15   Logistic Challenges

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Project: Predicting the demand for after care from hospitals

Challenge

Christmas is coming close again, so the elves are busy preparing all the presents! Due to the enormous number of presents, the elves start delivering presents three weeks in advance. That is, this year, they will be delivering during the weeks of December 2-8 (week 1), December 9-15 (week 2), and December 16-22 (week 3). The closer to Christmas, the more presents they deliver per week. However, not every day the same amount of presents is delivered. There are red and green gifts. The ratio between red and green gifts depends only on the day of the week and is the same throughout the three-week period.

To plan when each of the elves needs to work, the head elf wants to predict the number of deliveries per day. He has data on the number of presents of last year, which is given in Table 1 (given on the next page). Luckily, humans are creatures of habit, so the present delivery number for this year will abide the following two rules:

1. The deviation of the number of presents delivered on a day of the week from the average number of presents delivered on that day during that week is the same as last year. For example, if on average three presents are delivered and on Monday one present is delivered, than the deviation for Monday from the average of that week is -2.

2. The fraction of red presents delivered on a day of the week (with respect to the total number of presents delivered on that day) will be the same as last year. For example, if on Monday there were one red

and two green presents delivered, then the fraction of red presents on Monday of that week is 1/3.

Day	(Week 1) Date	Red	Green	(Week 2) Date	Red	Green	(Week 3) Date	Red	Green
Mon	12/04	2	2	12/11	5	5	12/18	11	11
Tue	12/05	3	3	12/12	6	6	12/19	12	12
Wed	12/06	3	3	12/13	6	6	12/20	12	12
Thu	12/07	4	4	12/14	7	7	12/21	13	13
Fri	12/08	3	6	12/15	5	10	12/22	9	18
Sat	12/09	2	1	12/16	6	3	12/23	14	7
Sun	12/10	5	1	12/17	10	2	12/24	20	4

Table 1: Number of red and green presents delivered on each day during a three-week period in the previous year 2023.

For example, in Table 1 we can observe

- on each of the three weeks, Tuesday had 2 more presents delivered than Monday,

- on each of the three Mondays, half of the delivered presents were red, while on each Friday only one third was red,

- in week 1 there was a total of 42 delivered presents and in week 2 the total was 84.

One thing has changed this year: Christmas become more popular! Thus, the head elf knows that this year the total number of presents per week triples every week during the delivery weeks. Moreover, he knows that on Monday in week 1 (December 2) the elves will need to deliver 8 red and 8 green presents. How many red and green presents are there to be delivered on Saturday in week 3 (December 21)?

(*Possible answers on next page.*)

Possible answers:

1. 56 red gifts and 28 green gifts

2. 108 red gifts and 108 green gifts

3. 108 red gifts and 36 green gifts

4. 84 red gifts and 21 green gifts

5. 72 red gifts and 26 green gifts

6. 90 red gifts and 18 green gifts

7. 106 red gifts and 53 green gifts

8. 108 red gifts and 54 green gifts

9. 56 red gifts and 56 green gifts

10. 30 red gifts and 15 green gifts

Project reference:

Predicting the demand for aftercare from hospitals is an important and topic of this project. One of the approaches we use is time series analysis. In time series decomposition, we split the time series (e.g., the number of requests for aftercare per day or the number of presents delivered per day) into a trend, a seasonal component, and an error term. The trend tells us how the time series behaves over more extended periods, while a weekly seasonality shows how it fluctuates per day of the week. Besides weekly seasonality, one could have, for example, daily seasonality (e.g., in the number of patients arriving at the emergency department in a hospital per hour) or yearly seasonality (e.g., in the number of ice cream per month).