PART 1

1. What are the characteristics of the situation that are important for forecasting? In particular,

a) Who prepares the forecast? Who uses the forecast?

According to the case, Connors and Rick Fields (Sales / Marketing Department Manager) will develop the quarterly demand forecasts for each product family - including PVB. Recently, Barge (newly promoted inventory manager) will also participate in the forecast.

The forecasts, generated by the sales / marketing department, are most likely used by the team to determine the optimal level of promotion effort to attract “fire protection and municipal waterworks customers as opportunities for growth.” By having a demand forecast of each product family, they can focus their effort and allocate resources accordingly.

b) If the forecast is inaccurate, what are the consequences?

If the forecast is inaccurate, the negative consequence is that there will either be an over / under resource allocation to cater to the demand forecasted figure. Forecasts are necessary because of implementation lead time. With poor forecasting, it will reduce profitability and productivity for the company. There may be additional waste such as inventory shortages and excess, lost sales, lost customers, and missed strategic opportunities.

2. Carry out a demand forecast for the PVB product family for the next three quarters, following the steps below.

a) Decompose the time series according to the multiplicative model and additive model.

<u>Multiplicative Model</u>

	QTR	Time Series	PVB	SMA(4)	CMA (2)	Primary SI	Unadjusted SI	Final SI	Deseasonal	Trend	Fit	Error
2002	1	1	27512					0.58	47788.45	44067.59	25369.88	2142.12
	2	2	45798	48534.00				0.97	47014.38	46128.02	44934.57	863.43
	3	3	76968	49301.00	48917.50	1.57	1.58	1.56	49205.94	48188.45	75376.43	1591.57
	4	4	43858	51151.00	50226.00	0.87	0.89	0.89	49502.95	50248.88	44518.87	-660.87
2003	1	5	30580	54085.00	52618.00	0.58	0.58	0.58	53117.58	52309.31	30114.67	465.33
	2	6	53198	56018.00	55051.50	0.97	0.98	0.97	54610.93	54369.74	52963.05	234.95
	3	7	88704	57216.00	56617.00	1.57	1.58	1.56	56708.82	56430.17	88268.14	435.86
	4	8	51590	58376.50	57796.25	0.89	0.89	0.89	58230.13	58490.6	51820.77	-230.77
2003	1	9	35372	59547.50	58962.00	0.60	0.58	0.58	61441.31	60551.03	34859.46	512.54
	2	10	57840	61376.50	60462.00	0.96	0.98	0.97	59376.22	62611.46	60991.54	-3151.54
	3	11	93388	62379.00	61877.75	1.51	1.58	1.56	59703.32	64671.89	101159.85	-7771.85
	4	12	58906	66723.75	64551.38	0.91	0.89	0.89	66487.77	66732.32	59122.66	-216.66
2004	1	13	39382	74093.75	70408.75	0.56	0.58	0.58	68406.69	68792.75	39604.26	-222.26
	2	14	75219	73116.25	73605.00	1.02	0.98	0.97	77216.80	70853.18	69020.03	6198.97
	3	15	122868	75310.50	74213.38	1.66	1.58	1.56	78549.99	72913.61	114051.56	8816.44
	4	16	54996					0.89	62074.52	74974.04	66424.56	-11428.56
2005	1	17	48159					0.58	83652.38	77034.47	44349.05	3809.95

Average Unadjusted SI	1.0077	
Regression Line	=2060.43t + 42007.16	

Logistic Regression

- Derived from Deseasonal (y-axis) and Time Series Period (x-axis) with Excel Data Analysis regression
  - $y = 2060.43t + 42007.16$

SUMMARY OUTPUT

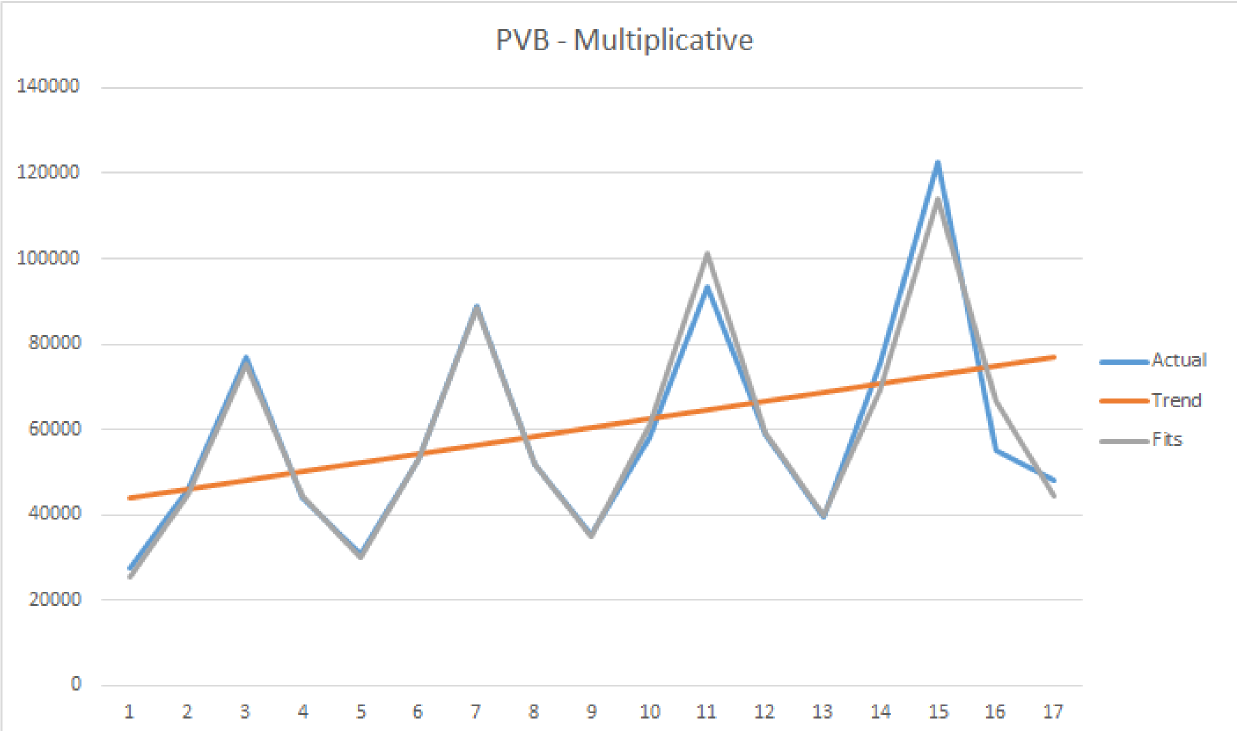
Regression Statistics	
Multiple R	0.904255461
R Square	0.817677939
Adjusted R Square	0.804654934
Standard Error	4794.700232
Observations	16

ANOVA

	df	SS	MS	F	Significance F
Regression	1	1443424304	1443424304	62.78719676	1.5305E-06
Residual	14	321848104.4	22989150.31		
Total	15	1765272408			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	42007.16169	2745.740155	15.29903025	3.91856E-10	36118.13476	47896.18863	36118.13476	47896.18863
1	2060.428499	260.0291291	7.92383725	1.5305E-06	1502.721485	2618.135514	1502.721485	2618.135514

Chart



Additive Model

QTR		Time Series	PVB	SMA(4)	CMA (2)	Primary SI	Unadjusted SI	Final SI	Deseasonal	Trend	Fit	Error
2002	1	1	27512					-26175.83	53687.83	43769.52	17593.69	9918.31
	2	2	45798	48534.00				-1578.08	47376.08	45802.71	44224.63	1573.37
	3	3	76968	49301.00	48917.50	28050.5	35075.59	34451.35	42516.65	47835.9	82287.25	-5319.25
	4	4	43858	51151.00	50226.00	-6368.0	-6073.21	-6697.45	50555.45	49869.09	43171.64	686.36
2003	1	5	30580	54085.00	52618.00	-22038.0	-25551.58	-26175.83	56755.83	51902.28	25726.45	4853.55
	2	6	53198	56018.00	55051.50	-1853.5	-953.83	-1578.08	54776.08	53935.47	52357.39	840.61
	3	7	88704	57216.00	56617.00	32087.0	35075.59	34451.35	54252.65	55968.66	90420.01	-1716.01
	4	8	51590	58376.50	57796.25	-6206.3	-6073.21	-6697.45	58287.45	58001.85	51304.40	285.60
2003	1	9	35372	59547.50	58962.00	-23590.0	-25551.58	-26175.83	61547.83	60035.04	33859.21	1512.79
	2	10	57840	61376.50	60462.00	-2622.0	-953.83	-1578.08	59418.08	62068.23	60490.15	-2650.15
	3	11	93388	62379.00	61877.75	31510.3	35075.59	34451.35	58936.65	64101.42	98552.77	-5164.77
	4	12	58906	66723.75	64551.38	-5645.4	-6073.21	-6697.45	65603.45	66134.61	59437.16	-531.16
2004	1	13	39382	74093.75	70408.75	-31026.8	-25551.58	-26175.83	65557.83	68167.8	41991.97	-2609.97
	2	14	75219	73116.25	73605.00	1614.0	-953.83	-1578.08	76797.08	70200.99	68622.91	6596.09
	3	15	122868	75310.50	74213.38	48654.6	35075.59	34451.35	88416.65	72234.18	106685.53	16182.47
	4	16	54996					-6697.45	61693.45	74267.37	67569.92	-12573.92
2005	1	17	48159					-26175.83	74334.83	76300.56	50124.73	-1965.73

Average Unadjusted SI	624.24
Regression Line	=2033.19t + 41736.33

Logistic Regression

- Derived from Deseasonal (y-axis) and Time Series Period (x-axis) with Excel Data Analysis regression
  - y = 2033.19t + 41736.33

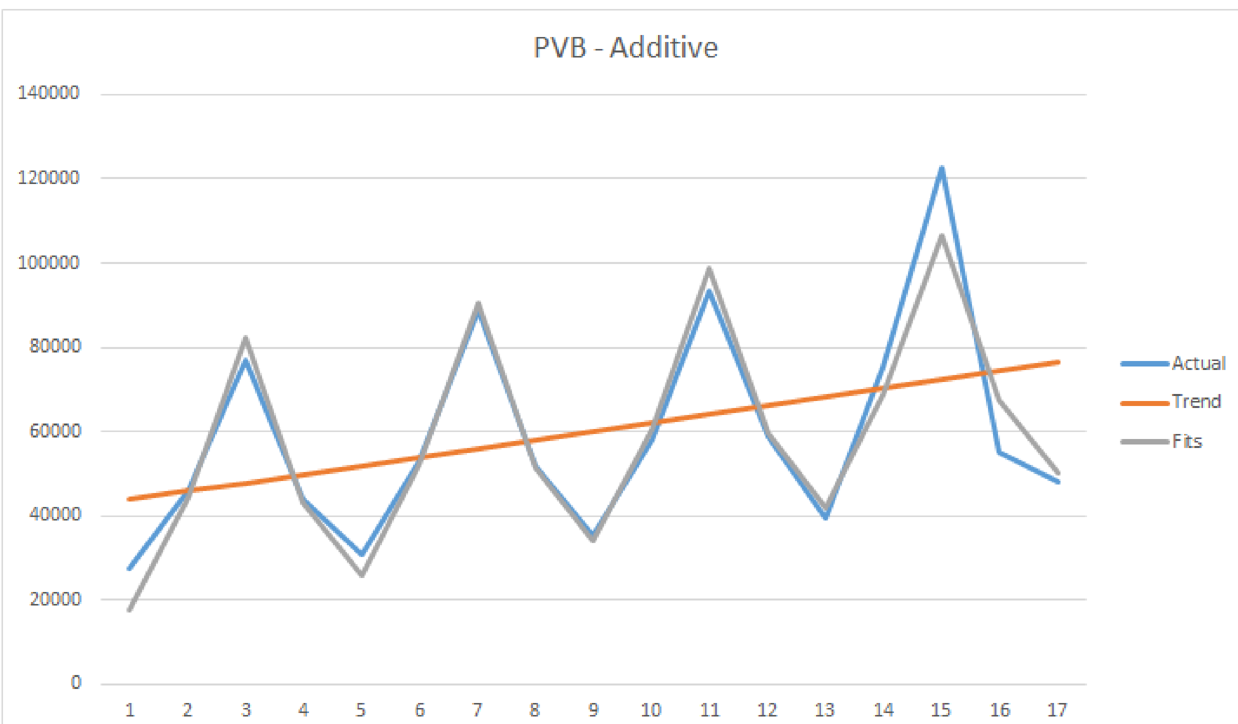
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.843707218
R Square	0.71184187
Adjusted R Square	0.691259147
Standard Error	6374.949778
Observations	16

ANOVA

	df	SS	MS	F	Significance F
Regression	1	1405510920	1405510920	34.58443528	3.99866E-05
Residual	14	568959785.4	40639984.67		
Total	15	1974470705			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	41736.33385	3650.688207	11.43245643	1.73761E-08	33906.38639	49566.28132	33906.38639	49566.28132
1	2033.188542	345.7301935	5.880853278	3.99866E-05	1291.671025	2774.706058	1291.671025	2774.706058



b) Find the seasonal indexes and trends for both models.

Multiplicative Model

Primary SI	Unadjusted SI	Final SI	Deseasonal	Trend
		0.58	47788.45	44067.59
		0.97	47014.38	46128.02
1.57	1.58	1.56	49205.94	48188.45
0.87	0.89	0.89	49502.95	50248.88
0.58	0.58	0.58	53117.58	52309.31
0.97	0.98	0.97	54610.93	54369.74
1.57	1.58	1.56	56708.82	56430.17
0.89	0.89	0.89	58230.13	58490.6
0.60	0.58	0.58	61441.31	60551.03
0.96	0.98	0.97	59376.22	62611.46
1.51	1.58	1.56	59703.32	64671.89
0.91	0.89	0.89	66487.77	66732.32
0.56	0.58	0.58	68406.69	68792.75
1.02	0.98	0.97	77216.80	70853.18
1.66	1.58	1.56	78549.99	72913.61
		0.89	62074.52	74974.04
		0.58	83652.38	77034.47

Additive Model

Primary SI	Unadjusted SI	Final SI	Deseasonal	Trend
		-26175.83	53687.83	43769.52
		-1578.08	47376.08	45802.71
28050.5	35075.59	34451.35	42516.65	47835.9
-6368.0	-6073.21	-6697.45	50555.45	49869.09
-22038.0	-25551.58	-26175.83	56755.83	51902.28
-1853.5	-953.83	-1578.08	54776.08	53935.47
32087.0	35075.59	34451.35	54252.65	55968.66
-6206.3	-6073.21	-6697.45	58287.45	58001.85
-23590.0	-25551.58	-26175.83	61547.83	60035.04
-2622.0	-953.83	-1578.08	59418.08	62068.23
31510.3	35075.59	34451.35	58936.65	64101.42
-5645.4	-6073.21	-6697.45	65603.45	66134.61
-31026.8	-25551.58	-26175.83	65557.83	68167.8
1614.0	-953.83	-1578.08	76797.08	70200.99
48654.6	35075.59	34451.35	88416.65	72234.18
		-6697.45	61693.45	74267.37
		-26175.83	74334.83	76300.56

See answer for part a for more detail.

c) Use both models to do forecasting.

Yellow highlighted cells contain the next 3 quarters forecasting (calculated based on Final Seasonal Index and Trend).

<u>Multiplicative Model</u>

	QTR	Time Series	PVB	SMA(4)	CMA (2)	Primary SI	Unadjusted SI	Final SI	Deseasonal	Trend	Fit	Error
2005	2	18						0.97		79094.9	77048.51	
	3	19						1.56		81155.33	126943.27	
	4	20						0.89		83215.76	73726.45	

- 2005 - Q2: 77048.51, Q3: 126943.27, Q4: 72726.45

<u>Additive Model</u>

	QTR	Time Series	PVB	SMA(4)	CMA (2)	Primary SI	Unadjusted SI	Final SI	Deseasonal	Trend	Fit	Error
2005	2	18						-1578.08		78333.75	76755.67	
	3	19						34451.35		80366.94	114818.29	
	4	20						-6697.45		82400.13	75702.68	

- 2005 - Q2: 76755.67, Q3: 114818.29, Q4: 75702.68

d) Which model is better? Explain your reasons briefly.

Comparison of the Errors:

Multiplicative Model

Error	| Error |	APE	Error^2
2142.12	2142.12	7.79	4588660.96
863.43	863.43	1.89	745512.82
1591.57	1591.57	2.07	2533083.35
-660.87	660.87	1.51	436749.72
465.33	465.33	1.52	216527.87
234.95	234.95	0.44	55199.34
435.86	435.86	0.49	189971.85
-230.77	230.77	0.45	53252.86
512.54	512.54	1.45	262692.22
-3151.54	3151.54	5.45	9932204.68
-7771.85	7771.85	8.32	60401669.77
-216.66	216.66	0.37	46942.07
-222.26	222.26	0.56	49397.44
6198.97	6198.97	8.24	38427284.89
8816.44	8816.44	7.18	77729617.19
-11428.56	11428.56	20.78	130611905.16
3809.95	3809.95	7.91	14515750.90

MAD	2867.86154
MAPE	449.463083
MSE	20046848.42

Additive Model

Error	| Error |	APE	Error^2
9918.31	9918.305521	36.0508	98372784.40
1573.37	1573.365521	3.43545	2475479.06
-5319.25	5319.251562	6.91099	28294437.19
686.36	686.3605208	1.56496	471090.76
4853.55	4853.545521	15.8716	23556904.12
840.61	840.6055208	1.58014	706617.64
-1716.01	1716.011563	1.93454	2944695.68
285.60	285.6005208	0.5536	81567.66
1512.79	1512.785521	4.27679	2288520.03
-2650.15	2650.154479	4.58187	7023318.76
-5164.77	5164.771563	5.53044	26674865.29
-531.16	531.1594792	0.90171	282130.39
-2609.97	2609.974479	6.62733	6811966.78
6596.09	6596.085521	8.76917	43508344.20
16182.47	16182.46844	13.1706	261872284.73
-12573.92	12573.91948	22.8633	158103451.07
-1965.73	1965.734479	4.08176	3864112.04

MAD	4410.594099
MAPE	815.9127348
MSE	39254857.05

Conclusion:

Multiplicative models are better at forecasting. Based on the chart above, the seasonal variation seems to be proportional to the smooth level trend - when the smooth level is larger, seasonal variation is also larger. This is confirmed by the error forecasting analysis. The Mean Absolute Deviation (MAD), Mean Absolute Percentage Error (MAPE), and Mean Squared Error (MSE) are all lower in the Multiplicative Model.

PART 2

1. Please comment on the pros and cons of the forecasting method by Wilkins.

Wilkins forecasts the demand for each product family by looking at the disaggregated family data - only the previous year data (by quarters) is considered. It calculates a proportion of units sales per product family and uses the aggregated product demand to deduce the respective product family demand.

The pros of using this method is that at the aggregated level, the forecasts are decently accurate. They are able to forecast the annual demand for the product by aggregating the quarterly expected demand.

However, the cons is that at the disaggregated level the accuracy of the forecast is greatly reduced. This is mainly due to having unequal weighting for each product family. Those with a higher proportion will skew the product forecast at the aggregated level, so that when it is disaggregated, the forecasts are inaccurate. Furthermore, based on their forecasting method, another possible con is that they did not consider the seasonality when they aggregate the forecast for product demand. They are only able to produce a forecast for the 12-month demand, yet the forecast per quarter is critical for business decisions. Seasonality plays a huge role in forecasting the quarterly demand, which was ignored by Wilkins forecasting methods.

2. Use one of the two procedures to determine the starting values for Winters' method

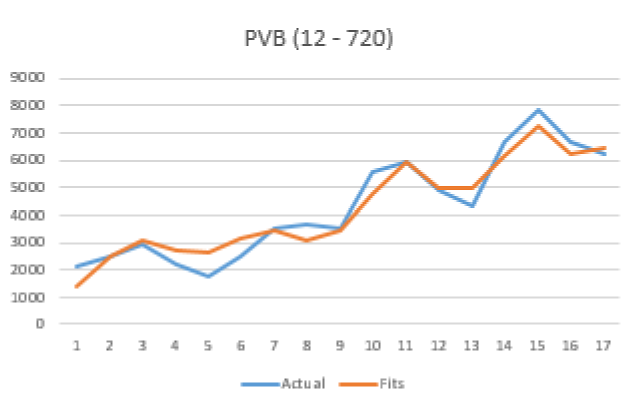
The starting values $\{S_0, B_0, I_{-3}, I_{-2}, I_{-1}, I_0\}$ are all determined by procedure 2 - by running a least square regression on the time series.

Starting Values	PVB (12-720)	PVB (34-720)	PVB (1-720)	PVB (34-420)	PVB (1-420)
S_0	1264.04	8355.57	21654.40	8086.77	3621.23
B_0	336.34	825.76	531.45	-64.14	159.13
I_{-3}	0.86	0.78	0.43	0.70	0.46
I_{-2}	1.07	1.01	0.92	1.04	1.14
I_{-1}	1.16	1.39	1.86	1.28	1.50
I_{-0}	0.91	0.81	0.80	0.98	0.89

a) Apply the procedure to the multiplicative model for the demand of each product in the PVB product family.

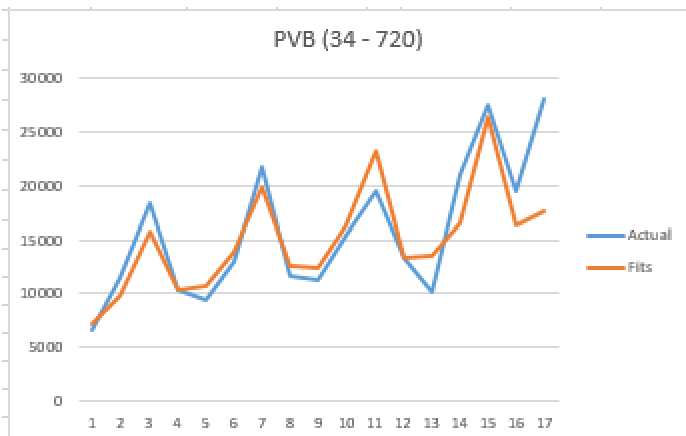
<u>PVB (12-720)</u>

Period (t)	Y	Ŷ	De-Trend	Level (S)	Trend (b)	Seasonal (I)	Fit (F)	Error (e)	APE
-3						0.86			
-2						1.07			
-1						1.16			
0				1264.04	336.34	0.91			
1	2108	1600.37	1.32	2006.26	336.34	0.86	1382.41	725.59	34.42
2	2516	1936.71	1.30	2342.60	336.34	1.07	2516.00	0.00	0.00
3	2954	2273.04	1.30	2620.16	336.34	1.16	3094.51	-140.51	4.76
4	2224	2609.38	0.85	2712.68	336.34	0.91	2681.68	-457.68	20.58
5	1788	2945.72	0.61	2575.90	336.34	0.86	2633.75	-845.75	47.30
6	2512	3282.05	0.77	2635.19	336.34	1.07	3127.80	-615.80	24.51
7	3540	3618.39	0.98	3016.50	336.34	1.16	3432.49	107.51	3.04
8	3666	3954.72	0.93	3685.69	336.34	0.91	3041.18	624.82	17.04
9	3546	4291.06	0.83	4062.17	336.34	0.86	3474.25	71.75	2.02
10	5596	4627.39	1.21	4790.78	336.34	1.07	4724.08	871.92	15.58
11	5948	4963.73	1.20	5137.80	336.34	1.16	5922.48	25.52	0.43
12	4892	5300.07	0.92	5435.08	336.34	0.91	4965.30	-73.30	1.50
13	4311	5636.40	0.76	5394.18	336.34	0.86	4985.38	-674.38	15.64
14	6637	5972.74	1.11	5947.51	336.34	1.07	6154.69	482.31	7.27
15	7823	6309.07	1.24	6519.92	336.34	1.16	7258.64	564.36	7.21
16	6652	6645.41	1.00	7086.96	336.34	0.91	6218.95	433.05	6.51
17	6235	6981.75	0.89	7324.13	336.34	0.86	6412.27	-177.27	2.84



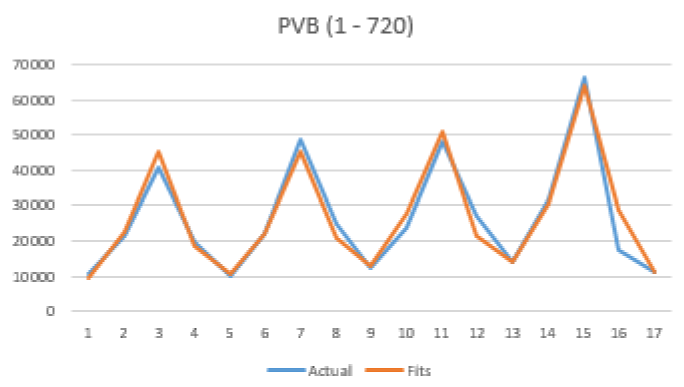
PVB (34-720)

Period (t)	Y	Ŷ	De-Trend	Level (S)	Trend (b)	Seasonal (I)	Fit (F)	Error (e)	APE
-3						0.78			
-2						1.01			
-1						1.39			
0				8355.57	825.76	0.81			
1	6716	9181.33	0.73	8936.15	825.76	0.78	7203.57	-487.57	7.26
2	11510	10007.09	1.15	10418.04	825.76	1.01	9834.62	1675.38	14.56
3	18438	10832.85	1.70	12024.97	825.76	1.39	15677.36	2760.64	14.97
4	10456	11658.61	0.90	12850.73	825.76	0.81	10456.00	0.00	0.00
5	9464	12484.37	0.76	13039.64	825.76	0.78	10730.42	-1266.42	13.38
6	12942	13310.13	0.97	13463.32	825.76	1.01	13968.68	-1026.68	7.93
7	21640	14135.89	1.53	14774.82	825.76	1.39	19923.45	1716.55	7.93
8	11650	14961.65	0.78	15094.61	825.76	0.81	12693.41	-1043.41	8.96
9	11270	15787.41	0.71	15306.40	825.76	0.78	12490.94	-1220.94	10.83
10	15322	16613.17	0.92	15767.81	825.76	1.01	16252.32	-930.32	6.07
11	19424	17438.93	1.11	15543.02	825.76	1.39	23136.63	-3712.63	19.11
12	13310	18264.69	0.73	16364.67	825.76	0.81	13318.46	-8.46	0.06
13	10214	19090.45	0.54	15544.33	825.76	0.78	13487.42	-3273.42	32.05
14	20983	19916.21	1.05	18128.89	825.76	1.01	16492.02	4490.98	21.40
15	27492	20741.97	1.33	19255.53	825.76	1.39	26428.70	1063.30	3.87
16	19535	21567.73	0.91	21630.99	825.76	0.81	16339.15	3195.85	16.36
17	28020	22393.49	1.25	27686.96	825.76	0.78	17619.31	10400.69	37.12



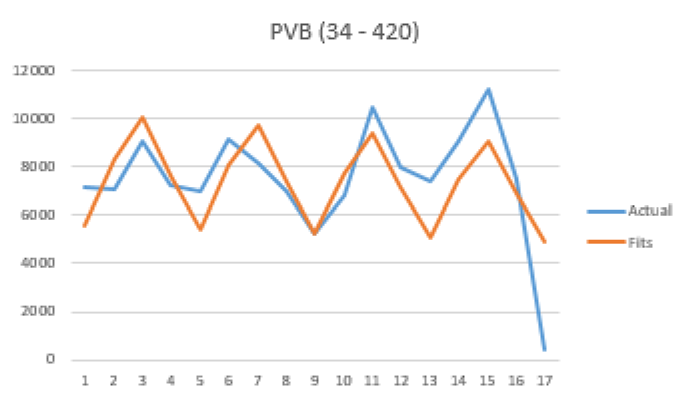
PVB (1-720)

Period (t)	Y	Ŷ	De-Trend	Level (S)	Trend (b)	Seasonal (I)	Fit (F)	Error (e)	APE
-3						0.43			
-2						0.92			
-1						1.86			
0				21654.40	531.45	0.80			
1	10688	22185.84	0.48	24273.27	531.45	0.43	9456.43	1231.57	11.52
2	21688	22717.29	0.95	23957.67	531.45	0.92	22764.01	-1076.01	4.96
3	40814	23248.74	1.76	22684.90	531.45	1.86	45448.81	-4634.81	11.36
4	19510	23780.18	0.82	24059.01	531.45	0.80	18576.69	933.31	4.78
5	9824	24311.63	0.40	23476.26	531.45	0.43	10481.37	-657.37	6.69
6	21848	24843.07	0.88	23862.41	531.45	0.92	22032.57	-184.57	0.84
7	48936	25374.52	1.93	25820.15	531.45	1.86	45272.02	3663.98	7.49
8	24640	25905.97	0.95	29561.00	531.45	0.80	21085.38	3554.62	14.43
9	12400	26437.41	0.47	29369.52	531.45	0.43	12826.52	-426.52	3.44
10	23692	26968.86	0.88	26949.72	531.45	0.92	27440.98	-3748.98	15.82
11	47904	27500.30	1.74	26275.31	531.45	1.86	51001.69	-3097.69	6.47
12	26990	28031.75	0.96	31809.11	531.45	0.80	21449.58	5540.42	20.53
13	13851	28563.20	0.48	32452.84	531.45	0.43	13784.75	66.25	0.48
14	31507	29094.64	1.08	33957.57	531.45	0.92	30270.64	1236.36	3.92
15	66644	29626.09	2.25	35515.38	531.45	1.86	64007.40	2636.60	3.96
16	17337	30157.53	0.57	25658.19	531.45	0.80	28843.07	-11506.07	66.37
17	11163	30688.98	0.36	26189.64	531.45	0.43	11163.00	0.00	0.00



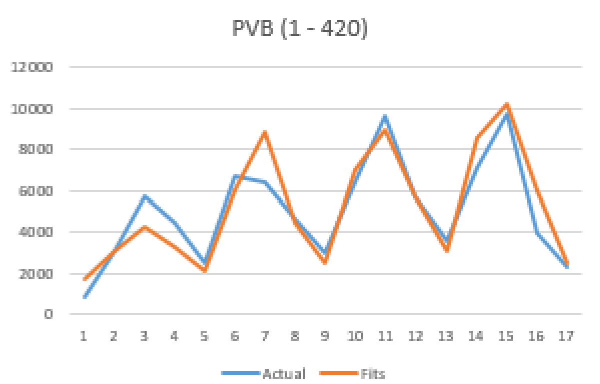
PVB (34-420)

Period (t)	Y	Ŷ	De-Trend	Level (S)	Trend (b)	Seasonal (I)	Fit (F)	Error (e)	APE
-3						0.70			
-2						1.04			
-1						1.28			
0				8086.77	-64.14	0.98			
1	7158	8022.63	0.89	8022.63	-64.14	0.70	5608.32	1549.68	21.65
2	7034	7958.48	0.88	7958.48	-64.14	1.04	8297.15	-1263.15	17.96
3	9026	7894.34	1.14	7894.34	-64.14	1.28	10082.93	-1056.93	11.71
4	7254	7830.19	0.93	7830.19	-64.14	0.98	7682.58	-428.58	5.91
5	6968	7766.05	0.90	7766.05	-64.14	0.70	5428.96	1539.04	22.09
6	9156	7701.90	1.19	7701.90	-64.14	1.04	8029.65	1126.35	12.30
7	8134	7637.76	1.06	7637.76	-64.14	1.28	9755.22	-1621.22	19.93
8	6958	7573.62	0.92	7573.62	-64.14	0.98	7430.84	-472.84	6.80
9	5208	7509.47	0.69	7509.47	-64.14	0.70	5249.59	-41.59	0.80
10	6806	7445.33	0.91	7445.33	-64.14	1.04	7762.16	-956.16	14.05
11	10446	7381.18	1.42	7381.18	-64.14	1.28	9427.50	1018.50	9.75
12	7960	7317.04	1.09	7317.04	-64.14	0.98	7179.09	780.91	9.81
13	7397	7252.89	1.02	7252.89	-64.14	0.70	5070.23	2326.77	31.46
14	9043	7188.75	1.26	7188.75	-64.14	1.04	7494.66	1548.34	17.12
15	11233	7124.60	1.58	7124.60	-64.14	1.28	9099.79	2133.21	18.99
16	7496	7060.46	1.06	7060.46	-64.14	0.98	6927.35	568.65	7.59
17	384	6996.31	0.05	6996.31	-64.14	0.70	4890.86	-4506.86	1173.66



PVB (1-420)

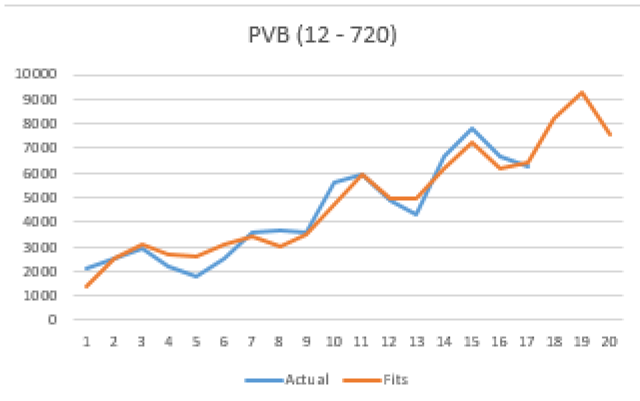
Period (t)	Y	Ŷ	De-Trend	Level (S)	Trend (b)	Seasonal (I)	Fit (F)	Error (e)	APE
-3						0.46			
-2						1.14			
-1						1.50			
0				3621.23	159.13	0.89			
1	842	3780.35	0.22	2517.36	159.13	0.46	1756.10	-914.10	108.56
2	3050	3939.48	0.77	2676.49	159.13	1.14	3050.00	0.00	0.00
3	5736	4098.60	1.40	3467.63	159.13	1.50	4257.52	1478.48	25.78
4	4414	4257.73	1.04	4466.28	159.13	0.89	3244.03	1169.97	26.51
5	2536	4416.85	0.57	5160.60	159.13	0.46	2148.65	387.35	15.27
6	6740	4575.98	1.47	5701.54	159.13	1.14	6062.10	677.90	10.06
7	6454	4735.10	1.36	4858.03	159.13	1.50	8799.47	-2345.47	36.34
8	4676	4894.23	0.96	5152.27	159.13	0.89	4487.69	188.31	4.03
9	2948	5053.35	0.58	5975.55	159.13	0.46	2467.32	480.68	16.31
10	6424	5212.48	1.23	5815.44	159.13	1.14	6990.78	-566.78	8.82
11	9666	5371.60	1.80	6271.88	159.13	1.50	8970.49	695.51	7.20
12	5754	5530.73	1.04	6432.20	159.13	0.89	5752.35	1.65	0.03
13	3609	5689.85	0.63	7347.26	159.13	0.46	3061.88	547.12	15.16
14	7049	5848.98	1.21	6658.76	159.13	1.14	8553.92	-1504.92	21.35
15	9676	6008.10	1.61	6578.21	159.13	1.50	10236.69	-560.69	5.79
16	3976	6167.23	0.64	5266.09	159.13	0.89	6026.34	-2050.34	51.57
17	2357	6326.35	0.37	5199.74	159.13	0.46	2520.19	-163.19	6.92



b) Forecast the demand for each PVB product for the remaining three quarters of 2005 with the starting values found in (a).

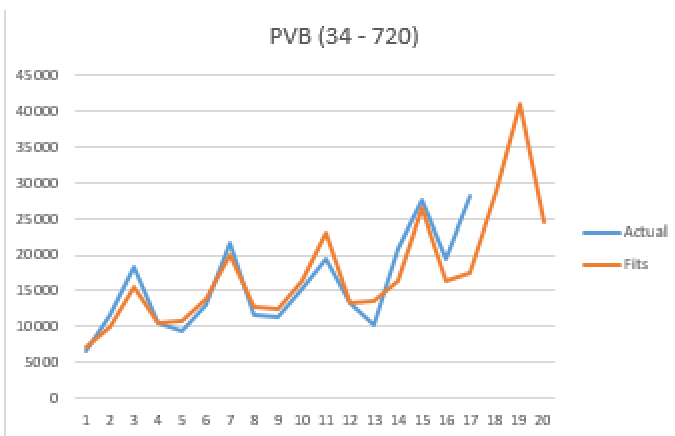
PVB (12-720)

Period	Forecast
2005 Q2	8227.49
2005 Q3	9237.32
2005 Q4	7558.54



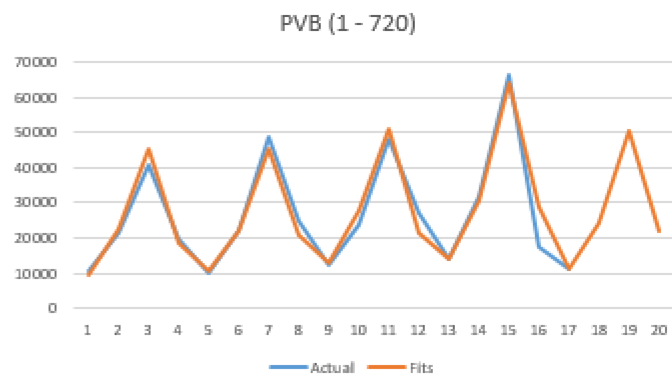
PVB (34-720)

Period	Forecast
2005 Q2	28725.10
2005 Q3	40907.00
2005 Q4	24543.14



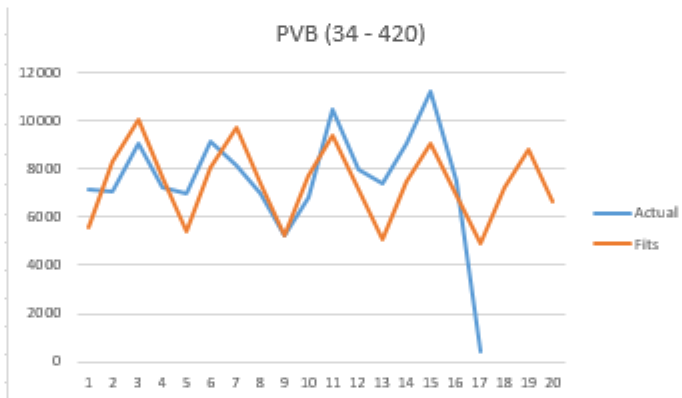
PVB (1-720)

Period	Forecast
2005 Q2	24522.71
2005 Q3	50577.37
2005 Q4	22231.51



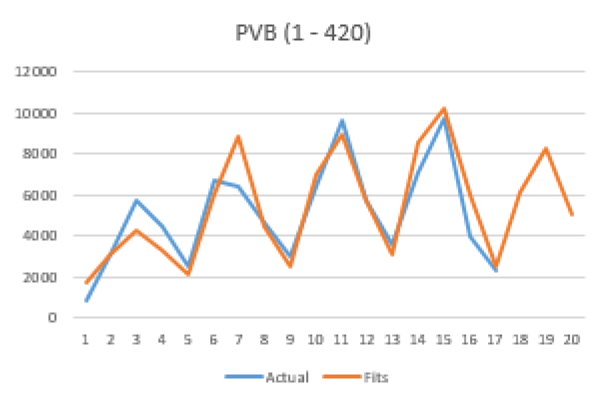
PVB (34-420)

Period	Forecast
2005 Q2	7227.16
2005 Q3	8772.08
2005 Q4	6675.61



PVB (1-420)

Period	Forecast
2005 Q2	6106.71
2005 Q3	8284.96
2005 Q4	5078.01



c) Please explain how you choose the smoothing constants for the Winters' method.

All smoothing constants were optimized by using Excel-Solver to minimize the Mean Absolute Percentage Error (MAPE), while making sure the constants are within the constraints of ($0 \leq x \leq 1$).

Alpha constant (α) is associated with the level of the series, Beta constant (β) is associated with the trend, and Gamma (γ) is associated with the seasonality factors.

The constants closer to 1.00 means that distant observations are ignored, while the constants closer to 0.00 means that the series is fairly stable and going through random fluctuations.

<u>PVB (12-720)</u>

α	β	γ
0.483	0.000	0.000

MAPE	MAD
12.39	405.38

<u>PVB (34-720)</u>

α	β	γ
0.395	0.000	0.000

MAPE	MAD
13.05	2251.37

<u>PVB (1-720)</u>

α	β	γ
0.722	0.000	0.000

MAPE	MAD
10.77	2599.71

PVB (34-420)

α	β	γ
0.000	0.000	0.000

MAPE	MAD
82.45	1349.34

PVB (1-420)

α	β	γ
0.642	0.000	0.000

MAPE	MAD
21.16	807.79

3. Redo Question 2 using the Winters' method with the additive model. Compare the result to that of Question 2 under the multiplicative model.

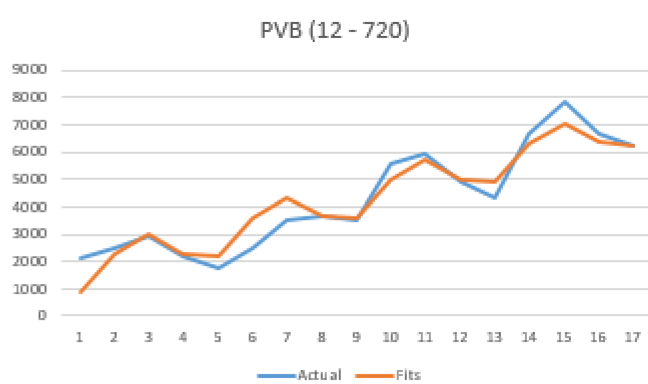
The starting values $\{S_0, B_0, I_{-3}, I_{-2}, I_{-1}, I_0\}$ are all determined by procedure 2 - by running a least square regression on the time series.

Starting Values	PVB (12-720)	PVB (34-720)	PVB (1-720)	PVB (34-420)	PVB (1-420)
S_0	1264.04	8355.57	21654.40	8086.77	3621.23
B_0	336.34	825.76	531.45	-64.14	159.13
I_{-3}	-736.80	-2816.28	-15780.48	-2216.88	-2757.14
I_{-2}	317.19	61.93	-2150.48	305.73	759.34
I_{-1}	731.85	5795.43	23708.83	2069.88	2667.46
I_{-0}	-312.24	-3041.08	-5777.87	-158.73	-669.66

a) Apply the procedure to the additive model for the demand of each product in the PVB product family.

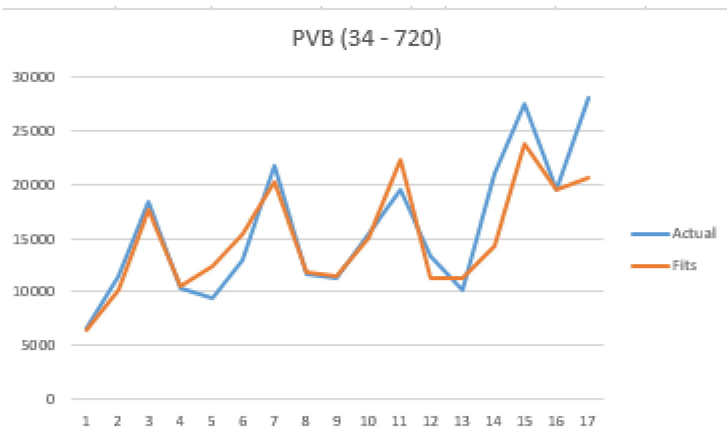
PVB (12-720)

Period (t)	Y	Ŷ	De-Trend	Level (S)	Trend (b)	Seasonal (I)	Fit (F)	Error (e)	APE
-3						-736.80			
-2						317.19			
-1						731.85			
0				1264.04	336.34	-312.24			
1	2108	1600.37	507.63	1600.37	336.34	-736.80	863.57	1244.43	59.03
2	2516	1936.71	579.29	1936.71	336.34	317.19	2253.89	262.11	10.42
3	2954	2273.04	680.96	2273.04	336.34	731.85	3004.89	-50.89	1.72
4	2224	2609.38	-385.38	2609.38	336.34	-312.24	2297.14	-73.14	3.29
5	1788	2945.72	-1157.72	2945.72	336.34	-736.80	2208.92	-420.92	23.54
6	2512	3282.05	-770.05	3282.05	336.34	317.19	3599.24	-1087.24	43.28
7	3540	3618.39	-78.39	3618.39	336.34	731.85	4350.24	-810.24	22.89
8	3666	3954.72	-288.72	3954.72	336.34	-312.24	3642.49	23.51	0.64
9	3546	4291.06	-745.06	4291.06	336.34	-736.80	3554.26	-8.26	0.23
10	5596	4627.39	968.61	4627.39	336.34	317.19	4944.58	651.42	11.64
11	5948	4963.73	984.27	4963.73	336.34	731.85	5695.58	252.42	4.24
12	4892	5300.07	-408.07	5300.07	336.34	-312.24	4987.83	-95.83	1.96
13	4311	5636.40	-1325.40	5636.40	336.34	-736.80	4899.60	-588.60	13.65
14	6637	5972.74	664.26	5972.74	336.34	317.19	6289.92	347.08	5.23
15	7823	6309.07	1513.93	6309.07	336.34	731.85	7040.92	782.08	10.00
16	6652	6645.41	6.59	6645.41	336.34	-312.24	6333.17	318.83	4.79
17	6235	6981.75	-746.75	6981.75	336.34	-736.80	6244.95	-9.95	0.16



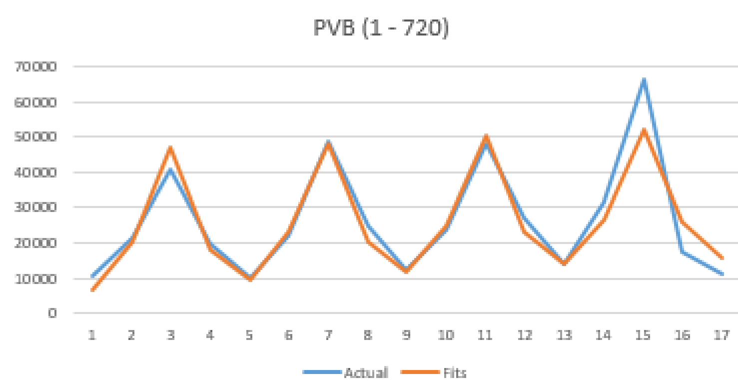
PVB (34-720)

Period (t)	Y	Ŷ	De-Trend	Level (S)	Trend (b)	Seasonal (I)	Fit (F)	Error (e)	APE
-3						-2816.28			
-2						61.93			
-1						5795.43			
0				8355.57	825.76	-3041.08			
1	6716	9181.33	-2465.33	9282.40	926.82	-2697.59	6365.06	350.94	5.23
2	11510	10007.09	1502.91	10565.97	1283.57	480.89	10271.15	1238.85	10.76
3	18438	10832.85	7605.15	12077.92	1511.94	6063.61	17644.97	793.03	4.30
4	10456	11658.61	-1202.61	13563.14	1485.23	-3072.46	10548.77	-92.77	0.89
5	9464	12484.37	-3020.37	14217.05	653.92	-3673.85	12350.77	-2886.77	30.50
6	12942	13310.13	-368.13	14176.99	-40.05	-334.08	15351.86	-2409.86	18.62
7	21640	14135.89	7504.11	14551.47	374.47	6550.41	20200.56	1439.44	6.65
8	11650	14961.65	-3311.65	14867.34	315.87	-3141.27	11853.48	-203.48	1.75
9	11270	15787.41	-4517.41	15114.28	246.94	-3754.80	11509.37	-239.37	2.12
10	15322	16613.17	-1291.17	15446.14	331.85	-234.37	15027.14	294.86	1.92
11	19424	17438.93	1985.07	14941.60	-504.53	5568.19	22328.40	-2904.40	14.95
12	13310	18264.69	-4954.69	15017.11	75.50	-2460.11	11295.80	2014.20	15.13
13	10214	19090.45	-8876.45	14768.98	-248.12	-4134.85	11337.82	-1123.82	11.00
14	20983	19916.21	1066.79	16449.28	1680.27	2030.27	14286.49	6696.51	31.91
15	27492	20741.97	6750.03	19222.20	2772.90	6851.34	23697.75	3794.25	13.80
16	19535	21567.73	-2032.73	21995.11	2772.90	-2460.11	19535.00	0.00	0.00
17	28020	22393.49	5626.51	26895.23	4900.09	-1636.76	20633.16	7386.84	26.36



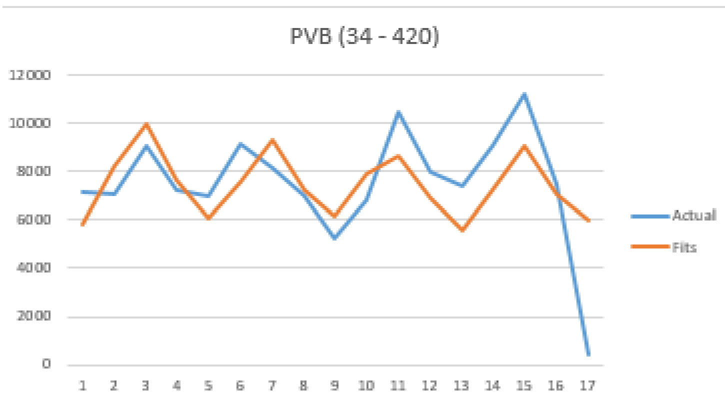
PVB (1-720)

Period (t)	Y	Ŷ	De-Trend	Level (S)	Trend (b)	Seasonal (I)	Fit (F)	Error (e)	APE
-3						-15780.48			
-2						-2150.48			
-1						23708.83			
0				21654.40	531.45	-5777.87			
1	10688	22185.84	-11497.84	22185.84	531.45	-14962.25	6405.37	4282.63	40.07
2	21688	22717.29	-1029.29	22717.29	531.45	-1936.27	20566.81	1121.19	5.17
3	40814	23248.74	17565.26	23248.74	531.45	22535.05	46957.56	-6143.56	15.05
4	19510	23780.18	-4270.18	23780.18	531.45	-5489.82	18002.31	1507.69	7.73
5	9824	24311.63	-14487.63	24311.63	531.45	-14871.57	9349.38	474.62	4.83
6	21848	24843.07	-2995.07	24843.07	531.45	-2138.56	22906.81	-1058.81	4.85
7	48936	25374.52	23561.48	25374.52	531.45	22731.16	47909.57	1026.43	2.10
8	24640	25905.97	-1265.97	25905.97	531.45	-4682.82	20416.15	4223.85	17.14
9	12400	26437.41	-14037.41	26437.41	531.45	-14712.20	11565.84	834.16	6.73
10	23692	26968.86	-3276.86	26968.86	531.45	-2356.04	24830.30	-1138.30	4.80
11	47904	27500.30	20403.70	27500.30	531.45	22286.48	50231.46	-2327.46	4.86
12	26990	28031.75	-1041.75	28031.75	531.45	-3987.17	23348.93	3641.07	13.49
13	13851	28563.20	-14712.20	28563.20	531.45	-14712.20	13851.00	0.00	0.00
14	31507	29094.64	2412.36	29094.64	531.45	-1445.00	26738.60	4768.40	15.13
15	66644	29626.09	37017.91	29626.09	531.45	25101.03	51912.57	14731.43	22.10
16	17337	30157.53	-12820.53	30157.53	531.45	-5674.85	26170.37	-8833.37	50.95
17	11163	30688.98	-19525.98	30688.98	531.45	-15631.90	15976.78	-4813.78	43.12



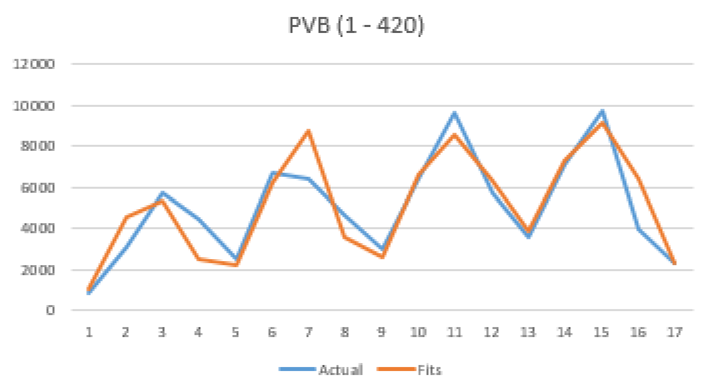
PVB (34-420)

Period (t)	Y	Ŷ	De-Trend	Level (S)	Trend (b)	Seasonal (I)	Fit (F)	Error (e)	APE
-3						-2216.88			
-2						305.73			
-1						2069.88			
0				8086.77	-64.14	-158.73			
1	7158	8022.63	-864.63	8022.63	-64.14	-1687.71	5805.75	1352.25	18.89
2	7034	7958.48	-924.48	7958.48	-64.14	-175.68	8264.21	-1230.21	17.49
3	9026	7894.34	1131.66	7894.34	-64.14	1702.73	9964.21	-938.21	10.39
4	7254	7830.19	-576.19	7830.19	-64.14	-322.09	7671.46	-417.46	5.75
5	6968	7766.05	-798.05	7766.05	-64.14	-1339.56	6078.34	889.66	12.77
6	9156	7701.90	1454.10	7701.90	-64.14	462.09	7526.22	1629.78	17.80
7	8134	7637.76	496.24	7637.76	-64.14	1230.60	9340.49	-1206.49	14.83
8	6958	7573.62	-615.62	7573.62	-64.14	-436.96	7251.52	-293.52	4.22
9	5208	7509.47	-2301.47	7509.47	-64.14	-1715.98	6169.91	-961.91	18.47
10	6806	7445.33	-639.33	7445.33	-64.14	31.08	7907.42	-1101.42	16.18
11	10446	7381.18	3064.82	7381.18	-64.14	1948.37	8611.78	1834.22	17.56
12	7960	7317.04	642.96	7317.04	-64.14	-14.36	6880.08	1079.92	13.57
13	7397	7252.89	144.11	7252.89	-64.14	-988.08	5536.91	1860.09	25.15
14	9043	7188.75	1854.25	7188.75	-64.14	744.53	7219.83	1823.17	20.16
15	11233	7124.60	4108.40	7124.60	-64.14	2793.64	9072.98	2160.02	19.23
16	7496	7060.46	435.54	7060.46	-64.14	161.70	7046.10	449.90	6.00
17	384	6996.31	-6612.31	6996.31	-64.14	-3188.98	6008.23	-5624.23	1464.64



PVB (1-420)

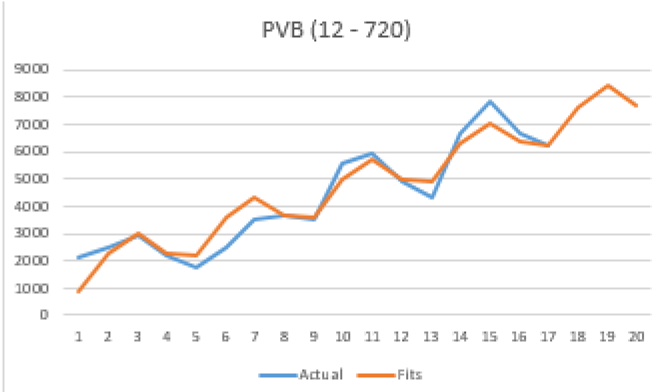
Period (t)	Y	Ŷ	De-Trend	Level (S)	Trend (b)	Seasonal (I)	Fit (F)	Error (e)	APE
-3						-2757.14			
-2						759.34			
-1						2667.46			
0				3621.23	159.13	-669.66			
1	842	3780.35	-2938.35	3621.96	159.13	-2757.14	1023.22	-181.22	21.52
2	3050	3939.48	-889.48	2478.41	159.13	759.34	4540.43	-1490.43	48.87
3	5736	4098.60	1637.40	3014.25	159.13	2667.46	5304.99	431.01	7.51
4	4414	4257.73	156.27	4843.03	159.13	-669.66	2503.71	1910.29	43.28
5	2536	4416.85	-1880.85	5256.48	159.13	-2757.14	2245.02	290.98	11.47
6	6740	4575.98	2164.02	5909.48	159.13	759.34	6174.95	565.05	8.38
7	6454	4735.10	1718.90	4074.00	159.13	2667.46	8736.07	-2282.07	35.36
8	4676	4894.23	-218.23	5205.52	159.13	-669.66	3563.47	1112.53	23.79
9	2948	5053.35	-2105.35	5662.25	159.13	-2757.14	2607.51	340.49	11.55
10	6424	5212.48	1211.52	5684.40	159.13	759.34	6580.71	-156.71	2.44
11	9666	5371.60	4294.40	6853.04	159.13	2667.46	8510.99	1155.01	11.95
12	5754	5530.73	223.27	6497.79	159.13	-669.66	6342.51	-588.51	10.23
13	3609	5689.85	-2080.85	6402.77	159.13	-2757.14	3899.78	-290.78	8.06
14	7049	5848.98	1200.02	6323.95	159.13	759.34	7321.23	-272.23	3.86
15	9676	6008.10	3667.90	6942.35	159.13	2667.46	9150.54	525.46	5.43
16	3976	6167.23	-2191.23	4955.01	159.13	-669.66	6431.81	-2455.81	61.77
17	2357	6326.35	-3969.35	5114.14	159.13	-2757.14	2357.00	0.00	0.00



b) Forecast the demand for each PVB product for the remaining three quarters of 2005 with the starting values found in (a).

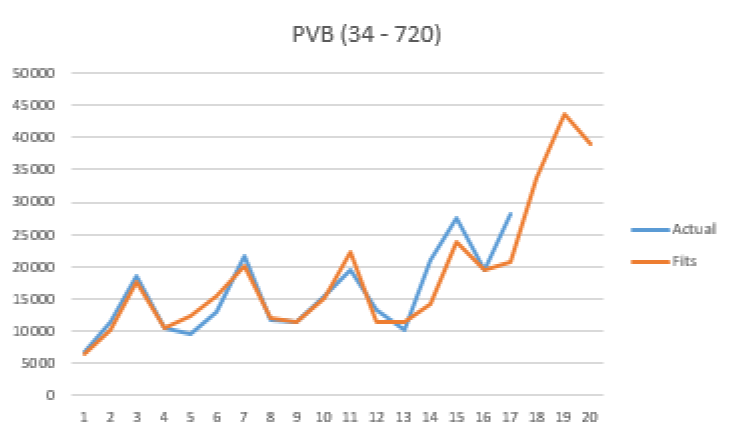
PVB (12-720)

Period	Forecast
2005 Q2	7635.27
2005 Q3	8386.27
2005 Q4	7678.52



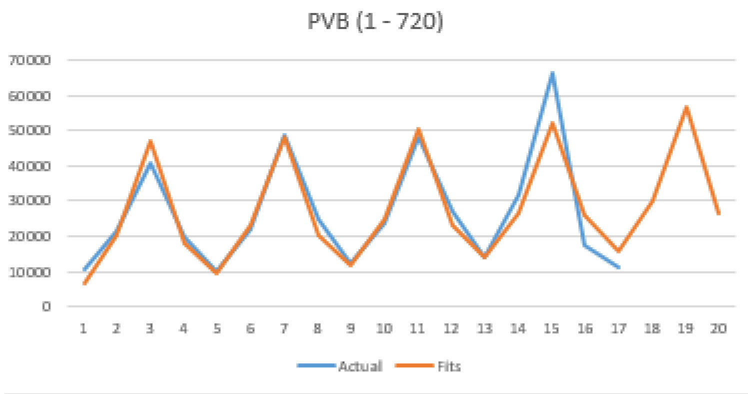
PVB (34-720)

Period	Forecast
2005 Q2	33825.59
2005 Q3	43546.76
2005 Q4	39135.41



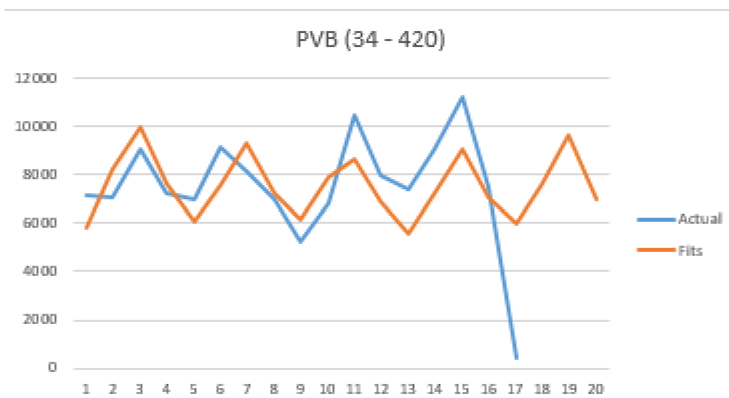
PVB (1-720)

Period	Forecast
2005 Q2	29775.42
2005 Q3	56852.90
2005 Q4	26608.47



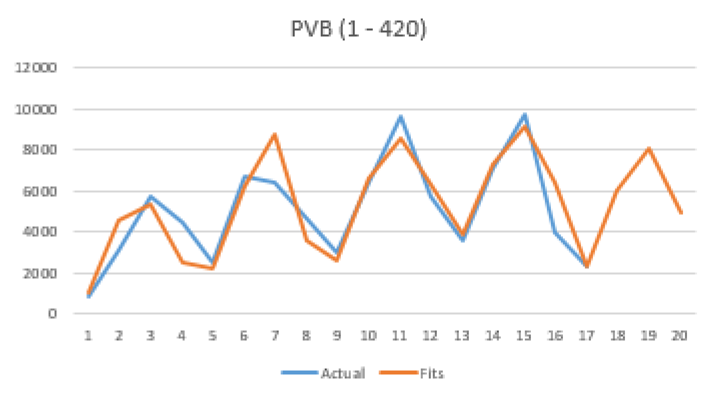
<u>PVB (34-420)</u>

Period	Forecast
2005 Q2	7676.70
2005 Q3	9661.67
2005 Q4	6965.58



<u>PVB (1-420)</u>

Period	Forecast
2005 Q2	6032.60
2005 Q3	8099.85
2005 Q4	4921.85



c) Please explain how you choose the smoothing constants for the Winters' method.

All smoothing constants were optimized the same way as the multiplicative model - refer to 2c.

*Regarding PVB (34-420), there was a huge dip in demand in 2005 Q1 (period 17). When the smoothing constants were optimized by Excel-Solver, a 1.00 was assigned to alpha constant (α), which means the level of the series distant observations are ignored. However, it is believed that the dip may be due to random fluctuation, so the alpha smoothing constant was adjusted back to 0.00, which gave an overall higher Mean Absolute Percentage Error (MAPE). Forecasts in the 17 periods may have a higher MAPE, but the overall 20 periods should have a lower MAPE.

PVB (12-720)

α	β	γ
0.000	0.050	0.000

MAPE	MAD
12.75	413.35

PVB (34-720)

α	β	γ
0.288	1.000	0.475

MAPE	MAD
11.52	1992.32

PVB (1-720)

α	β	γ
0.000	0.000	0.191

MAPE	MAD
15.18	3583.93

PVB (34-420)*

α	β	γ
0.000	0.000	0.391

MAPE	MAD
100.18	1461.91

PVB (1-420)

α	β	γ
0.874	0.000	0.000

MAPE	MAD
18.56	826.39

4. For each product, compare and comment on the following two approaches.

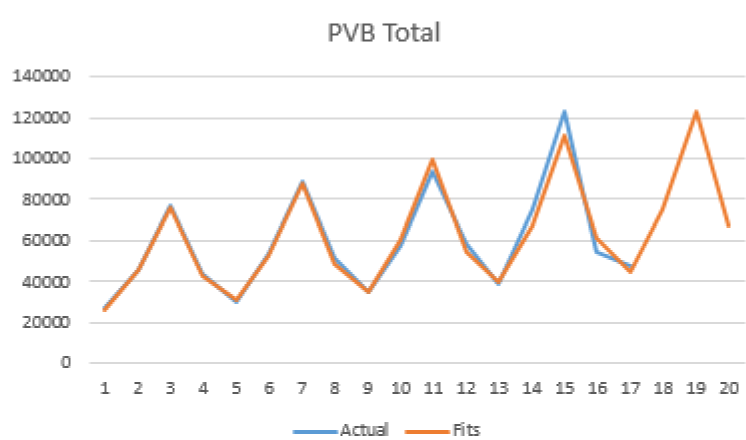
i) Forecast the product family total first, then disaggregate the family forecast into individual products based on the percentage of sales in the product family.

The forecasts are done using the Winter's Multiplicative Model and procedure 2 to gather the initial values.

Product Family Total Forecast

MAPE	MAD
4.38	2979.58

α	β	γ
0.008	1.000	0.000



Period (t)	Y	Ŷ	De-Trend	Level (S)	Trend (b)	Seasonal (I)	Fit (F)	Error (e)	APE
-3						0.60			
-2						0.98			
-1						1.57			
0				42982.01	1788.52	0.84			
1	27512	44770.53	0.61	44781.50	1799.50	0.60	26717.84	794.16	2.89
2	45798	46559.05	0.98	46580.40	1798.90	0.98	45869.20	-71.20	0.16
3	76968	48347.57	1.59	48383.66	1803.26	1.57	76135.34	832.66	1.08
4	43858	50136.10	0.87	50201.18	1817.52	0.84	42397.45	1460.55	3.33
5	30580	51924.62	0.59	52012.30	1811.12	0.60	31043.35	-463.35	1.52
6	53198	53713.14	0.99	53825.06	1812.77	0.98	53000.94	197.06	0.37
7	88704	55501.66	1.60	55643.83	1818.77	1.57	87558.22	1145.78	1.29
8	51590	57290.18	0.90	57492.34	1848.50	0.84	48543.88	3046.12	5.90
9	35372	59078.71	0.60	59340.27	1847.94	0.60	35413.00	-41.00	0.12
10	57840	60867.23	0.95	61168.00	1827.73	0.98	60253.20	-2413.20	4.17
11	93388	62655.75	1.49	62965.60	1797.60	1.57	99137.47	-5749.47	6.16
12	58906	64444.27	0.91	64804.15	1838.55	0.84	54711.36	4194.64	7.12
13	39382	66232.79	0.59	66637.33	1833.18	0.60	39770.55	-388.55	0.99
14	75219	68021.32	1.11	68535.78	1898.45	0.98	67424.21	7794.79	10.36
15	122868	69809.84	1.76	70497.23	1961.46	1.57	110843.56	12024.44	9.79
16	54996	71598.36	0.77	72398.01	1900.78	0.84	61212.43	-6216.43	11.30
17	48159	73386.88	0.66	74351.56	1953.55	0.60	44339.50	3819.50	7.93
18							75139.10		
19							123157.02		
20							67762.55		

Percentage of Sales Disaggregation

Disaggregation Based on %						
	7.26%	26.72%	44.75%	12.71%	8.55%	100.00%
Period (t)	PVB (12-720)	PVB (34 - 720)	PVB (1 - 720)	PVB (34 - 420)	PVB (1 - 420)	Total (Fit)
1	1940.59	7139.72	11956.09	3396.09	2285.34	26717.84
2	3331.61	12257.48	20526.23	5830.42	3923.47	45869.20
3	5529.93	20345.40	34070.17	9677.53	6512.31	76135.34
4	3079.45	11329.73	18972.64	5389.12	3626.51	42397.45
5	2254.77	8295.61	13891.74	3945.91	2655.32	31043.35
6	3849.61	14163.27	23717.65	6736.93	4533.49	53000.94
7	6359.61	23397.90	39181.84	11129.49	7489.37	87558.22
8	3525.88	12972.22	21723.13	6170.39	4152.25	48543.88
9	2572.15	9463.30	15847.13	4501.33	3029.08	35413.00
10	4376.37	16101.27	26962.99	7658.76	5153.81	60253.20
11	7200.64	26492.19	44363.50	12601.32	8479.82	99137.47
12	3973.85	14620.34	24483.05	6954.34	4679.79	54711.36
13	2888.65	10627.76	17797.11	5055.22	3401.81	39770.55
14	4897.22	18017.55	30171.98	8570.26	5767.19	67424.21
15	8050.89	29620.37	49601.91	14089.28	9481.11	110843.56
16	4446.04	16357.60	27392.24	7780.69	5235.86	61212.43
17	3220.51	11848.70	19841.69	5635.98	3792.62	44339.50
18	5457.57	20079.18	33624.36	9550.90	6427.09	75139.10
19	8945.25	32910.85	55112.12	15654.44	10534.35	123157.02
20	4921.79	18107.97	30323.39	8613.27	5796.13	67762.55
MAPE	33.03	14.12	21.80	100.81	27.54	

By using the disaggregated sales percentages to make forecasts, across all the product families the Mean Absolute Percentage Error (MAPE) is higher. This is mainly due to the aggregation of the products causing a skewed forecast for those with lower percentage sales. For example, the highest percentage of sale product families are PVB(34-720) [26.72%] and PVB(1-720) [44.75%] - so they have relatively lower MAPE. Meanwhile, lower percentage sale product families have relatively higher MAPE. A special case is PVB(34-420), with the MAPE of 100.81 in both the disaggregate family forecast and the individual product sale forecast, which is due to the dip in sales in period 17. The general consensus is that the forecasts are more accurate when done with the individual product sale data rather than the percentage sales disaggregated approach because the level of the series, trend, and seasonality is considered individually.

ii) Use the individual product sales data to forecast each product sales separately.

Refer to the graphs in answer 2a (Multiplicative Model) or 3a (Additive Model).

By using individual product sales data to forecast each product sales separately, each individual level of the series, trend, and seasonality are being taken into consideration. Mean Absolute Percentage Error (MAPE) is lower and the forecasts are more accurate. The downfall of using the disaggregated sales percentage to make forecasts is that the level of the series, trend, and seasonality and being generalized. The forecasts are biased towards those that occupy a higher sales percentage.

PART 3

1) Please explain whether or not 'unemployment rate', 'bank prime loan rate', and 'new privately owned housing units started' should be included in the multiple regression model to forecast the total demand for the PVB product family.

Yes, the variables - unemployment rate, bank prime loan rate, and new privately owned housing units started - should be included in the multiple regression model to forecast the total demand for PVB product families. Though they may not directly bear relations to the dependent variable (demand) but may be related to an explanatory variable whose value is unknown. They play the role of proxy variables. This is because the plumbing products are dependent on commercial and institutional construction activities and are affected by macroeconomic trends.

For example, when bank prime loan rates decrease, people are more willing to borrow money and the propensity of financing increases, which may increase the demand of PVB product families. On the contrary, when the unemployment rate increases, there will be less construction activities due to less workers in the construction workforce, which may decrease the demand of PVB product families. Lastly, when new privately owned housing units increase, this means there is more construction, so the demand of PVB product families will increase.

2) If you decide to include those variables in Question 1 in the multiple regression model, do you think the values of those variables are available at the time of the forecast? If not, what do you do?

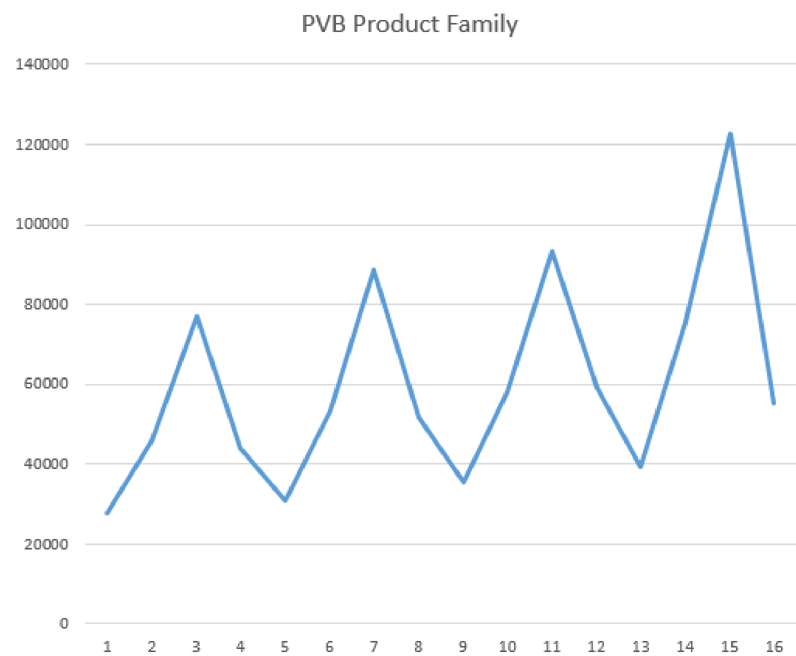
The included variables from above will not be available at the time of the forecast. This is because the variables in exhibit 5,6, and 7 are calculated after the period ends. For example, the unemployment rate from Oct - Dec 2004 is 5.43%. This is calculated after Dec, and the data between Oct and Dec are aggregated then the unemployment rate is determined.

Lagging variables will consider the positive and negative carry over effect of the variables. It can be adjusted to either according to the lagged period. For example, if the lagged period is 1, then only the previous period variable will be considered.

Unemployment Rate, Bank Prime Loan Rate, and New Privately Owned Housing Units will be lagged by 1 period (t-1).

3) When forecasting the total demand for the PVB product family, should we consider seasonal effects? If yes, how to include seasonal effects in the multiple regression model?

Yes, we should consider the seasonal effects when forecasting the total demand for PVB product families because PVB product family have a seasonality factor.



To include seasonal effects in the multiple regression model, it is common to create dummy variables for different seasonality. For example, the dataset is in quarters, for each quarter there will be a different seasonality dummy variable. Since there are 4 quarters, 3 dummy variables will be created - PVB (Q1), PVB (Q2), PVB (Q3) - while PVB (Q4) will be the baseline

4) Should we consider lag variables in the multiple regression model? how? Please explain.

Yes, we should consider the lagged variables in the multiple regression model.
Lagging variables will consider the positive and negative carry over effect of the variables. It can be adjusted to either according to the lagged period. For example, if the lagged period is 1, then only the previous period variable will be considered.

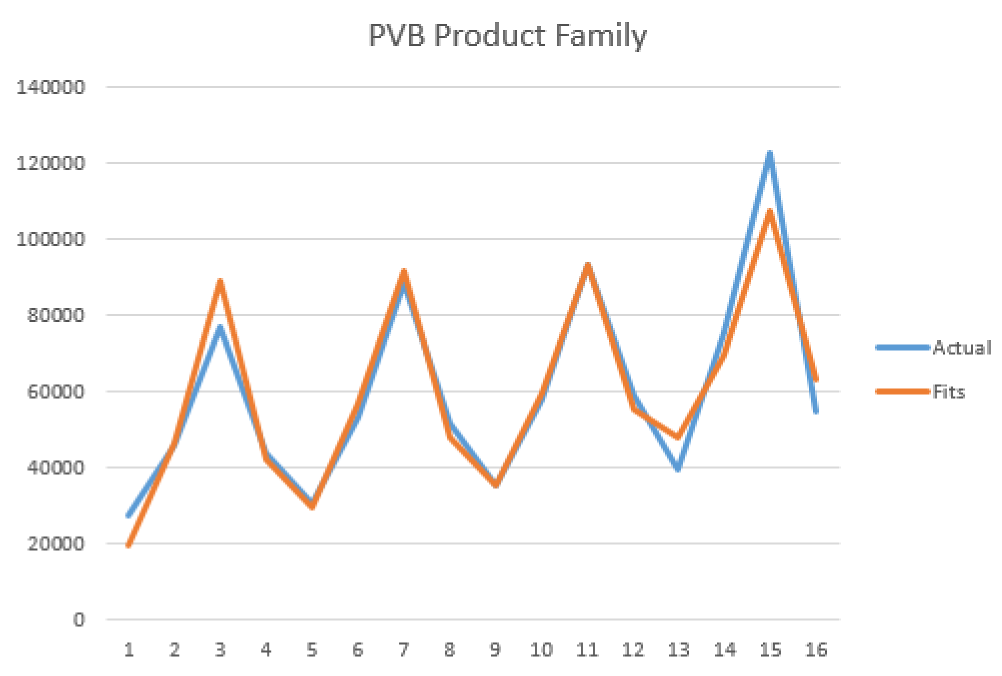
For example, in exhibit 6, the bank prime loan rate of Oct - Dec 2000 is 9.5%. If we decided to lag the variable by 1 period, then we would create a new variable 't-1', which is a 1 period lagged variable of the bank prime loan rate. In the next period of Jan - Mar 2001 the rate is 8.62%, while the lagged rate is 9.5%. Similarly exhibit 7 and 8 will also have the included lagging variables.

5) Please run a multiple regression, including all variables you consider necessary from Questions 1 - 4.

There are six variables in the multiple regression, three lagged variables and three seasonality dummy variables

Lagged Variable: Unemployment Rate (t-1), Bank Prime Loan Rate (t-1), Total Housing (t-1)
Seasonality Dummy Variable: PVB (Q1), PVB (Q2), PVB (Q3)

Year	Quarter	Period	Umemployment Rate (t-1)	Bank Prime Loan Rate (t-1)	Total Housing (t-1)	PVB (Q1)	PVB (Q2)	PVB (Q3)	PVB Product Family	Fits
2000	4		-	-	-	0	0	0	-	-
2001	1	1	3.90%	9.50%	357	1	0	0	27512	19573
	2	2	4.23%	8.62%	348	0	1	0	45798	46223
	3	3	4.40%	7.34%	461	0	0	1	76968	89004
	4	4	4.83%	6.57%	429	0	0	0	43858	42357
2002	1	5	5.53%	5.16%	366	1	0	0	30580	29742
	2	6	5.70%	4.75%	369	0	1	0	53198	56932
	3	7	5.83%	4.75%	475	0	0	1	88704	91565
	4	8	5.73%	4.75%	459	0	0	0	51590	48054
2003	1	9	5.87%	4.45%	403	1	0	0	35372	35613
	2	10	5.83%	4.25%	375	0	1	0	57840	59393
	3	11	6.13%	4.24%	490	0	0	1	93388	93590
	4	12	6.13%	4.00%	511	0	0	0	58906	55639
2004	1	13	5.87%	4.00%	472	1	0	0	39382	47918
	2	14	5.67%	4.00%	425	0	1	0	75219	69508
	3	15	5.57%	4.00%	540	0	0	1	122868	107768
	4	16	5.43%	4.42%	532	0	0	0	54996	63299
2005	1	17	5.43%	4.94%	460				48159	



SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.96627721
R Square	0.933691646
Adjusted R Square	0.889486077
Standard Error	8571.653811
Observations	16

ANOVA

	df	SS	MS	F	Significance F
Regression	6	9311228401	1551871400	21.12158398	7.95981E-05
Residual	9	661259241.5	73473249.05		
Total	15	9972487642			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%	| t Stat |
Intercept	71135.09266	135844.7692	0.523649847	0.613170505	-236167.125	378437.3103	-236167.125	378437.3103	0.52365
X Variable 1	-1030702.747	1346288.568	-0.765588278	0.463524995	-4076219.076	2014813.581	-4076219.076	2014813.581	0.765588
X Variable 2	-592439.7986	616866.1346	-0.960402534	0.361942514	-1987887.944	803008.3463	-1987887.944	803008.3463	0.960403
X Variable 3	139.6937822	95.027174	1.470040371	0.175623053	-75.27262017	354.6601845	-75.27262017	354.6601845	1.47004
X Variable 4	-4953.106358	8712.7408	-0.568490039	0.583606443	-24662.69536	14756.48265	-24662.69536	14756.48265	0.56849
X Variable 5	21141.06127	10955.16285	1.929780649	0.085702627	-3641.238835	45923.36137	-3641.238835	45923.36137	1.929781
X Variable 6	42306.4443	6165.276196	6.862051749	7.37311E-05	28359.6206	56253.26801	28359.6206	56253.26801	6.862052

6) Please run the 'best subsets regression' using a statistics software such as Minitab. What is the best regression model that you recommend? What criteria did you use to select the 'best regression model'?

Response is PVB

Vars	R-Sq	R-Sq (adj)	R-Sq (pred)	Mallows Cp	S	Unemployment_Rate (t-1)	Loan_Rate (t-1)	Total Housing (t-1)	PVB (Q1)	PVB (Q2)	PVB (Q3)
1	68.2	66.0	55.5	31.1	15041						X
1	40.2	35.9	16.6	69.1	20637			X			
2	81.1	78.2	69.6	15.6	12028				X		X
2	78.2	74.8	66.4	19.6	12942		X				X
3	92.5	90.6	85.3	2.2	7907.8			X		X	X
3	88.2	85.2	75.8	8.1	9915.4		X		X		X
4	92.8	90.2	84.4	3.7	8058.8		X	X		X	X
4	92.7	90.0	83.3	4.0	8162.5	X		X		X	X
5	93.1	89.7	80.2	5.3	8276.5	X	X	X		X	X
5	92.9	89.4	79.5	5.6	8392.4		X	X	X	X	X
6	93.4	88.9	75.0	7.0	8571.7	X	X	X	X	X	X

The best regression model that Minitab recommended is a model that uses Total Housing (t-1), PVB (Q2), and PVB (Q3) as the predictor variables.

The main criteria used to select the ‘best regression model’ is Mallows Criterion, because they have more drastic changes as compared to other metrics. The model with the lowest Mallows CP will be selected. At 3 variables, the Mallows CP is 2.2 with RMSE 7907.8. Similarly, The R-sq (adj) for that model is also the highest, at 90.6.

7) Are the signs of regression coefficients in the best model the same as you expected? Please interpret regression coefficients in the best model.

There are a total 3 predictor variables used in the best model [Total Housing (t-1), PVB (Q2), PVB (Q3)].

Year	Quarter	Period	Total Housing (t-1)	PVB (Q2)	PVB (Q3)	PVB Product Family	Fits		
2000	4		-	0	0	-	-	Intercept	-56511.21
2001	1	1	357	0	0	27512	23840	X1	225.07
	2	2	348	1	0	45798	50980	X2	29165.70
	3	3	461	0	1	76968	88617	X3	41369.40
	4	4	429	0	0	43858	40045		
2002	1	5	366	0	0	30580	25866		
	2	6	369	1	0	53198	55707		
	3	7	475	0	1	88704	91768		
	4	8	459	0	0	51590	46798		
2003	1	9	403	0	0	35372	34194		
	2	10	375	1	0	57840	57057		
	3	11	490	0	1	93388	95144		
	4	12	511	0	0	58906	58502		
2004	1	13	472	0	0	39382	49724		
	2	14	425	1	0	75219	68311		
	3	15	540	0	1	122868	106398		
	4	16	532	0	0	54996	63228		
2005	1	17	460			48159			

X1 [Total Housing (t-1)] is positive. This is because as there is more New Privately Owned Housing Units the demand for PVB product families will also increase. When there are more construction activities due to having higher housing units, the demand will similarly increase.

X2 [PVB (Q2)] and X3 [PVB (Q3)] are positive. This is because compared to the baseline at PVB (Q4) there is more demand for the PVB product families. This could be due to seasonality and customer inventory build up. It can be deduced that in Q2 and Q3 the demand for PVB product families is higher because New Privately Owned Housing Units are higher so constructions during those quarters are higher. In Q4 and Q1 the New Privately Owned Housing Units are lower; hence the demand is lower. Also, construction institutions may have sufficient

PVB product families in Q4 and Q1 because they accumulated inventory in Q2 and Q3; hence there isn't a need to purchase more in Q4 and Q1, so demand is lower.

8) Please compare the RMSEs you obtained from the best regression model, with those from Winters' method and Decomposition method. Which method produces the best result? Please comment.

Model	RMSE
Best Regression Model	7907.80
Winters' Method (multiplicative)	4402.63
Decomposition Method (multiplicative)	4477.37

The method that produces the result is the **Winters' Method**.

For the Best Regression Model, a multiple regression is run on 3 predictor variables [Total Housing (t-1), PVB (Q2), PVB (Q3)]. The model can predict the value pretty decently but uses 3 predictors, which increases the degrees of freedom. Also it uses multiple lagging variables so the samples (n) decrease too. This inevitably causes the RMSE to increase and be relatively higher.

For both Decomposition Method and Winters' Method, their degrees of freedom are less. Similarly, they also account for trend and seasonality so their standard deviation of the residuals (SSE) is lower. Additionally, Decomposition Method and Winters' Method did not have lagged variables, so samples (n) will be higher compared to the multiple regression model. While the Decomposition Method accounts for consistent parameters for trend and seasonality, Winter's Method accounts for varying parameters for trends and seasonality. It is more elaborate in capturing the movements and random fluctuations in the PVB product family; hence it has the lowest RMSE and performs the best.