Homework 1

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```
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.5.1     v tibble    3.2.1
## v lubridate 1.9.3     v tidyr     1.3.1
## v purrr     1.0.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(minpack.lm)
```

```
data <- read.csv('Data.csv', stringsAsFactors = FALSE, sep = ";")
data$AR.Hardware <- as.numeric(data$AR.Hardware)
```

```
## Warning: NAs introduced by coercion
```

```
data$AR.Software <- as.numeric(data$AR.Software)
data$AR.Hardware[is.na(data$AR.Hardware)] <- 0
filtered_data <- data %>% filter(Year <= 2023) %>%
  select(Year, AR.Software, AR.Hardware)
filtered_data <- filtered_data %>%
  mutate(Total.AR.Adoption = AR.Software + AR.Hardware)
filtered_data
```

```
##   Year AR.Software AR.Hardware Total.AR.Adoption
## 1 2017      137.20        0.00            137.20
## 2 2018      143.50        0.00            143.50
## 3 2019      154.71        0.00            154.71
## 4 2020      172.96        9.05            182.01
## 5 2021      199.01       13.58            212.59
## 6 2022      230.94       21.92            252.86
## 7 2023      263.36       49.45            312.81
```

```r
bass_model_cumulative <- function(t, p, q, M) {
  adoption <- M * (1 - exp(-(p + q) * t)) / (1 + (q / p) * exp(-(p + q) * t))
  return(adoption)
}

time_periods <- 1:nrow(filtered_data)
total_adoption <- filtered_data$Total.AR.Adoption

initial_guess <- c(p = 0.03, q = 0.38, M = max(total_adoption) * 2)

fit <- nlsLM(Total.AR.Adoption ~ bass_model_cumulative(time_periods, p, q, M),
             data = filtered_data, start = initial_guess)

params <- coef(fit)
p <- params['p']
q <- params['q']
M <- params['M']
```

```r
cat("Estimated p (Coefficient of innovation):", p, "\n")
```

```
## Estimated p (Coefficient of innovation): 0.2200149
```

```r
cat("Estimated q (Coefficient of imitation):", q, "\n")
```

```
## Estimated q (Coefficient of imitation): -0.2200872
```

```r
cat("Estimated M (Market potential):", M, "\n")
```

```
## Estimated M (Market potential): 449.5019
```

```r
future_years <- 1:(nrow(filtered_data) + 12)

predicted_cumulative_adoption <- bass_model_cumulative(future_years, p, q, M)
predicted_yearly_adoption <- c(0, diff(predicted_cumulative_adoption))

prediction_df <- data.frame(
  Year = 2020:(2020 + length(future_years) - 1),
  Cumulative_Adoption = predicted_cumulative_adoption,
  Yearly_Adoption = predicted_yearly_adoption
)

print(prediction_df)
```

```
##    Year Cumulative_Adoption Yearly_Adoption
## 1  2020             81.0598        0.000000
## 2  2021            137.3473       56.287534
## 3  2022            178.7132       41.365861
## 4  2023            210.3965       31.683294
## 5  2024            235.4406       25.044156
## 6  2025            255.7346       20.293927
```

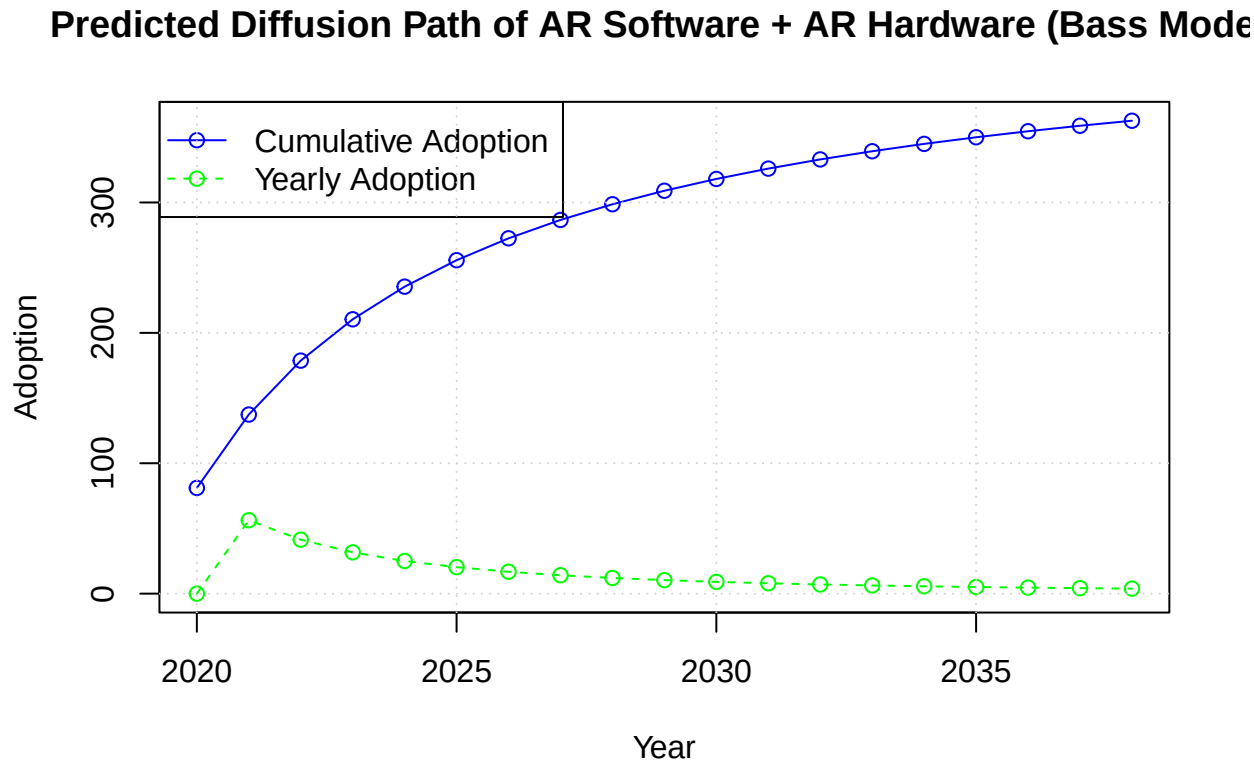
```
## 7  2026            272.5127       16.778123
## 8  2027            286.6158       14.103124
## 9  2028            298.6364       12.020622
## 10 2029            309.0041       10.367666
## 11 2030            318.0378        9.033724
## 12 2031            325.9795        7.941666
## 13 2032            333.0158        7.036343
## 14 2033            339.2933        6.277479
## 15 2034            344.9284        5.635097
## 16 2035            350.0149        5.086520
## 17 2036            354.6293        4.614330
## 18 2037            358.8342        4.204975
## 19 2038            362.6820        3.847780
```

```r
plot(prediction_df$Year, prediction_df$Cumulative_Adoption, type = "o", col = "blue",
     xlab = "Year", ylab = "Adoption", main = "Predicted Diffusion Path of AR Software + AR Hardware (Ba
     ylim = range(c(prediction_df$Cumulative_Adoption, prediction_df$Yearly_Adoption)))

lines(prediction_df$Year, prediction_df$Yearly_Adoption, type = "o", col = "green", lty = 2)

legend("topleft", legend = c("Cumulative Adoption", "Yearly Adoption"), col = c("blue", "green"),
       lty = c(1, 2), pch = c(1, 1))

grid()
```



As my data is related to only Italy I decided to analyze the diffusion focusing on a country-specific analysis.

```r
bass_model_cumulative <- function(t, p, q, M) {
  adoption <- M * (1 - exp(-(p + q) * t)) / (1 + (q / p) * exp(-(p + q) * t))
  return(adoption)
}
future_years <- 1:15

predicted_cumulative_adoption <- bass_model_cumulative(future_years, p, q, M)

predicted_yearly_adoption <- c(0, diff(predicted_cumulative_adoption))

adoption_df <- data.frame(
  Year = 2020:(2020 + length(future_years) - 1),
  Cumulative_Adoption = predicted_cumulative_adoption,
  Yearly_Adoption = predicted_yearly_adoption
)

print(adoption_df)
```

```
##    Year Cumulative_Adoption Yearly_Adoption
## 1  2020             81.0598        0.000000
## 2  2021            137.3473       56.287534
## 3  2022            178.7132       41.365861
## 4  2023            210.3965       31.683294
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