MSc in Strategic Management and Digital Marketing

MGT5204: Management Science and Decision Analysis Assignment

Karsten Guenther (02956967M)

Question 1: Time-Series and Forecasting.

You are provided with a data set containing daily information regarding the number of persons that have been tested positive for the COVID-19 and the number of persons that have been swabbed between March 6 and April 23 in Malta.

1. In not more than 100 words, mention two main problems that have been encountered by policy makers when forecasting the novel COVID-19 and provide suggestions on how policy makers can overcome them. (6 marks)

    a. County-level heterogeneity is a challenge faced by researchers and policy makers when forecasting the spread and mortality of covid19 in which they have to take into consideration that an array of country-specific assumptions and variables would have been included in the forecast and thus could not be used by policy makers on an . These variables could include density of regions, psychological behaviours of people, region resources ect.
    b. No past data available for forecast is another issue that the policy makers had to face since this was a novel virus and thus no prior exact data is available on which models can be based.

    To address these issues policymakers must use a range of forecasts and fully understand how sensitive models are to the smallest changes in assumptions, the second suggestion is that widespread, randomized testing is critical to generating credible forecasts and developing a full understanding of the disease and to make well-informed decisions.

2. Prepare an excel sheet with two columns – one for 'Period' (1,2,3, … 49), one for the day of the week (Fri, Sat, Sun, Mon, Tue, Wed, Thurs) and another with an 'Index' (correct to 4 decimal places) for the number of persons who tested positive as a percentage of the number of swabs administered. Copy and paste as a Table in your document (4 marks).
3. Using the Index column, forecast the next period using (i) a 7-day moving average, (ii) exponential smoothing with $\alpha = 0.25$, and (iii) the trend line. (6 marks)
4. Calculate the mean absolute deviation for the techniques mentioned in part (c). Which is the best forecasting technique in this case and why? (6 marks)

Period	*Day*	*Positives*	*Index %*	*7-Day Moving Average*	*Error*	*Exponential Smoothing*	*Error*	*Trend Line*	*Error*
1	Friday	3	3.2609			3.2609	0.0000	3.4827	0.2218
2	Saturday	0	0.0000			3.2609	3.2609	3.4261	3.4261
3	Sunday	1	1.3333			2.4457	1.1123	3.3695	2.0362
4	Monday	1	1.3889			2.1676	0.7787	3.3130	1.9241
5	Tuesday	2	1.5152			1.9729	0.4578	3.2564	1.7412
6	Wednesday	5	2.9240			1.8585	1.0655	3.1998	0.2758
7	Thursday	1	0.6579			2.1248	1.4669	3.1432	2.4853
8	Friday	5	4.3478	1.5829	2.7650	1.7581	2.5897	3.0866	1.2612
9	Saturday	3	3.4091	1.7382	1.6709	2.4055	1.0036	3.0301	0.3790
10	Sunday	9	7.0866	2.2252	4.8614	2.6564	4.4302	2.9735	4.1131
11	Monday	8	5.0314	3.0471	1.9844	3.7640	1.2675	2.9169	2.1145
12	Tuesday	10	4.9261	3.5674	1.3587	4.0808	0.8453	2.8603	2.0658
13	Wednesday	5	1.7794	4.0547	2.2753	4.2922	2.5128	2.8037	1.0244
14	Thursday	11	4.3137	3.8912	0.4225	3.6640	0.6498	2.7472	1.5666
15	Friday	9	3.6290	4.4135	0.7844	3.8264	0.1974	2.6906	0.9385
16	Saturday	17	6.0071	4.3108	1.6963	3.7771	2.2300	2.6340	3.3731
17	Sunday	17	5.5195	4.6819	0.8376	4.3346	1.1849	2.5774	2.9421
18	Monday	3	0.7500	4.4580	3.7080	4.6308	3.8808	2.5208	1.7708
19	Tuesday	19	4.7980	3.8464	0.9516	3.6606	1.1374	2.4642	2.3337
20	Wednesday	5	1.1628	3.8281	2.6653	3.9449	2.7821	2.4077	1.2449
21	Thursday	5	0.9398	3.7400	2.8002	3.2494	2.3096	2.3511	1.4112
22	Friday	10	2.0534	3.2580	1.2046	2.6720	0.6186	2.2945	0.2411
23	Saturday	2	0.3419	3.0329	2.6911	2.5174	2.1755	2.2379	1.8960
24	Sunday	5	0.7849	2.2236	1.4387	1.9735	1.1886	2.1813	1.3964
25	Monday	13	2.3091	1.5473	0.7618	1.6763	0.6327	2.1248	0.1843
26	Tuesday	19	3.3748	1.7700	1.6048	1.8345	1.5403	2.0682	1.3066
27	Wednesday	7	0.9485	1.5667	0.6182	2.2196	1.2711	2.0116	1.0631
28	Thursday	7	0.9346	1.5361	0.6015	1.9018	0.9672	1.9550	1.0204

29	Friday	11	1.6692	1.5353	0.1339	1.6600	0.0092	1.8984	0.2292
30	Saturday	14	2.1341	1.4804	0.6537	1.6623	0.4718	1.8419	0.2923
31	Sunday	14	2.5225	1.7365	0.7861	1.7803	0.7423	1.7853	0.7373
32	Monday	52	6.3030	1.9847	4.3183	1.9658	4.3372	1.7287	4.5743
33	Tuesday	6	0.6042	2.5553	1.9510	3.0501	2.4459	1.6721	1.0679
34	Wednesday	38	3.7328	2.1595	1.5734	2.4387	1.2942	1.6155	2.1173
35	Thursday	13	1.4444	2.5572	1.1128	2.7622	1.3177	1.5589	0.1145
36	Friday	20	1.5528	2.6301	1.0773	2.4328	0.8800	1.5024	0.0504
37	Saturday	8	0.7685	2.6134	1.8449	2.2128	1.4443	1.4458	0.6773
38	Sunday	6	0.5952	2.4183	1.8231	1.8517	1.2565	1.3892	0.7940
39	Monday	9	0.8563	2.1430	1.2867	1.5376	0.6813	1.3326	0.4763
40	Tuesday	6	0.5797	1.3649	0.7852	1.3673	0.7876	1.2760	0.6963
41	Wednesday	13	1.2720	1.3614	0.0894	1.1704	0.1016	1.2195	0.0526
42	Thursday	10	0.9174	1.0099	0.0924	1.1958	0.2784	1.1629	0.2454
43	Friday	4	0.4115	0.9346	0.5231	1.1262	0.7147	1.1063	0.6948
44	Saturday	1	0.1271	0.7715	0.6445	0.9475	0.8205	1.0497	0.9226
45	Sunday	4	0.6969	0.6799	0.0170	0.7424	0.0455	0.9931	0.2963
46	Monday	13	1.7906	0.6944	1.0962	0.7310	1.0596	0.9366	0.8541
47	Tuesday	1	0.1238	0.8279	0.7041	0.9959	0.8722	0.8800	0.7562
48	Wednesday	1	0.1560	0.7628	0.6068	0.7779	0.6219	0.8234	0.6674
49	Thursday	2	0.3273	0.6033	0.2760	0.6224	0.2951	0.7668	0.4395
				MAD 7DMA	***1.4071***	***MAD ES***	***1.3068***	***MAD TL***	***1.2758***

The mean absolute deviation for the 7-day moving average, exponential smoothing with $\alpha = 0.25$, and the trend line was formulated by:

- Deducting the actual results from the forecasted results which are denoted by the heading ‘Error’ in the table.
- All the values were aggregated and averaged out to deduce the sum of errors and are divided by n which is 49 days (42 for 7-Day Moving Average).
- The best forecasting technique reflecting the results I got is the trendline since it gave us the best MAD ratio denoting its accuracy.
- The trend line forecast is the most appropriate since the slope and y-intercept were calculated considering every positive case.

5. Reorganise the Index data by completing the cross-tabulation provided.
    a. Obtain seasonal indices (correct to 4 decimal places) for each day of the week.

Day	Week1	Week2	Week3	Week4	Week5	Week6	Week7
Friday	3.0000	5.0000	9.0000	10.0000	11.0000	20.0000	4.0000
Saturday	0.0000	3.0000	17.0000	2.0000	14.0000	8.0000	1.0000
Sunday	1.0000	9.0000	17.0000	5.0000	14.0000	6.0000	4.0000
Monday	1.0000	8.0000	3.0000	13.0000	52.0000	9.0000	13.0000
Tuesday	2.0000	10.0000	19.0000	19.0000	6.0000	6.0000	1.0000
Wednesday	5.0000	5.0000	5.0000	7.0000	38.0000	13.0000	1.0000
Thursday	1.0000	11.0000	5.0000	7.0000	13.0000	10.0000	2.0000
Week Average	***1.8571***	***7.2857***	***10.7143***	***9.0000***	***21.1429***	***10.2857***	***3.7143***

The seasonal indices were calculated by dividing the number of positive cases for the days of the week by the week average of positive cases.

- Week Average = (3+0+1+1+2+5+1)/7) = 1.8571 this represents the average positive case during week 1
    - We repeated this step for all the subsequent weeks till week 7.
    - The daily positive cases were then divided by the weekly average do deduce whether it is over of under the weekly average.
        - These are present in the table below under every week.
        - Week 1 resulted in having 3 days having more positive cases than the average weekly cases.
            - Friday, Tuesday, Wednesday.
        - All the seasonal indices for the week amount to 7.

If it was forecasted that during the week starting 24 April 2020, 30 persons would have tested positive for COVID-19, and an equal number of swabs were administered each day (and hence there is no need to control for this), compute forecasts (correct to 2 decimal places) for each day of the week starting 24 April 2020 and ending 30 April 2020. (8 marks)

Day	1	2	3	4	5	6	7	8	Positives	Y intercept	Slope
Friday	1.6154	0.6863	0.8400	1.1111	0.5203	1.9444	1.0769	1.1965	5.13	1.0305	0.0208
Saturday	0.0000	0.4118	1.5867	0.2222	0.6622	0.7778	0.2692	0.6493	2.78	0.4735	0.0220
Sunday	0.5385	1.2353	1.5867	0.5556	0.6622	0.5833	1.0769	0.8036	3.44	0.9788	-0.0219
Monday	0.5385	1.0980	0.2800	1.4444	2.4595	0.8750	3.5000	2.9733	12.74	-0.0604	0.3792
Tuesday	1.0769	1.3725	1.7733	2.1111	0.2838	0.5833	0.2692	0.2827	1.21	1.8516	-0.1961
Wednesday	2.6923	0.6863	0.4667	0.7778	1.7973	1.2639	0.2692	0.4529	1.94	1.8195	-0.1708
Thursday	0.5385	1.5098	0.4667	0.7778	0.6149	0.9722	0.5385	0.6416	2.75	0.9065	-0.0331
	7.0000	**7.0000**	**7.0000**	**7.0000**	**7.0000**	**7.0000**	**7.0000**	**7.0000**	30.00		

The forecast for week 8 was done through a trend projection by taking the data set for the prior 7 weeks and every day and calculating the:

- Intercept by using =INTERCEPT(B12:H12,$B$11:$H$11) // (<1.6154 , 0.6863, 0.8400, 1.1111, 0.5203, 1.9444, 1.0769>, <1, 2,3,4,5 ,6,7,8>).
- Slope of the line by using =SLOPE(B12:H12,$B$11:$H$11) // (<1.6154 , 0.6863, 0.8400, 1.1111, 0.5203, 1.9444, 1.0769>, <1, 2,3,4,5 ,6,7,8>).
    - This resulted in having week 8 projections in column 8 which were then multiplied by 4.2857 (30/7) which was the average of the week.
    - All daily positive cases forecasted amounted to 30 positive cases.

Question 2: Transportation and Assignment Models:

1. Which of the proposed locations will yield the lowest cost for Water Services plc in combination with existing distribution centres and regions?

Transportation costs FROM/TO	***North***	***South***	***West***	***East***	**Production Costs Distribution Centre**	**Production Cost per unit (€)**
Marsascala	€ 50.00	€ 21.00	€ 25.00	€ 30.00	***Marsascala***	€ 40.00
Mosta	€ 35.00	€ 45.00	€ 38.00	€ 36.00	***Mosta***	€ 60.00
Xewkija	€ 25.00	€ 70.00	€ 52.00	€ 55.00	***Xewkija***	€ 70.00
Mellieha	€ 5.00	€ 60.00	€ 47.00	€ 34.00	***Mellieha***	€ 35.00

Solution

	North	***South***	***West***	***East***	***Total Supply***
Marsascala	50	21	25	30	***16,000***
	0	16000	0	0	
Mosta	35	45	38	36	***12,000***
	0	1000	0	11000	
Xewkija	25	70	52	55	***14,000***
	4000	0	10000	0	
Mellieha	5	60	47	34	***18,000***
	16000	0	0	2000	
Total Demand	***20,000***	***17,000***	***10,000***	***13,000***	

Total Transport Cost	***€ 1,545,000.00***
Total Production Cost	***€ 2,970,000.00***
Total cost	***€ 4,515,000.00***

Transportation cost per Unit

FROM/TO	***North***	***South***	***West***	***East***	**Production Costs Distribution Centre**	**Production Cost per Unit (€)**
Marsascala	€ 50.00	€ 21.00	€ 25.00	€ 30.00	Marsascala	€ 40.00
Mosta	€ 35.00	€ 45.00	€ 38.00	€ 36.00	Mosta	€ 60.00
Xewkija	€ 25.00	€ 70.00	€ 52.00	€ 55.00	Xewkija	€ 70.00
Zebbug	€ 40.00	€ 38.00	€ 12.00	€ 27.00	Zebbug	€ 42.00

Solution	***North***		***South***		***West***		***East***		***Total Supply***
Marsascala	0	50	16000	21	0	25	0	30	***16,000***
Mosta	6000	35	1000	45	0	38	5000	36	***12,000***
Xewkija	14000	25	0	70	0	52	0	55	***14,000***
Zebbug	0	40	0	38	10000	12	8000	27	***18,000***
Total Demand	***20,000***		***17,000***		***10,000***		***13,000***		

Total Transport Cost ***€ 1,457,000.00***

Total Production Cost ***€ 3,096,000.00***

Total cost ***€ 4,553,000.00***

The location that will yield the lowest cost for Water Services plc is Mellieha with a total cost of € 4,515,000.00 comprising of transport cost amounting to € 1,545,000.00 and production cost of € 2,970,000.00

Whilst the Zebbug distribution centre would cost Water Services plc € 4,553,000.00 made up of Total Transport Cost of € 1,457,000.00 and total production cost of € 3,096,000.00

To get the results I used Transportation and Assignment models using the Northwest Corner Rule and the Stepping-Stone Method. I handled degeneracy in transportation problems by using cells which were occupied and iterated as needed until the values were all positive.

Use the assignment method to find the best solution.

Attacker	Rome	Naples	Milan	Bergamo
Ronaldo	0.9	0.8	0.7	0.8
Higuain	0.7	0.4	0.8	0.3
Dybala	0.6	0.8	0.5	0.4
Pjanic	0.5	0.3	0.4	0.2

Opportunity Cost	Rome	Naples	Milan	Bergamo
Ronaldo	0	0.1	0.2	0.1
Higuain	0.2	0.5	0.1	0.6
Dybala	0.3	0.1	0.4	0.5
Pjanic	0.4	0.6	0.5	0.7

Row Subtraction	Rome	Naples	Milan	Bergamo
Ronaldo	0	0	0.1	0
Higuain	0.1	0.4	0	0.5
Dybala	0.2	0	0.3	0.4
Pjanic	0	0.2	0.1	0.3

Column Subtraction	Rome	Naples	Milan	Bergamo
Ronaldo	0	0	0	0
Higuain	0	0.2	0	0.2
Dybala	0.1	0	0.2	0.1
Pjanic	0	0	0	0

- The best solution for Juventus is to start Ronaldo with Bergamo, Higuain with Milan, Dybala with Naples, and Pjanic with Rome since it would maximum minimal risk for the club.
    1. First, I Converted the maximization efficiency table into a minimizing opportunity cost table by subtracting each rating from 0.9, the largest rating in the whole table.
    2. The smallest number in each row is subtracted from every number in that row and the smallest number in each column is subtracted from every number in that column.
    3. Juventus Best Solution:

Attacker	Opponent	
Ronaldo	Bergamo	0.1
Higuain	Milan	0.1
Dybala	Naples	0.1
Pjanic	Rome	0.4
TMOC		0.7

Question 3: Bets and Odds:

1. Calculate the quota key for the above 3-Way odds.
    - 'Quota key' = (100/4) % + (100/3.25) % + (100/1.9) % = 108.40%

2. Convert the above 3-Way odds to the 2-Way odds using a quota key of 108%.
    - *We convert the above odds to fair percentages/odds:*
        - (100/108) *100% = 92.2502417
        - (92.2502417/4) % + (92.2502417/3.25) % + (92.2502417/1.9) % = 100%
            - Home Win = 23.06%
            - Draw = 28.38%
            - Away Win = 48.55%

    - *From 3-Way to 2-Way odds: Combining Home and Away Wins*
        - Therefore, (23.062+48.55) = 71.612 %

    - Calculating the new percentage chance of winning the game:
        - Probability of Home team to win: 23.062/71.612 = 0.322040999 = 32.20%
        - Probability of Away team to win: 48.55/71.612 = 0.677959001 = 67.79%

3. *Convert the above 3-Way odds to the 2-Way odds using fair odds*
        - Fair Odds:
            - 100/32.20 = 3.10
            - 100/67.79 = 1.47

    - *Converting odds to a quota key of 108% quota key*
            - (100/108) *100 = 92.59 92.57/32.20 = 2.87484472
            - (100/108) *100 = 92.59 92.57/67.79 = 1.36554064

4. *Convert the above 3-Way odds to double chance odds using a quota key of 120%.*
    - *Using the previous fair percentages:*
        - Home Win = 23.06%
        - Draw = 28.38%
        - Away Win = 48.55%

    - Step 1 - Combining Home and Draw percentages (Event A)
    - Step 2 - Combining Away and Draw percentages (Event B)
    - Step 3 - Combining Home and Away percentages (Event C)
        - Step 1 – (23.06 + 28.38) = 51.44
        - Step 2 – (48.55 + 28.38) = 76.93
        - Step 3 – (23.06 + 48.55) = 71.61

        - *Fair Odds*
            - 100/51.44 = 1.944012442
            - 100/76.93 = 1.299883011
            - 100/71.61 = 1.396453009

        - *Non-Fair Odds Based on Quota Key of 120:*
            - 83.33/51.44 = 1.619945568
            - 83.33/76.93 = 1.083192513
            - 83.33/71.61 = 1.163664293

5. *If 1 goal advantage is given to the home team, what will be the new probability of the 'draw'?*
    - Based on a Quota key of 120
        - 1 – 1 Goal Score 83.33/7 = 11.90%
        - 2 – 2 Goal Score 83.33/7 = 11.90%
        - 3 – 3 Goal Score 83.33/20 = 4.17%
            - Probability of a draw is = 27.97%

6. *If 1 goal advantage is given to the home team, what will be the new probability of the 'Home win'?*
    - Draw + Home Win = 28.38% +23.06% = 51.44%

7. *If 1 goal advantage is given to the home team, what will be the new probability of the 'Away win'?*
    - 100 – (27.97 + 51.44%) = 20.59%

8. *If 1 goal advantage is given to the home team, calculate the new 3-Way Handicap odds. Use a quota key of 115%.*
    - (100/115) X 100 = 86.95%
        - Home Win = 86.95/51.64 = 1.68
        - Draw = 86.94/20.59 = 4.26
        - Away Win = 86.94/27.97 = 3.11