# Homework 1. Bass Model

Sate Antaranyan

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Innovation I chose is LG Signature OLED M Television. This tv has one cable for power and no inputs or outputs like other tvs.

The look-alike innovation from the past I chose is LCD television. I chose LCD tv because it's a television like the LG Signature OLED M Television. This tv uses liquid crystal display, has advantages that are - it consumes less power than plasma displays, it is compact, thin. I wanted the look-alike innovation to also have some kind of advantages as the LG one focuses on its advantage, which is having only one cable and so it brings comfort to its customers, while the LCD one focuses on bringing comfort by being thin and using less power which results in small heat emitted during operation.

I found a TV sales in Germany dataset that has LCD TV sales from 2005-2022.I added a sheet in the dataset with just the LCD TV sales column and the year column.

```
library(readxl)
library(ggplot2)
library(ggpubr)
library(diffusion)
```

Reading the data.

```
lcd <- read_excel('tv-set-sales.xlsx')
```

```
## New names:
## * `` -> `...3`
## * `` -> `...4`
## * `` -> `...5`
```

```
lcd
```

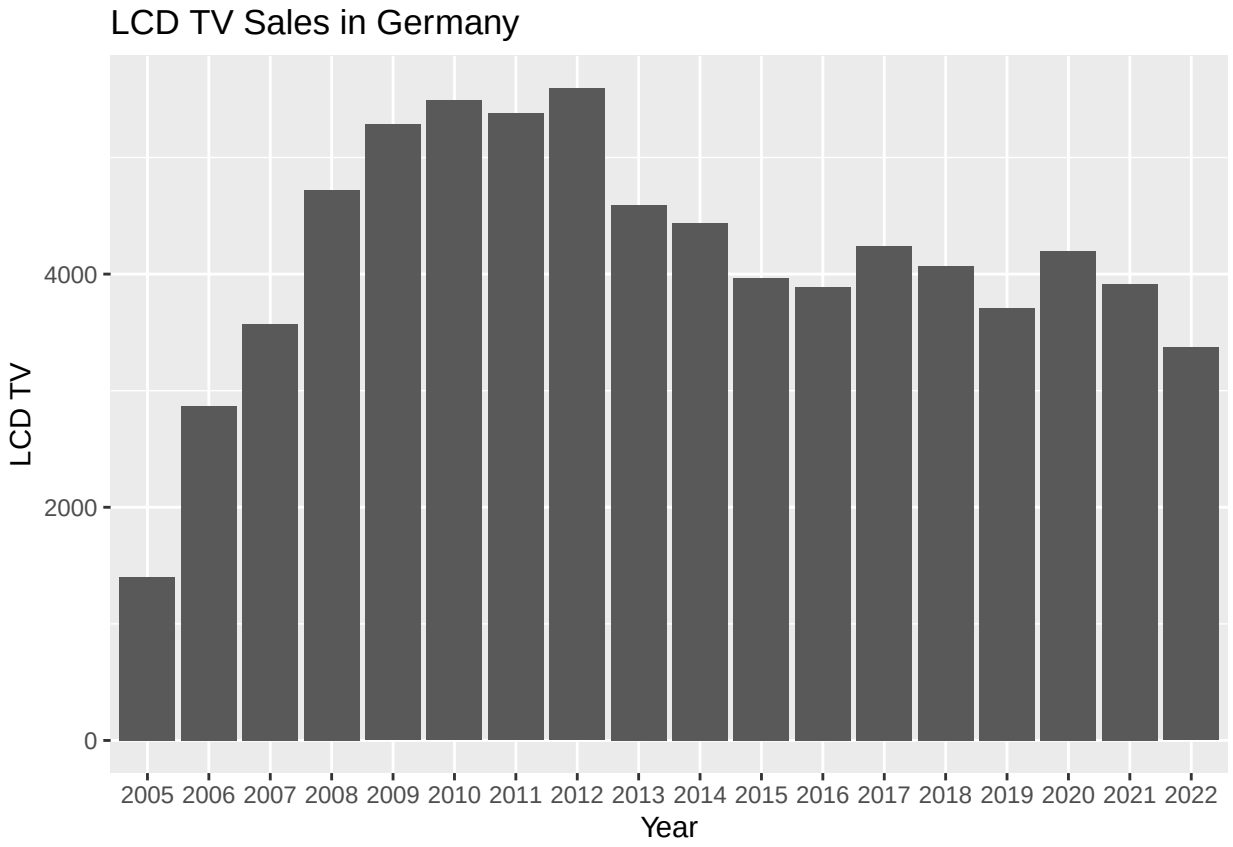
```
## # A tibble: 18 x 5
##    Year  `LCD TV` ...3  ...4  ...5
##    <chr>    <dbl> <lgl> <lgl> <lgl>
##  1 2005      1404 NA    NA    NA
##  2 2006      2865 NA    NA    NA
##  3 2007      3569 NA    NA    NA
##  4 2008      4722 NA    NA    NA
##  5 2009      5283 NA    NA    NA
##  6 2010      5489 NA    NA    NA
##  7 2011      5377 NA    NA    NA
##  8 2012      5592 NA    NA    NA
##  9 2013      4591 NA    NA    NA
## 10 2014      4439 NA    NA    NA
## 11 2015      3970 NA    NA    NA
## 12 2016      3890 NA    NA    NA
## 13 2017      4238 NA    NA    NA
## 14 2018      4073 NA    NA    NA
```

```
## 15 2019       3706 NA     NA     NA
## 16 2020       4198 NA     NA     NA
## 17 2021       3913 NA     NA     NA
## 18 2022       3370 NA     NA     NA
```

Plotting the data.

```
sales = ggplot(data = lcd, aes(x=Year,y=`LCD TV`)) +
  geom_bar(stat = 'identity') +
  ggtitle('LCD TV Sales in Germany')

sales
```




Defining f(t) and F(t)

```
bass.f <- function(t,p,q){
  ((p+q)^2/p)*exp(-(p+q)*t)/
    (1+(q/p)*exp(-(p+q)*t))^2
  }

bass.F <- function(t,p,q){ (1-exp(-(p+q)*t))/
    (1+(q/p)*exp(-(p+q)*t))
  }
```

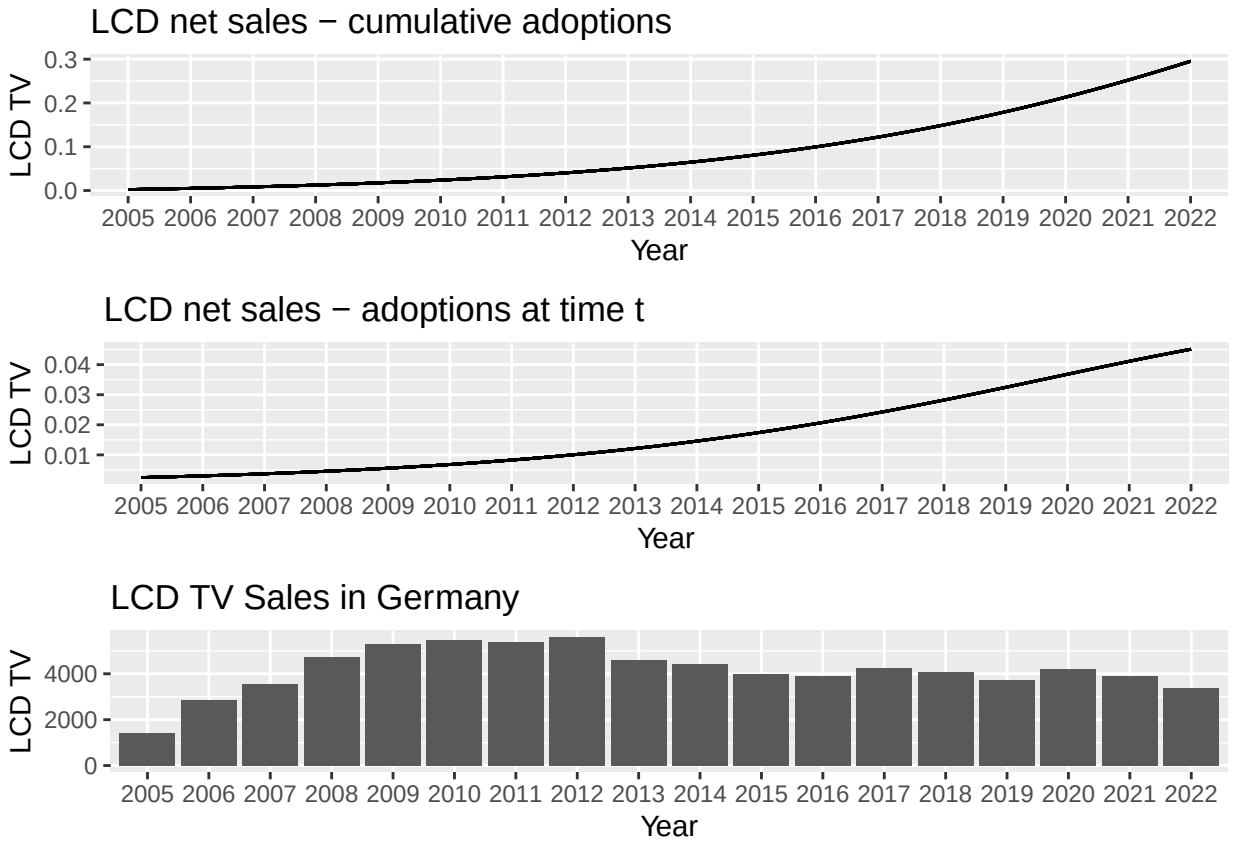
Adoptions and Cumulative Adoptions

```
c_adopt = ggplot(data = lcd, aes(x =Year, y = `LCD TV`)) +
  stat_function(fun = bass.F, args = c(p = 0.002, q = 0.21))+
  labs(title = "LCD net sales - cumulative adoptions")
```

```
t_adopt = ggplot(data = lcd, aes(x = Year, y = `LCD TV`)) +
  stat_function(fun = bass.f, args = c(p = 0.002, q = 0.21))+
  labs(title = "LCD net sales - adoptions at time t")

ggarrange(c_adopt, t_adopt, sales, ncol = 1)
```

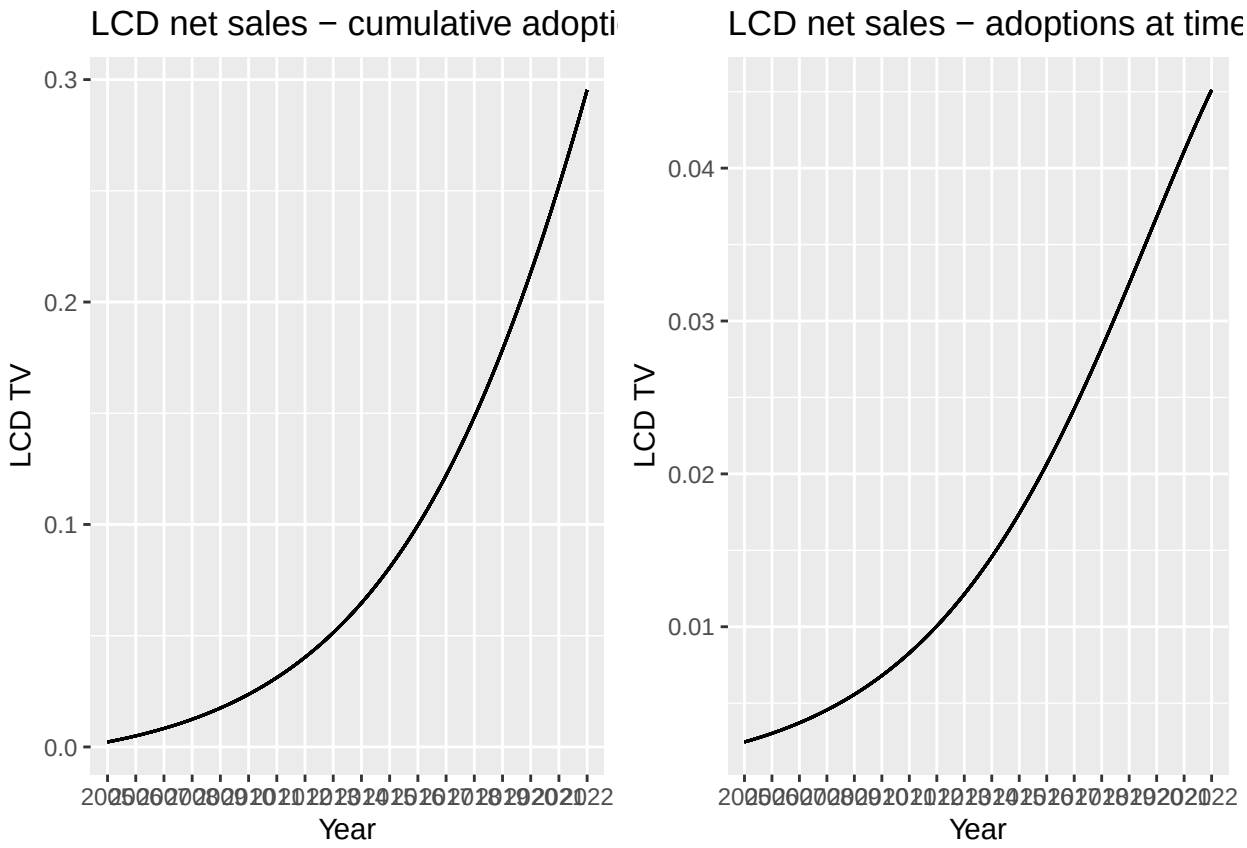
```
## Warning: Multiple drawing groups in `geom_function()`
## i Did you use the correct group, colour, or fill aesthetics?
## Multiple drawing groups in `geom_function()`
## i Did you use the correct group, colour, or fill aesthetics?
```




The same plots just plotted without the Sales in Germany plot because it's more visible this way.

```
ggarrange(c_adopt, t_adopt)
```

```
## Warning: Multiple drawing groups in `geom_function()`
## i Did you use the correct group, colour, or fill aesthetics?
## Multiple drawing groups in `geom_function()`
## i Did you use the correct group, colour, or fill aesthetics?
```

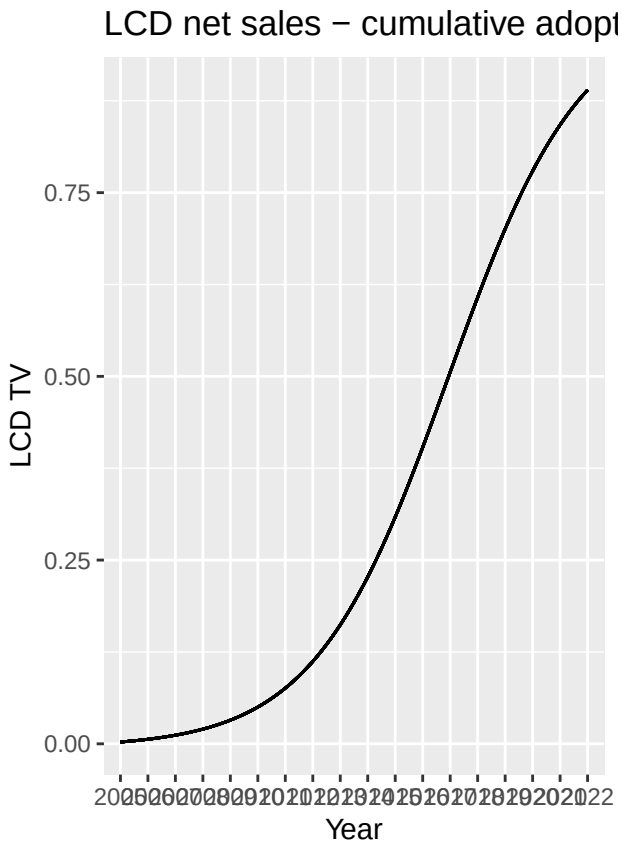


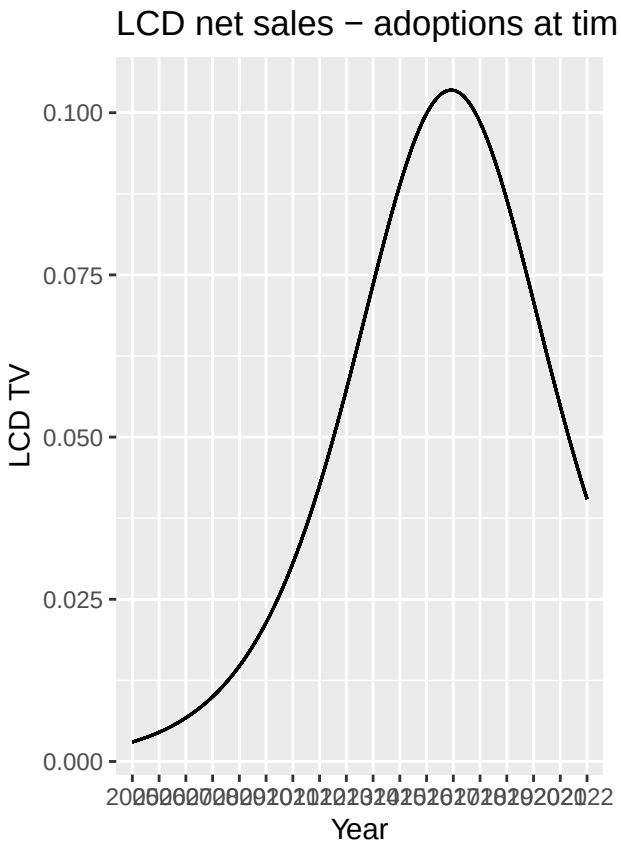

Changing the q parameter.

```
c_adopt = ggplot(data = lcd, aes(x =Year, y = `LCD TV`)) +
  stat_function(fun = bass.F, args = c(p = 0.002, q = 0.41))+
  labs(title = "LCD net sales - cumulative adoptions")

t_adopt = ggplot(data = lcd, aes(x = Year, y = `LCD TV`)) +
  stat_function(fun = bass.f, args = c(p = 0.002, q = 0.41))+
  labs(title = "LCD net sales - adoptions at time t")
ggarrange(c_adopt, t_adopt)
```

```
## Warning: Multiple drawing groups in `geom_function()`
## i Did you use the correct group, colour, or fill aesthetics?
## Multiple drawing groups in `geom_function()`
## i Did you use the correct group, colour, or fill aesthetics?
```




The "diffusion" library helps to estimate the Bass model parameters.

```
diff_m = diffusion(lcd$`LCD TV`)
p=round(diff_m$w,4)[1]
q=round(diff_m$w,4)[2]
m=round(diff_m$w,4)[3]
diff_m
```

```
## bass model
##
## Parameters:
##                                 Estimate p-value
## p - Coefficient of innovation     0.0308      NA
## q - Coefficient of imitation      0.1592      NA
## m - Market potential          88641.8825      NA
##
## sigma: 719.5613
```

Parameter Estimation using Non-linear Least Squares

```
sales = lcd$`LCD TV`
t = 1:length(sales)
bass_m = nls(sales ~ m*(((p+q)**2/p)*exp(-(p+q)*t))/
               (1+(q/p)*exp(-(p+q)*t))**2,
             start=c(list(m=sum(sales),p=0.02,q=0.4)),control=nls.control(maxiter = 100, minFactor = 1/
```

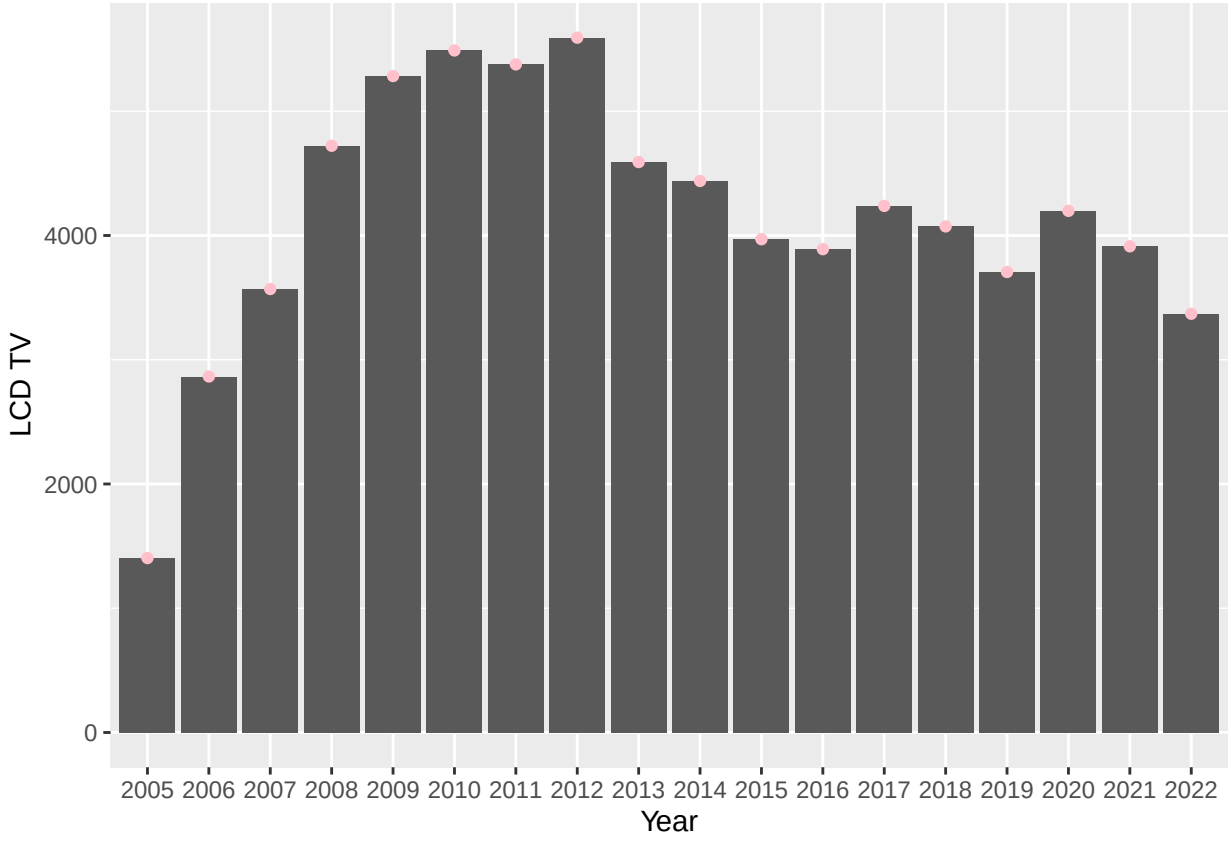
```
##   It.   1, fac=           1, eval (no.,total): ( 1,  1): new dev = 2.08613e+07
##   It.   2, fac=           1, eval (no.,total): ( 1,  2): new dev = 1.04337e+07
##   It.   3, fac=           1, eval (no.,total): ( 1,  3): new dev = 9.064e+06
##   It.   4, fac=           1, eval (no.,total): ( 1,  4): new dev = 9.05197e+06
```

```
##   It.   5, fac=           1, eval (no.,total): ( 1,  5): new dev = 9.0514e+06
##   It.   6, fac=           1, eval (no.,total): ( 1,  6): new dev = 9.05137e+06
##   It.   7, fac=           1, eval (no.,total): ( 1,  7): new dev = 9.05137e+06
##   It.   8, fac=           1, eval (no.,total): ( 1,  8): new dev = 9.05137e+06
##   It.   9, fac=           1, eval (no.,total): ( 1,  9): new dev = 9.05137e+06
```

```
bass_m
```

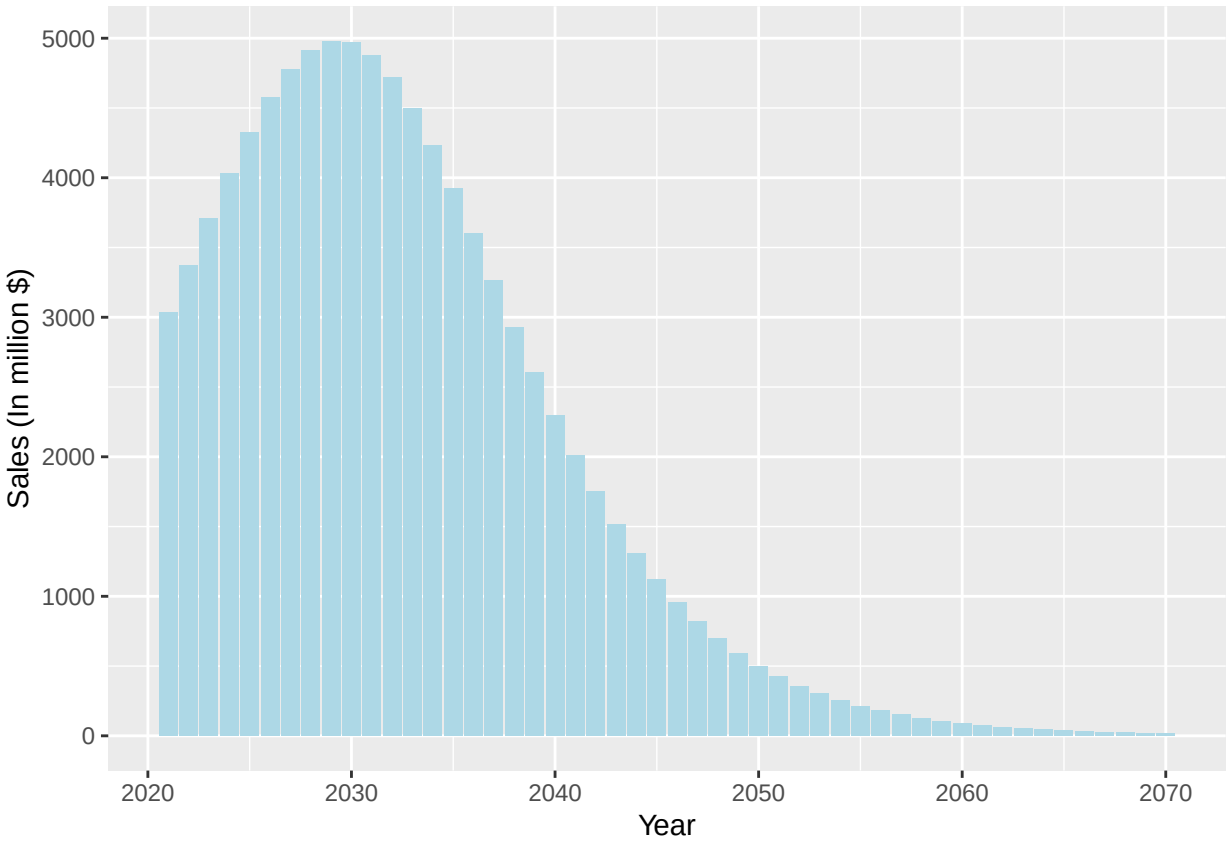
```
## Nonlinear regression model
##   model: sales ~ m * (((p + q)^2/p) * exp(-(p + q) * t))/(1 + (q/p) *     exp(-(p + q) * t))^2
##    data: parent.frame()
##         m         p         q
## 9.499e+04 2.853e-02 1.473e-01
##  residual sum-of-squares: 9051367
##
## Number of iterations to convergence: 9
## Achieved convergence tolerance: 6.131e-06
```

```
lcd$pred_sales = bass.f(1:length(sales), p = 2.853e-02, q = 1.473e-01) * 9.499e+04
ggplot(data = lcd, aes(x = Year, y = `LCD TV`)) +
  geom_bar(stat = 'identity') +
  geom_point(mapping = aes(x = Year, y = `LCD TV`), color = 'pink')
```




```
innovation_prediction <- bass.f(1:50, p = 2.853e-02, q = 1.473e-01) * 9.499e+04
years <- seq(from = 2021, to = 2021 + 49, by = 1)
innovation_data <- data.frame(Year = years, Sales = innovation_prediction)

ggplot(data = innovation_data, aes(x = Year, y = Sales)) +
  geom_bar(stat='identity', fill = 'lightblue') + ylab("Sales (In million $)")
```




The LG Signature OLED TV has different sizes 97 inch, 83, inch, 77 inch. I calculated the average price and got 12460 euros. I've got the information that OLED TVs are making up 738k of the whole 5.5 million units shipped.

```
average_price <- 12460
oled_shipments <- 738000
revenue_oled <- average_price * oled_shipments
total_revenue_oled <- 5500000000
market_share <- revenue_oled / total_revenue_oled
total_market_size <- total_revenue_oled / market_share
```

```
cumulative_adopters <- cumsum(innovation_data$Sales)
new_adopters <- c(cumulative_adopters[1], diff(cumulative_adopters))
estimated_adopters = data.frame(Year = years, New_Adopters = new_adopters, Market_Share = market_share)
estimated_adopters
```

```
##    Year New_Adopters Market_Share
## 1  2021   3038.52390     1.671905
## 2  2022   3374.83184     1.671905
## 3  2023   3709.33629     1.671905
## 4  2024   4030.37664     1.671905
## 5  2025   4324.83433     1.671905
## 6  2026   4579.02138     1.671905
## 7  2027   4779.85067     1.671905
## 8  2028   4916.15095     1.671905
## 9  2029   4979.92306     1.671905
## 10 2030   4967.30857     1.671905
## 11 2031   4879.07656     1.671905
## 12 2032   4720.52557     1.671905
```

```
## 13 2033   4500.82186     1.671905
## 14 2034   4231.91187     1.671905
## 15 2035   3927.22163     1.671905
## 16 2036   3600.36945     1.671905
## 17 2037   3264.07700     1.671905
## 18 2038   2929.38940     1.671905
## 19 2039   2605.23552     1.671905
## 20 2040   2298.29573     1.671905
## 21 2041   2013.10662     1.671905
## 22 2042   1752.32000     1.671905
## 23 2043   1517.03978     1.671905
## 24 2044   1307.17683     1.671905
## 25 2045   1121.78161     1.671905
## 26 2046    959.33164     1.671905
## 27 2047    817.96500     1.671905
## 28 2048    695.65964     1.671905
## 29 2049    590.36417     1.671905
## 30 2050    500.08787     1.671905
## 31 2051    422.95835     1.671905
## 32 2052    357.25467     1.671905
## 33 2053    301.42268     1.671905
## 34 2054    254.07797     1.671905
## 35 2055    214.00063     1.671905
## 36 2056    180.12506     1.671905
## 37 2057    151.52701     1.671905
## 38 2058    127.40936     1.671905
## 39 2059    107.08795     1.671905
## 40 2060     89.97778     1.671905
## 41 2061     75.58027     1.671905
## 42 2062     63.47162     1.671905
## 43 2063     53.29236     1.671905
## 44 2064     44.73819     1.671905
## 45 2065     37.55186     1.671905
## 46 2066     31.51620     1.671905
## 47 2067     26.44805     1.671905
## 48 2068     22.19308     1.671905
## 49 2069     18.62137     1.671905
## 50 2070     15.62358     1.671905
```

The last estimations are done worldwide.

Reference: Average price for plasma screen and LCD TV sets sold in Germany from 2005 to 2022 (in euros) Retrieved from Statista on 20th February 2024. https://www.statista.com/statistics/462655/plasma-and-lcd-tvs-average-prices-germany/