13	0
	III	19	16,553	17333.81	528.4592	0.95	16399.01	-154	154	-117	3,591,259	1,400	1	13	0
	IV	20	6,692	17767.95	523.7432	0.42	7482.1757	790	790	673	3,442,915	1,369	12	13	0
2007	I	21				0.76	13,959.13								
	II	22				1.89	34,650.37								
	III	23				0.95	17,321.08								
	IV	24				0.42	7,623.41								

Figure 3.11



Analyzing all of the above figures and tables, we conclude that Julie should use Winter's forecasting method to forecast both black and clear plastic. We arrive at this conclusion from observing that this method yields the lowest values of MAD and MAPE for both types of plastics. This is also verified visually in Figures 3.11 and 3.10. Intuitively this result also makes sense seeing as Winter's method corrects for level, trend, and seasonality. Interestingly, the basic method of static forecasting is almost as good a forecast for this data set. Upon analyzing the data we can see that this too makes sense since the greatest factor in the data is seasonality and that there is not a very significant trend.

Taking our results from Tables 3.9 and 3.10, the demand forecast for each quarter of 2007 is as follows:

2007 Demand Forecast for Black Plastic ('000 lb.):

Year	Quarter	Demand Forecast
2007	I	13,361
	II	8,929
	III	10,383
	IV	26,604

2007 Demand Forecast for Clear Plastic ('000 lb.):

Year	Quarter	Demand Forecast
2007	I	13,959
	II	34,650
	III	17,321
	IV	7,623

Step 4: Check work

Our calculations are checked by hand on the following five pages.

Step 5: Learn and Generalize

Before performing any forecasting, one must first understand the data by plotting it and visually interpreting any level, trend, or seasonality which may exist. Also, it is important to perform all methods of forecasting available so as to obtain the most accurate forecast possible.

Problem 4: Cycle Inventory for Polystyrene and SPC

Structured Problem Solving

Step 1: Define the problem

Why should SPC have a cycle inventory? SPC buys polystyrene resin from a supplier in 1000-pound units, and each unit costs $50.00, and the percent holding cost is 12%. The fixed shipping cost per order is $250. If we assume that 1000 pounds of resin yields 1000 pounds of clear plastic, what are the following values for clear plastic:

a) Lot size per shipment to minimize total cost
b) Economic order quantity (EOQ)
c) Number of shipments/year of polystyrene resin in order to meet the forecasted demand for clear plastic in 2007.
d) Cycle inventory
e) Cycle inventory holding cost
f) Replenishment cycle time
g) Average flow time

Read section on Short-Term Discounting in text. If the supplier offers a promotional discount of 25% per unit at the beginning of the year, what is the optimal order quantity, and how much should the forward buy on polystyrene be?

Step 2: Plan

- identify and state why SPC should have a cycle inventory
- given the numbers presented in the question, calculate the values a-g
- create a diagram showing clear plastic inventory as a function of time to illustrate these values.
- read section in text on Short-Term Discounting
- identify the optimal order quantity and how much the forward buy on polystyrene be if the supplier offers a promotional discount of 25% per unit at the beginning of the year.

Step 3: Execute

SPC should have a cycle inventory to minimize their total inventory costs. By calculating the optimal quantity of inventory to receive from a supplier per shipment, SPC can minimize the total cost of transportation and holding inventory.

We now calculate values (a) through (g) as listed in the problem definition. All calculations are shown by hand on the following two pages.

Summary of Calculations (answers to (a) through (g)):

a) Lot size per shipment to minimize total cost = 2,476 units/shipment
b) EOQ = 2,476 units
c) Number of shipments per year = 30 shipments/year
d) Cycle inventory = 1,238 units
e) Cycle inventory holding cost = $7,428/year
f) Replenishment cycle time, T, = 12 days
g) Average flow time = 6 days

Now, if the supplier offers a promotional discount of 25% per unit at the beginning of the year, we determine the optimal order quantity and the size of the forward buy below:

Problem 5: Safety Inventory for Polystyrene Resin at SPC

Structured Problem Solving

Step 1: Define the problem

Should SPC have a safety inventory? Why? How much safety inventory would you recommend for SPC?

Step 2: Plan

- do some brief studying on safety inventory
- determine if SPC should have a safety inventory and why
- give a recommendation for how much safety inventory SPC should have

Step 3: Execute

Referring back to our earlier Tables 3.9 and 3.10, we see that the forecast for both clear and black plastic does not contain a significant bias. That being said, SPC should still hold safety inventory because there is always uncertainty in forecasting and it is more costly to run a backlog then keep low levels of added inventory. After considering the tracking signal and % error for both our forecast of clear and black plastic, I would recommend that SPC keep a safety inventory of 5-7% of total demand for both black and clear plastic. These rough estimates come from a tight tracking signal for both products, and correspond to the MAPE of each.

Step 4: Check work

After understanding the definition of safety inventory and using our forecasts of demand for black and clear plastic, my estimates of amount of safety inventory that SPC should hold seem reasonable, as do my justifications for holding safety inventory.

Step 5: Learn and Generalize

Even with a basic understanding of safety inventory, a manager can still arrive at a reasonable estimate for the amount of safety inventory to have.

Problem 6: Execution of Your Plan

On the following page, I use a table to compare my plan from Problem 1 with its execution. Included are reasons for differences between the plan and execution, as well as how things could have been done differently to better follow the plan in the future.

Table 6.1: Execution of Plan

Plan of each problem	Execution	Reasons for difference	What could be changed
Problem 2: 1.5 hrs, finish by 3pm Saturday	Finished on time	No difference, plan was well executed and work done accurately	Nothing needs to be changed for this type of problem in the future
Problem 3: 5 hrs, finish Saturday night	Completed Winter's model Sunday, not done on time	A few errors in forecasting that had to be changed, took me longer to create spreadsheets then I first expected	In the future I should automate to process of forecasting using Visual Basic. Would save a tremendous amount of time and eliminate lost time due to error correction
Problem 4: Finish by Sunday night, 1.5 hrs	Completed on time	Despite backlog from Problem 3, this was done on time since it did not take me as long to execute as I planned. Also, I was working harder to make up for previous lost time	Was executed well, but now I know that this type of problem does not take an excessive amount of time and can implement that fact into future project plans.
Problem 5: 15 minutes, finish by Monday afternoon	Completed on time	No difference due to being on schedule going into this phase of the project	Although this was done as planned, in the future I will have a better understanding of safety inventory and will be able to give a more sophisticated answer.