Forecasting Apple Sales

Data Set

Trend	Year Qtr	Revs
1	19794	19.54
2	19801	23.55
3	19802	32.569
4	19803	41.467
5	19804	67.621
6	19811	78.765
7	19812	90.719
8	19813	97.678
9	19814	133.553
10	19821	131.019
11	19822	142.681
12	19823	175.808
13	19824	214.293
14	19831	227.982

Part 1

The Bass Diffusion Model

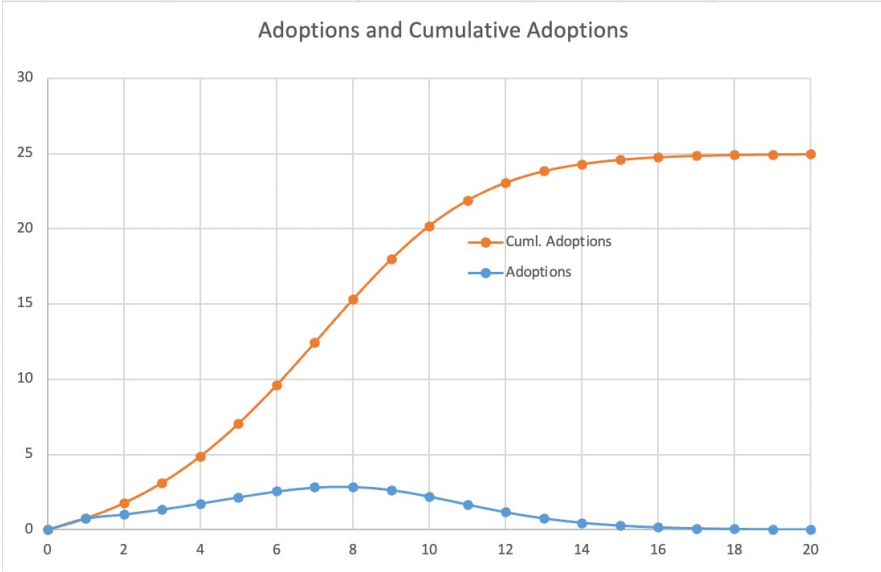
Context

- For Part I of the exercise, I examined the properties of the Bass Diffusion Model.
- I assume a market size of 25MM and a forecast period of 20 years (i.e., T=20).
- Note that I also use the terms sales and adoption interchangeably

Bass Diffusion Model

- First, I built a forecast of sales and the cumulative sales by taking coefficients for innovation and imitation in considerations. Assuming p = 0.03, q = 0.4, and m = 25MM. I plotted both sales and cumulative sales on the same graph.
- As seen below, when the coefficient for innovation is smaller than imitation, there is a steady rise and fall of adoption. Additionally, the cumulative adoption/sales grow for about 15 years, and then level off.

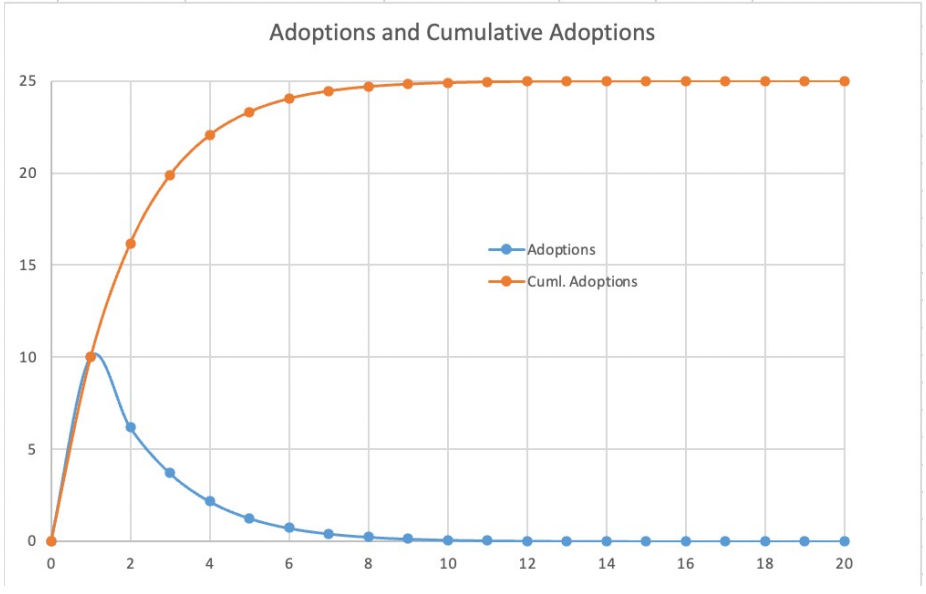
	p	q	m	
	0.030	0.400	25	
Year	Market Penetration	Year	Adoptions	Cuml. Adoptions
0	0	0	0	0
1	3%	1	0.75	0.75
2	7%	2	1.02	1.77
3	12%	3	1.35	3.12
4	19%	4	1.75	4.87
5	28%	5	2.17	7.05
6	38%	6	2.56	9.61
7	50%	7	2.83	12.44
8	61%	8	2.88	15.31
9	72%	9	2.66	17.98
10	81%	10	2.23	20.21
11	88%	11	1.69	21.90
12	92%	12	1.18	23.08
13	95%	13	0.77	23.85
14	97%	14	0.47	24.32
15	98%	15	0.28	24.61
16	99%	16	0.17	24.77
17	99%	17	0.10	24.87
18	100%	18	0.06	24.93
19	100%	19	0.03	24.96
20	100%	20	0.02	24.98



Bass Diffusion Model Continued

- Now, I built a forecast of sales and the cumulative sales by changing my coefficients. Assuming p = 0.4, q = 0.03, and m = 25MM. I plotted both sales and cumulative sales on the same graph.
- When innovation is larger than imitation, there is an immediate rise and fall of adoption. Additionally, cumulative adoption increases sharply for 5 years and then levels off.

	p	q	m	
	0.400	0.030	25	
Year	Market Penetration	Year	Adoptions	Cuml. Adoptions
0	0	0	0	0
1	40%	1	10.00	10.00
2	65%	2	6.18	16.18
3	80%	3	3.70	19.88
4	88%	4	2.17	22.05
5	93%	5	1.26	23.31
6	96%	6	0.72	24.03
7	98%	7	0.42	24.45
8	99%	8	0.24	24.68
9	99%	9	0.14	24.82
10	100%	10	0.08	24.90
11	100%	11	0.04	24.94
12	100%	12	0.03	24.97
13	100%	13	0.01	24.98
14	100%	14	0.01	24.99
15	100%	15	0.00	24.99
16	100%	16	0.00	25.00
17	100%	17	0.00	25.00
18	100%	18	0.00	25.00
19	100%	19	0.00	25.00
20	100%	20	0.00	25.00



Source of Sales

- Share of sales due to innovators and imitators from the last two models

Model 1

	Source of Sales	
Year	Innovators	Imitators
1	0.7500	-
2	0.7275	0.2910
3	0.6969	0.6574
4	0.6563	1.0931
5	0.6038	1.5691
6	0.5386	2.0239
7	0.4618	2.3662
8	0.3769	2.4999
9	0.2906	2.3734
10	0.2107	2.0201
11	0.1438	1.5495
12	0.0930	1.0860
13	0.0576	0.7091
14	0.0346	0.4401
15	0.0204	0.2642
16	0.0118	0.1552
17	0.0068	0.0901
18	0.0039	0.0519
19	0.0022	0.0297
20	0.0013	0.0170

Model 2

	Source of Sales	
Year	Innovators	Imitators
1	10.0000	-
2	6.0000	0.1800
3	3.5280	0.1712
4	2.0483	0.1222
5	1.1801	0.0781
6	0.6768	0.0473
7	0.3872	0.0279
8	0.2211	0.0162
9	0.1262	0.0093
10	0.0720	0.0054
11	0.0410	0.0031
12	0.0234	0.0018
13	0.0133	0.0010
14	0.0076	0.0006
15	0.0043	0.0003
16	0.0025	0.0002
17	0.0014	0.0001
18	0.0008	0.0001
19	0.0005	0.0000
20	0.0003	0.0000

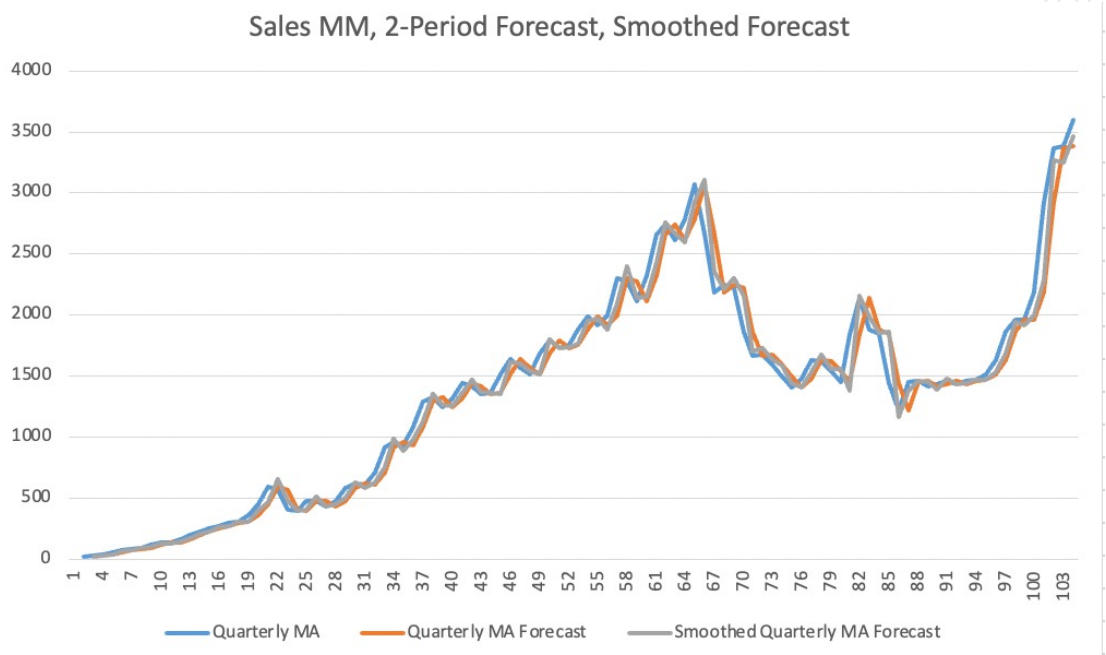
Part 2

Forecasting Sales

Forecasting Sales

For the first part of this assignment, I computed a simple 2-period moving average forecast (one quarter ahead). Using the 2-period MA, I computed an exponentially smoothed forecast in order to find the optimal alpha level. The alpha level determines the weight of the previous periods.

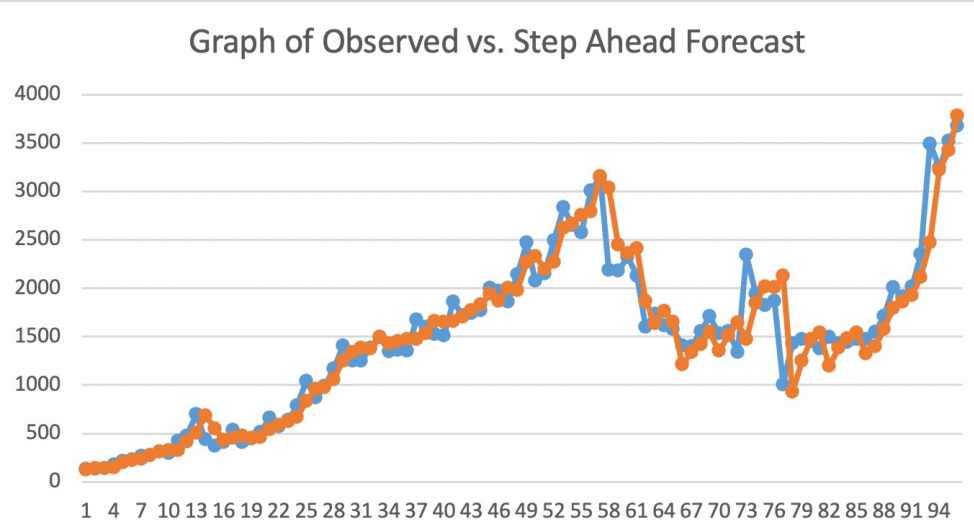
	Alpha =	0.81240526				
	SSE =	6768526.14				
Year Qtr	**Revs**	Quarterly MA	Quarterly MA Forecast	Smoothed Quarterly MA Forecast	Error	Error ^ 2
19794	19.53999996					
19801	23.54999995	21.54				
19802	32.56899989	28.06	21.54	21.54	11.02	121.5286
19803	41.46699989	37.02	28.06	30.50	10.97	120.2541
19804	67.62099981	54.54	37.02	39.41	28.21	795.8702
19811	78.76499987	73.19	54.54	62.33	16.44	270.1509
19812	90.71899986	84.74	73.19	75.68	15.04	226.1221
19813	97.67799997	94.20	84.74	87.90	9.78	95.6470
19814	133.553	115.62	94.20	95.84	37.71	1422.0187



Forecasting Sales Continued

- The next step was to improve the model and compute a one-step ahead forecast of the Apple Sales revenue data using a dynamic level, trend, and seasonality model (an additive Holt-Winters Model).
- I needed to find the alpha, beta, and gamma (which were set to 0.5 to begin with before using Solver). Based on these values, I computed the step ahead forecast, the errors, the squared errors, and the sum of squared errors. Using Solver, I found the values for alpha, beta, and gamma that minimize the sum of squared errors.

	a	b	g			
	0.683438182	0.158088526	0.277438			
		Seasonal				
		-7.32140559				
		7.4971696				
		1.470638342				
Level	Trend	-1.64640235	Forecast	Error	Error^2	SSE
104.9994056	13.60352576	-7.32140559				
123.7	14.41	8.151729551	126.1	7.5	55.54570	5740486.41
132.3	13.48	0.719115471	139.6	-8.6	73.22106	
144.8	13.33	-1.77058851	144.1	-1.4	1.99939	
175.2	16.04	-5.12373742	150.8	25.0	626.14636	
201.4	17.64	9.460175742	199.4	14.9	221.95419	
224.7	18.53	1.438684951	219.8	8.2	67.12698	
260.9	21.32	0.500195904	241.4	25.9	668.50311	
279.6	20.91	-5.46269639	277.1	-3.9	14.89518	
304.8	21.59	10.01399991	309.9	6.3	39.76449	



Blue = Observed Revenue
Orange = Step Ahead Forecast