

Assignment STAT702

Need to include formulas for question 2 #####

Group 5: Hitarth Asrani and Genevieve Connell

Product name: BIC Round Stic Xtra Life Ballpoint Pen, Medium Point (1.0mm), Red, 12-Count

Sales sku_id: 219884

Reviews asin: B00006IE7J

1 Analysis of Sales Data

1(a) For the product (sku_id) which has been assigned to your group (see page 6), compute the total monthly sales from January 2011 – July 2013. Present your results in an appropriate plot and write 2 – 3 sentences describing your results.

Hint: This will require some “wrangling” of the variable week. To do this, format week as a date and then use the appropriate lubridate function to extract the month.

Marking Criteria

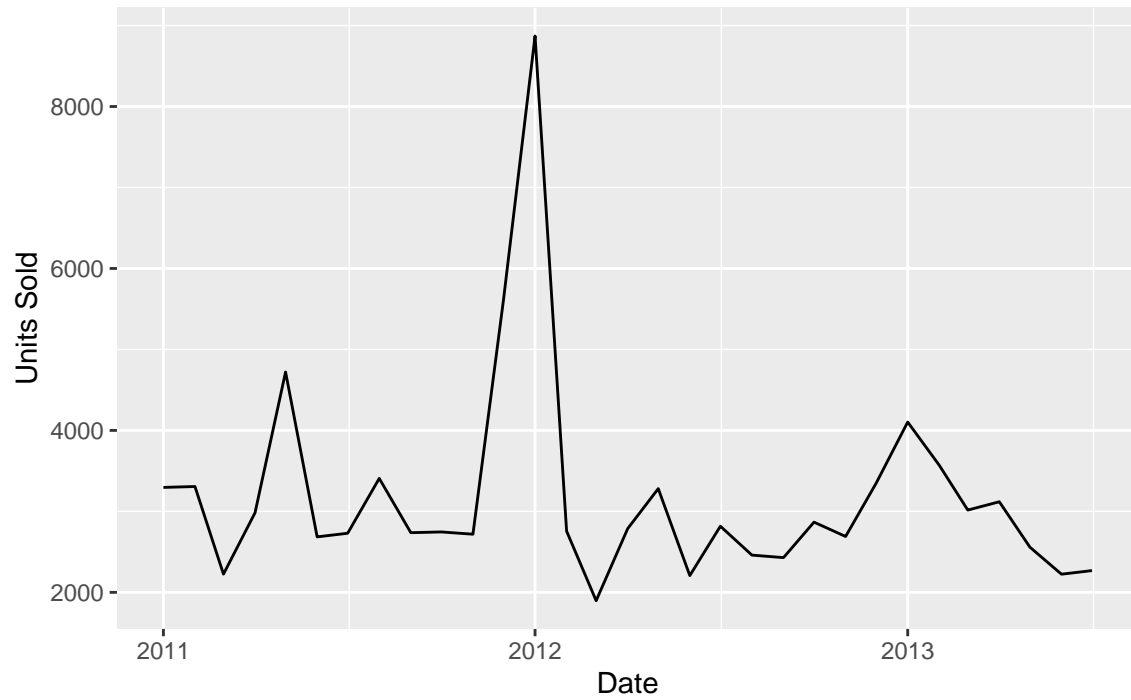
- Total monthly sales have been correctly computed and are displayed in an appropriate plot.
- Description of results/plot is correct and provides useful insights.
- Plot is constructed using ggplot2 and has appropriate titles, labels, scales etc.**

Answer

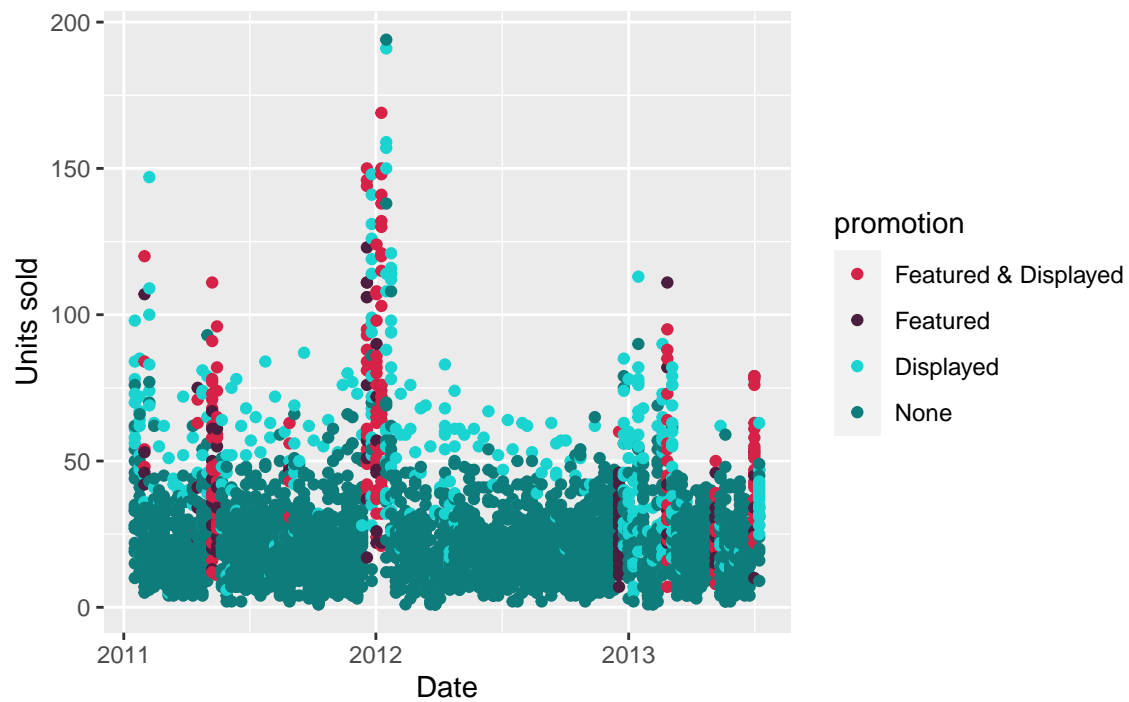
From Jan 2011 - July 2013 98434 units of sku 219844 were sold with a mean monthly sale of 3175.3. The interquartile range is 2621.5 - 3301.5. This means 50% of monthly sales lie within this range.

Monthly sales are plotted below, no trend or seasonal pattern is evident in this plot. There are three months with significantly more sales, May 2011, December 2011 and January 2012. The most significant outlier was in January 2012 when 8871 units were sold. As shown in the plots below these high monthly sales correspond a high proportion of stores featuring and/or displaying the product.

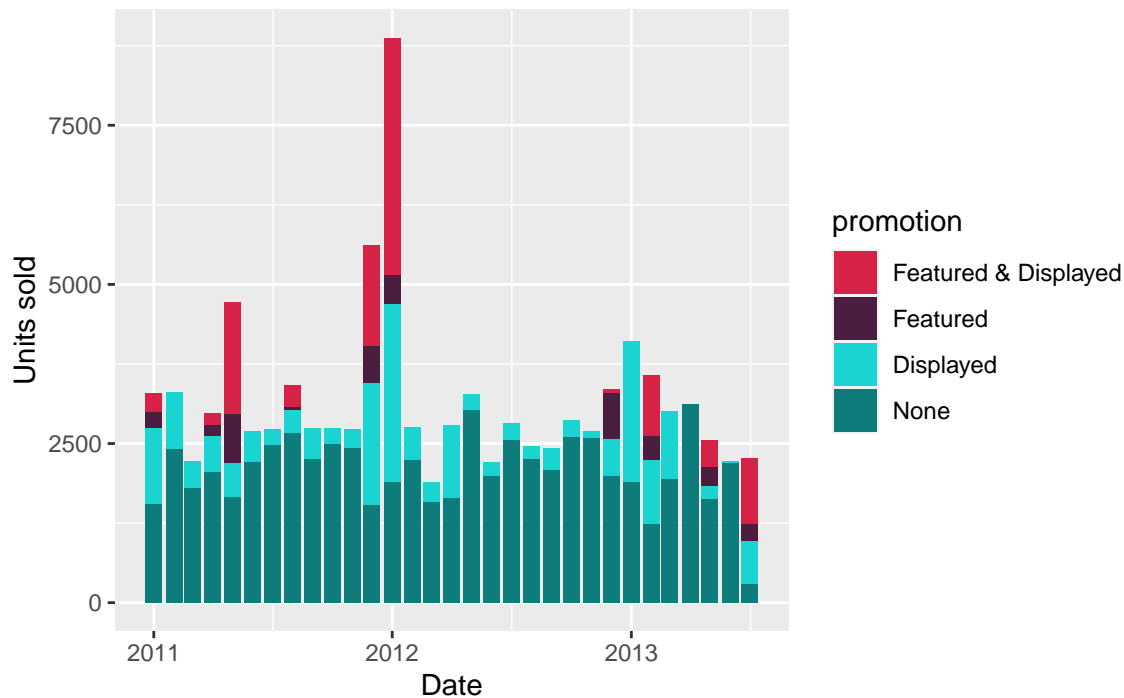
Monthly sales for product 219844 (Jan 2011 – July 2013)



Weekly sales for product 219844 with promotion categories



Monthly sales for product 219844 with promotion categories



1(b) The GM Sales wants to know which stores are performing well and which are not, in terms of product sales. For the product (sku_id) which has been assigned to your group, use appropriate summary statistics and plots to investigate sales performance across the stores and write 2 – 3 paragraphs summarising your findings.

Hint: You will need to decide what it means for a store to be “performing well” and how you will evaluate this using the data.

Marking criteria

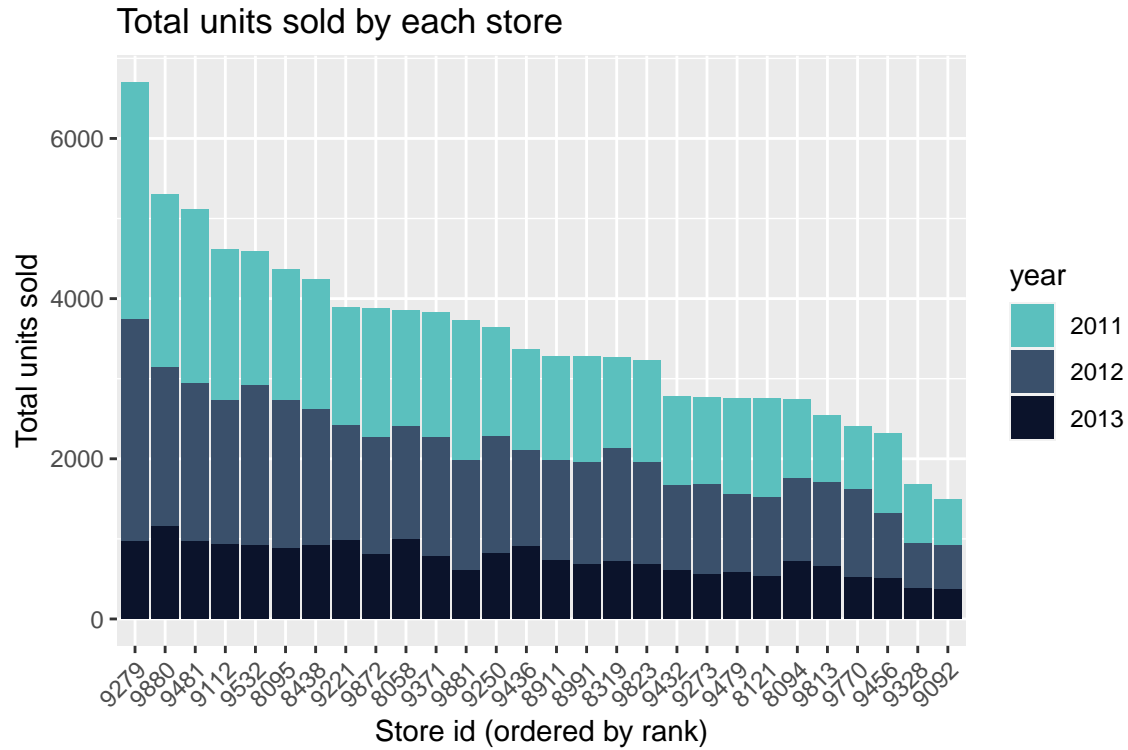
- Sales performance is clearly defined.
- Written summary includes relevant and appropriate summary statistics and plots.
- Plot/s are constructed using ggplot2 and have appropriate titles, labels, scales etc.
- Descriptions of results and plots are correct and provides useful insights.

Answer

All stores have been ranked based on their total sales from Jan 2011 to July 2013. The store with the highest total units sold is ranked ‘1’, this is store 9279 with 6698 units.

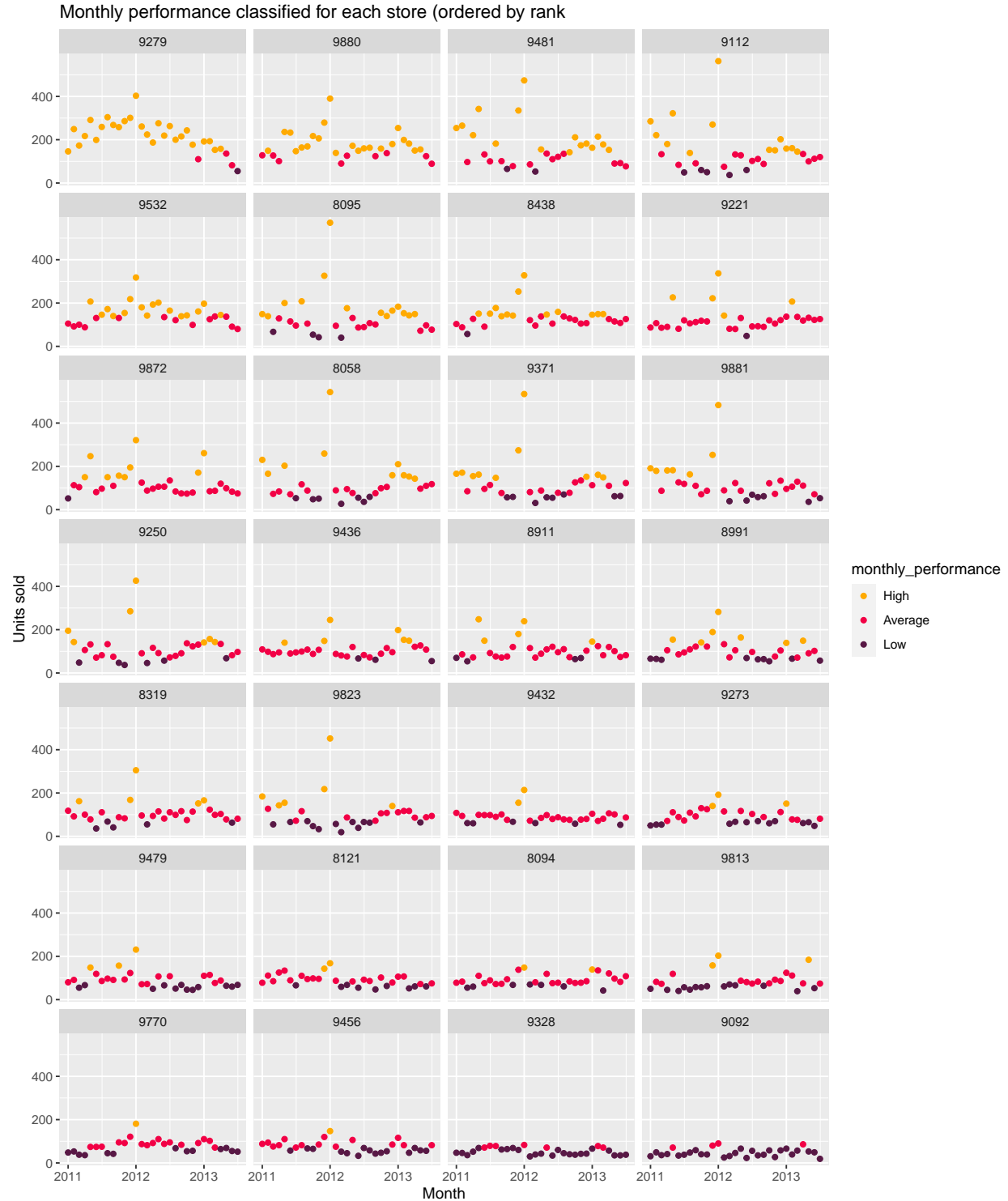
Below is a bar chart showing the total units sold with stores ordered by rank. Sales for 2013 are much lower than 2011 and 2012 as only half the years data is included.

|3 |9880 |5118|



Whilst some stores stand out with particularly high or low sales, many stores ranked in the middle have similar total sales.

For a more detailed look at store performance monthly sales have been plotted for each store and categorised as 'high', 'average' or 'low' performing. These categories are based on the interquartile range for monthly sales. This range is 71 - 138 and captures 50% of all monthly sales. Monthly sales within the range are classified as 'average', sales greater than 138 are classified as 'high' performing and those below 71 are classified as 'low' performing.

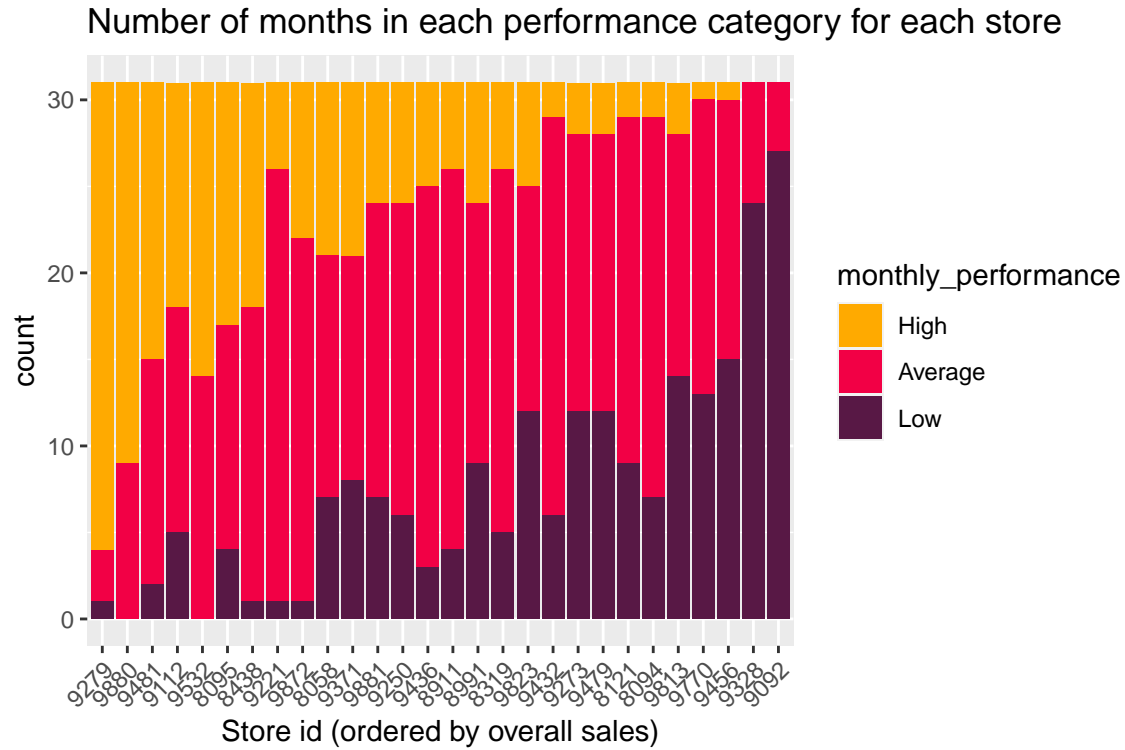


An interesting feature of these plots is that some stores perform highly more consistently than others. For example store 9112 had 5 low performing months but was ranked at 4 much higher than store 9872 which had only 1 low performing months but was ranked 9. Despite having higher overall sales store 9112 was less reliably successful than store 9872 and so was ranked more highly.

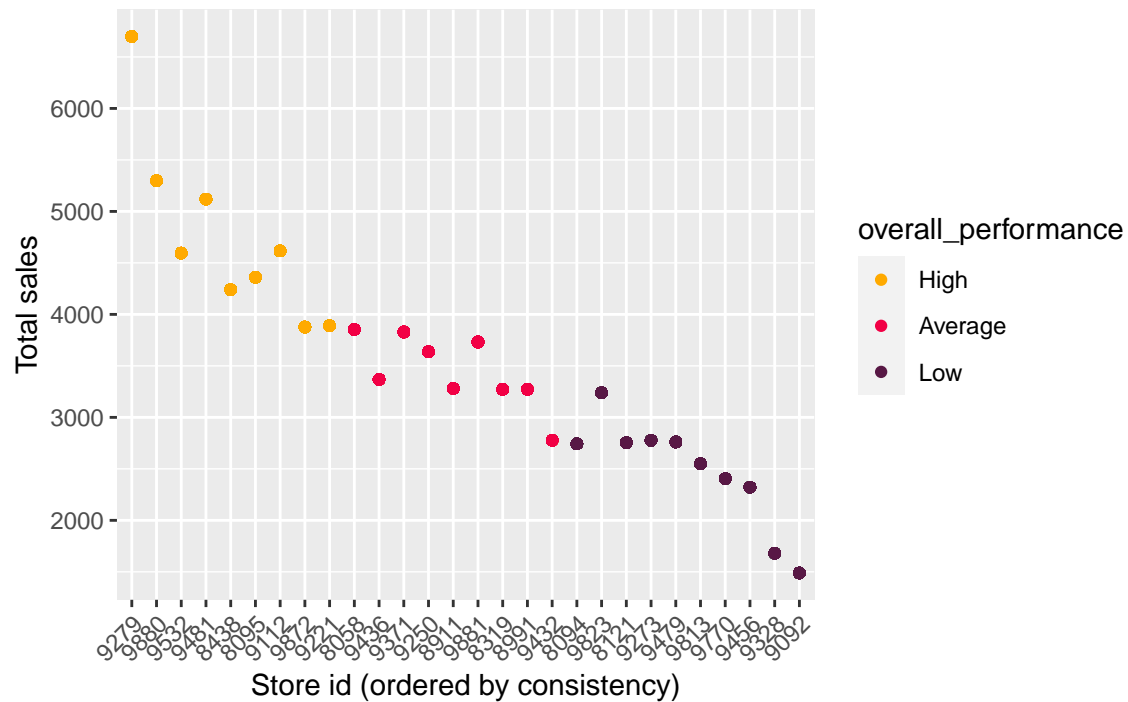
Stores with high occurrences of low sales are not reliable and are a source of risk. As an alternative to ranking stores based on their overall sales stores are ranked below using a consistency rating. For every

Below is a plot showing stores ordered according to the new consistency rank along with the number of High, Average and Low performing months they achieved. Another plot is included for comparison where stores are ranked according to overall sales. Under the new consistency ranking scheme stores with unreliable performance such as 9112 drop in rank whilst stores with reliable performance such as 9532 are ranked more highly.



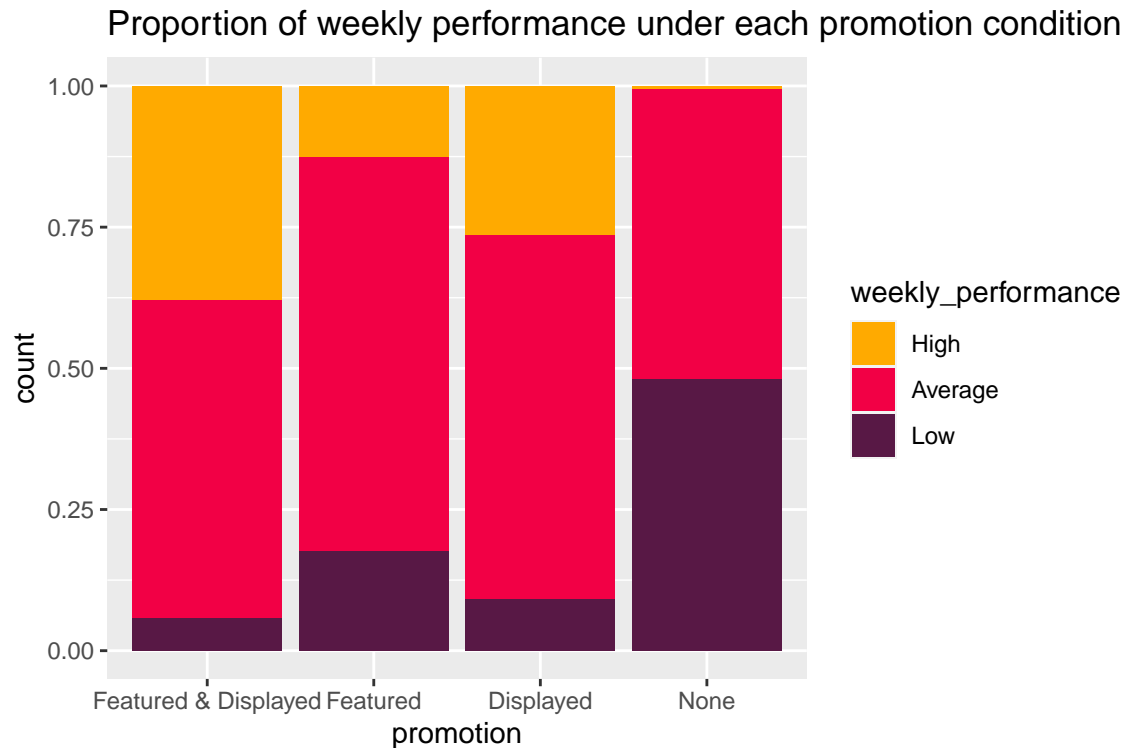


Stores with overall performance and total sales



Below is a plot showing that when a product is featured and/or displayed weekly sales are more likely to be high. Weekly performance has been categorised into 'High', 'Average' and 'Low' based on the interquartile range of weekly sales. When the product is featured and/or displayed a higher proportion of weekly sales have been 'High' or 'Average' compared to no promotion.

Low performing stores could boost their sales by increasing the number of weeks they promote the product. For high performing stores, performance reliability could be improved by introducing a weekly promotion if sales are unusually low.



Question 2

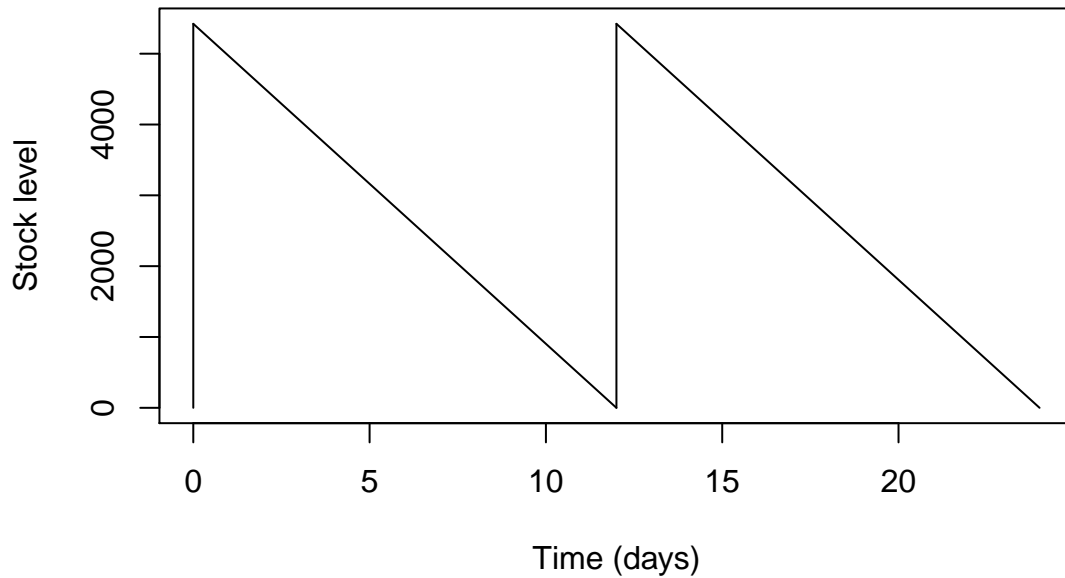
(a) The Operations Manager is interested in studying an EOQ model for

product 216233, based on sales in 2012. The setup and holding costs are known to be 130 per order and 1.50 per unit per year, respectively.

i) Determine the best order quantity in such a way that the costs are minimised. Write 1 – 2 paragraphs summarising your findings.

Marking criteria • Number of orders during a year, number of days between orders, and the total annual inventory cost are correctly computed and included in the findings. • The paragraphs clearly explain your findings. • Assumptions of the EOQ model are clearly stated

Inventory cycles for 216233



Optimum order quantity is 5422

Inventory cycle is 12

Annual inventory cost is 8132.6803762

Assumptions of EOQ model:

Known and constant demand

No lead time - orders arrive instantaneously

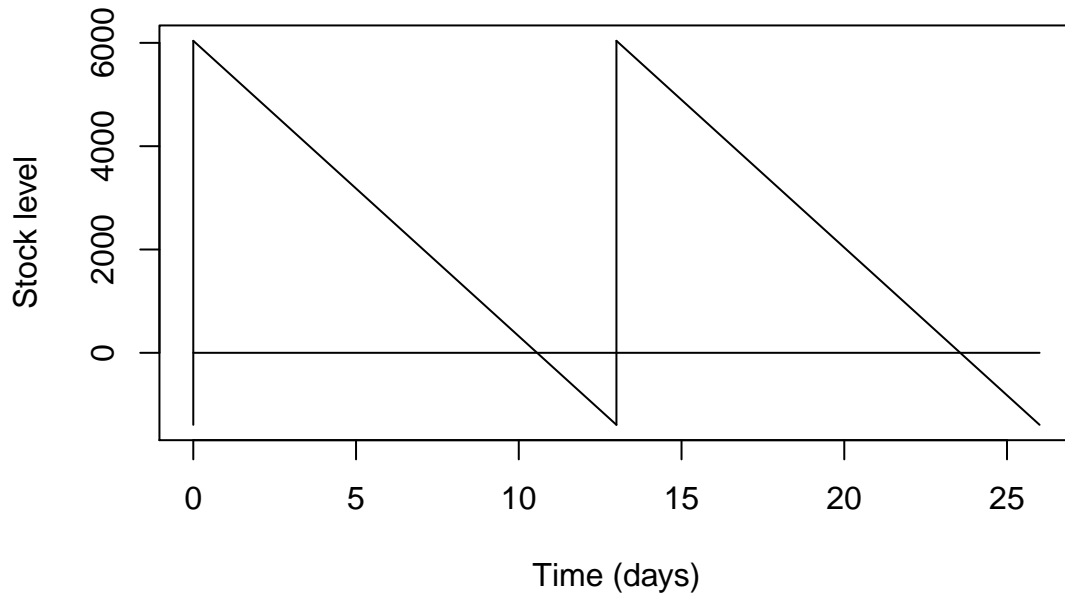
No back orders

ii) The Operations Manager is also interested in studying a model in

which backorders are permitted. According to its estimates, the cost of backorders is approximately 5% of the total price (price per unit). Determine the best order quantity in the sense that inventory costs are minimised. Write 1 -- 2 paragraphs summarising your findings and plot the first two inventory cycles.

Marking criteria • The optimum order quantity, maximum level of stock, optimum time between orders, proportion of time the company have to take backorders, and total annual inventory cost are correctly computed and included in your answer. • The paragraphs clearly explain your findings. • Assumptions of the model are clearly stated. • The first two inventory cycles are correctly plotted

Inventory cycles for 216233



Optimum ordering quantity 6040

Optimum maximum inventory level 4867

Optimum time between orders 13

Proportion of time taking back orders 23.0769231

Total inventory cost 7300.4389305

Assumptions of model:

known and constant demand

no lead time

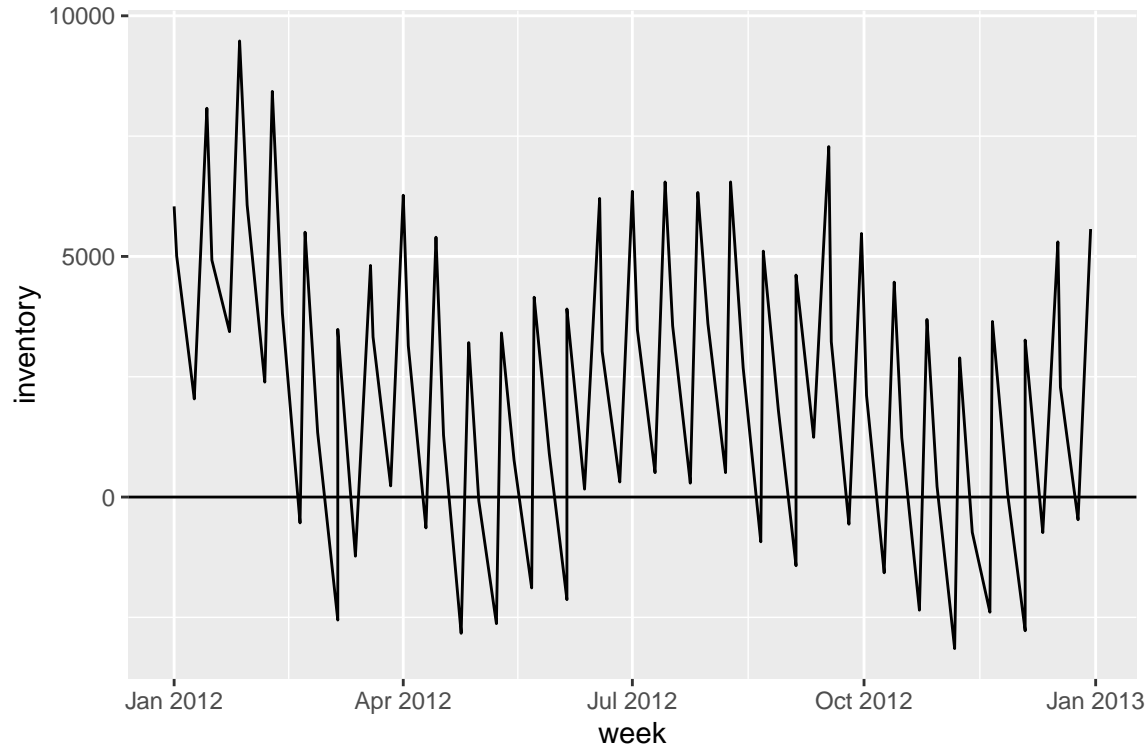
orders arrive instantaneously

back orders allowed

demand can be backordered when no stock

iii) Plot the inventory cycles associated with the model in part ii and compare with the observed inventory levels in 2012, assuming actual demand during 2012, and the order frequency and order quantity from the model. Write 2 – 3 sentences describing your plot.

Marking criteria • The inventory levels from the model and data are correctly plotted. • Accurate and insightful comments are made about the plot. • Note: This is a bonus question. The maximum mark that could be awarded for this project is 100

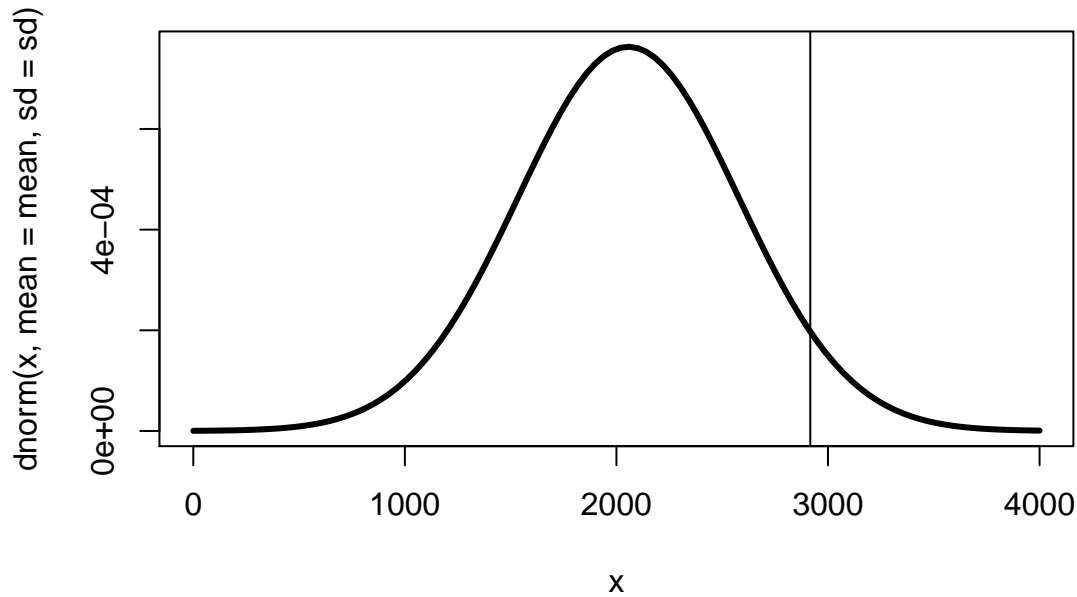


The Operations Manager is considering the option of a multi-period inventory model. The company, as a policy, is not willing to tolerate more than 5% chance of a stock-out. The Operations Manager has estimated that the annual holding cost is 6.50 per unit and the ordering cost is 20.50 per order.

- i. Calculate a multi-period inventory model for product 216425, based on the 2012 sales data. Create plot/s of the weekly average demand of this product. Use the costs stated in part (b) above. Write a paragraph explaining the results of your model and the plot/s.

Hint: Use the weekly demand to estimate the demand during a one-week lead time.

Marking criteria • The optimal order quantity, safety stock, expected annual cost, orders per years are correctly computed and included in your answer. • The paragraph clearly explains your findings. • The assumption of normality for the demand during a one-week lead time is discussed. • The weekly average demand of this product is correctly plotted and discussed



```
## integer(0)
```

Demand during a one week lead time has been estimated based off 2012 weekly demand. The mean weekly demand from 2012 and standard deviation have been applied to a normal distribution to estimate demand for this multi-inventory model.

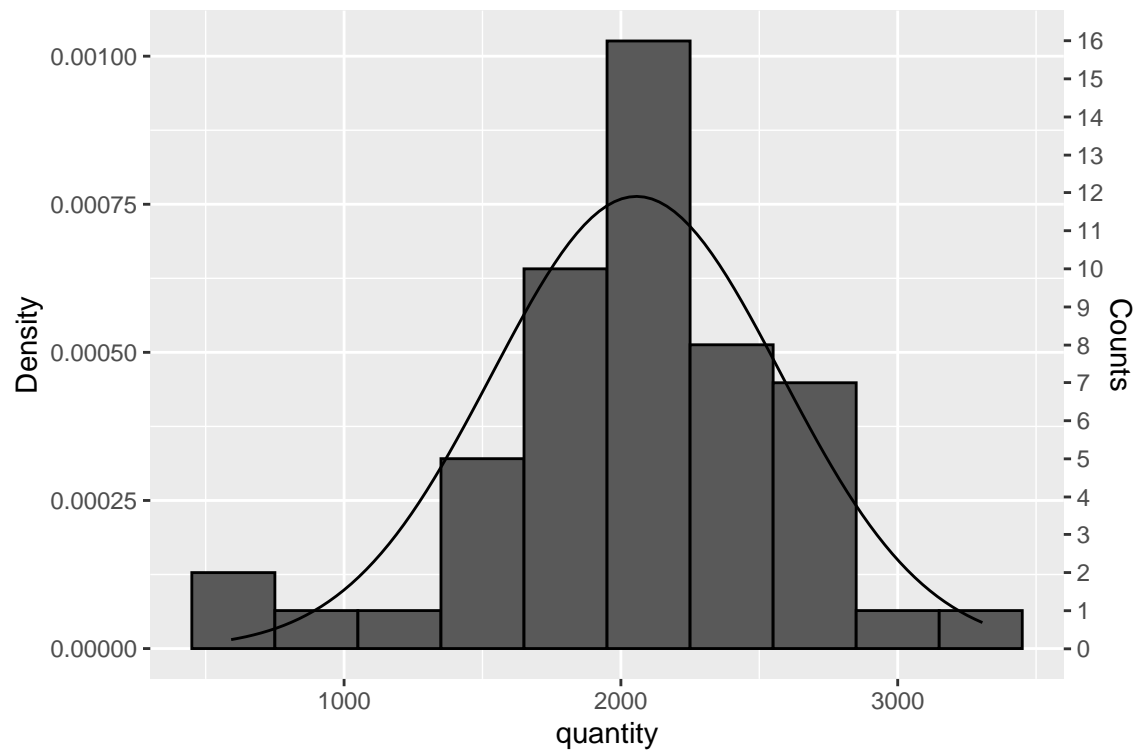
As the plot below shows, the actual demand for 2012 does not perfectly follow a normal distribution. It is difficult to determine the distribution of weekly demand based on only one year of observations. It is recommended that more data is used to for a more accurate model of demand distribution.

Based on 2012, where mean weekly demand was 2056.5192308 with standard deviation of 522.6820535, the expected annual demand is estimated to be 1.06939×10^5 .

Given this annual demand and the costs of holding and reordering stock, the recommended multi-inventory model is to order 821 units whenever the order quantity reaches the reorder point of 2916.2547022 units. Approximately 130 orders will be placed per year. Safety stock is 821.

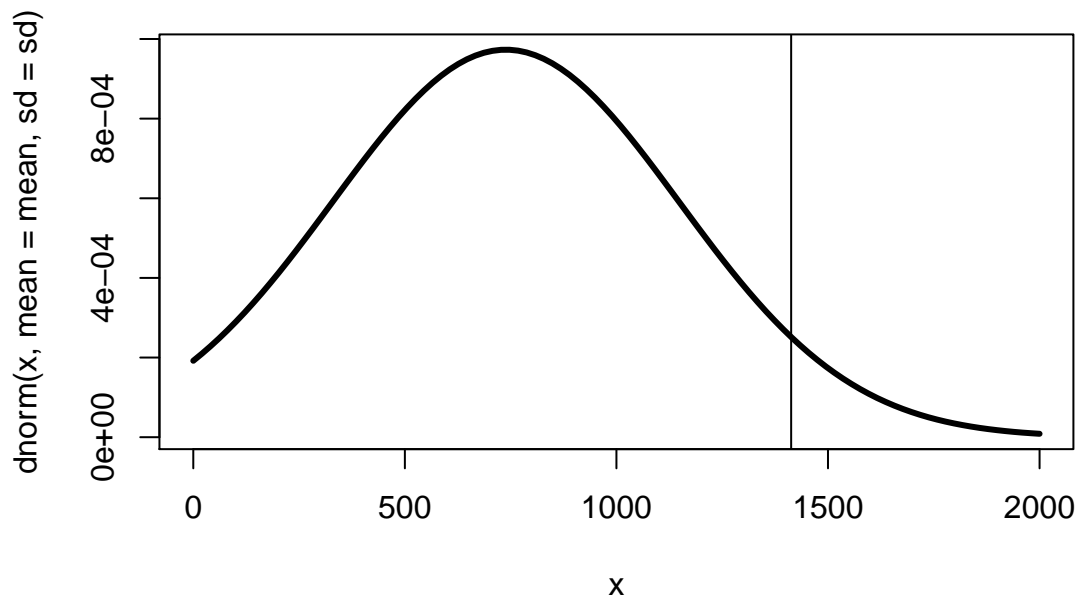
This approach ensures roughly 95% of the time the 2916.2547022 units will be able to satisfy demand during the lead time.

The expected annual costs are 1.0926749×10^4 per year. If demand was certain the annual costs would only be 1.0926749×10^4 , the additional cost of holding safety stock is the cost of uncertain demand.



2.b.ii. Investigate the use of a multi-period inventory model for the product which has been assigned to your group, based on the 2012 sales data. Create plot/s of the weekly average demand of this product. Use the costs stated in part (b) above.

Discuss the assumptions of the model and suggest a solution, in case of finding any problems. Write a paragraph explaining the results of your findings and the plot.



```
## integer(0)
```

Demand during a one week lead time has been estimated based off 2012 weekly demand. The mean weekly demand from 2012 and standard deviation have been applied to a normal distribution to estimate demand for this multi-inventory model.

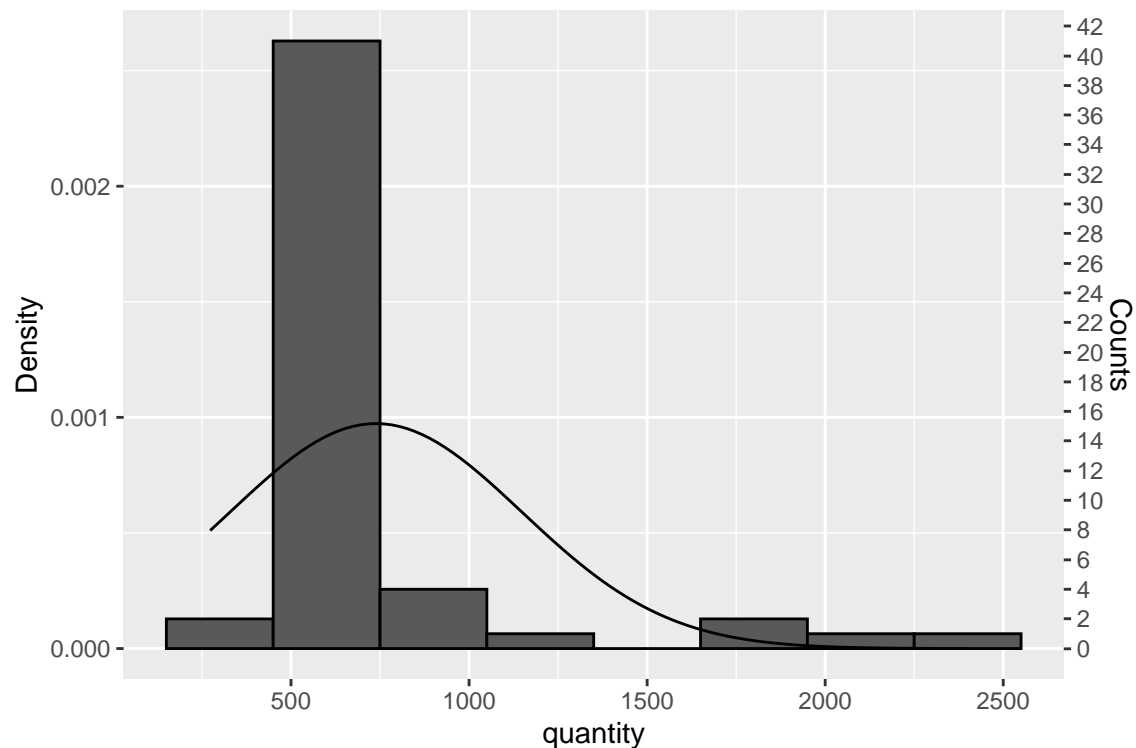
As the plot below shows the observed demand does not follow normal distribution with mean 738.6538462 409.9454715. It is recommended that a more suitable model is used to estimate demand.

Based on the flawed normal model, where mean weekly demand was 738.6538462 with standard deviation of 409.9454715, the expected annual demand is estimated to be 3.841×10^4 .

Given this annual demand and the costs of holding and reordering stock, the recommended multi-inventory model is to order 492 units whenever the order quantity reaches the reorder point of 1412.9541418 units. Approximately 78 orders will be placed per year. Safety stock is 492.

This approach ensures roughly 95% of the time the 1412.9541418 units will be able to satisfy demand during the lead time.

The expected annual costs are 7582.3685882 per year. If demand was certain the annual costs would only be 7582.3685882, the additional cost of holding safety stock is the cost of uncertain demand.



Question 3

Question 3a

```
## # A tibble: 6 x 14
##   title      brand main_cat price asin  document.id overall verified reviewTime
##   <chr>      <chr> <chr>   <chr> <chr>      <int>    <int> <lgl>    <chr>
## 1 BIC Round ~ BIC Office ~ $2.18 B000~    48735      4 TRUE   05 1, 2018
## 2 BIC Round ~ BIC Office ~ $2.18 B000~    48762      3 TRUE   04 24, 20~
## 3 BIC Round ~ BIC Office ~ $2.18 B000~    48763      5 TRUE   04 22, 20~
## 4 BIC Round ~ BIC Office ~ $2.18 B000~    48774      5 TRUE   04 21, 20~
## 5 BIC Round ~ BIC Office ~ $2.18 B000~    48775      5 TRUE   04 16, 20~
## 6 BIC Round ~ BIC Office ~ $2.18 B000~    48776      4 TRUE   04 10, 20~
## # ... with 5 more variables: reviewerID <chr>, reviewerName <chr>,
## #   reviewText <chr>, summary <chr>, unixReviewTime <int>
```

```
##   Min. 1st Qu. Median   Mean 3rd Qu.    Max.
## 1.000  5.000  5.000  4.669  5.000  5.000
```