



American University of Armenia

Akian College of Science and Engineering

Homework 1 | Bass Model

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From the TIME's highlighted 100 inventions in 2020, this paper discusses the new E-Assist Stroller, its look-alike innovation from the past, estimated Bass Model parameters, the predictions of the diffusion of the innovation and the potential market share of the product in Germany.

The stroller industry is a part of the market that specializes in creating, making, and supplying baby carriages or strollers. Although baby carriages have been present for many centuries, modern baby strollers were introduced in the early 1900s (McGregor, 2014). Over time the industry has expanded and adapted new features to meet the evolving needs of parents. Nowadays, the industry is a massive business worth billions of dollars, including a broad range of stroller options designed for various preferences and lifestyles.

One of the innovations in this industry is the new E-Assist Stroller (*see Figure 1*). It is Cybex's product which is a German company for baby carriages/strollers, car seats and furniture. The key innovation is that it is equipped with an electronic motor that provides parents with an additional push. Additionally, E-Assist Stroller detects downhill slopes and applies the brakes, which makes the product easy to handle and very safe (TIME, 2020).

A look-alike innovation to the E-Assist Stroller from the past are standard strollers (*see Figure 2*). They can be compared with each other through several main factors that provide means to use them as a look-alike innovation to the new E-Assist Stroller.

Firstly, they share a common design. The design is similar since they have a seat, a hood to keep the baby from the sun or rain, and four wheels for transportation. Different models have minor changes; for example, some baby carriages include some toys and adjustable handles, but the overall principle of the design for E-Assist Stroller and standard stroller is the same.

Both have the purpose of transporting babies with the help of an elder. The basic concept of four-wheeled device to transport babies remains the same for both products. E-Assist Strollers share the same purpose with standard baby carriages with an additional features to improve the convenience for babies and their parents.

Thirdly, as E-Assist Strollers have the same design and principle, people who use baby carriages change from using standard strollers to E-Assist Stroller without any trouble which shows that standard stroller is look-alike innovation for E-Assist Stroller.

For a look-alike innovation, the data is taken from [statista.com](https://www.statista.com). The time series data represents the sales volume of baby carriages and car seats in Germany from 2014 to 2022. And, it is represented in 1,000 units.

The data has three columns: year, car seats and baby carriages, and 9 observations.

Using Germany's sales data of the baby carriages over nine years, the following code makes predictions of the diffusion of the innovation and estimates the number of adopters by time period of E-Assist Stroller in Germany.



Figure 1: E-Assist Stroller



Figure 2: Standard Stroller

Bass Model

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

Data Manipulations

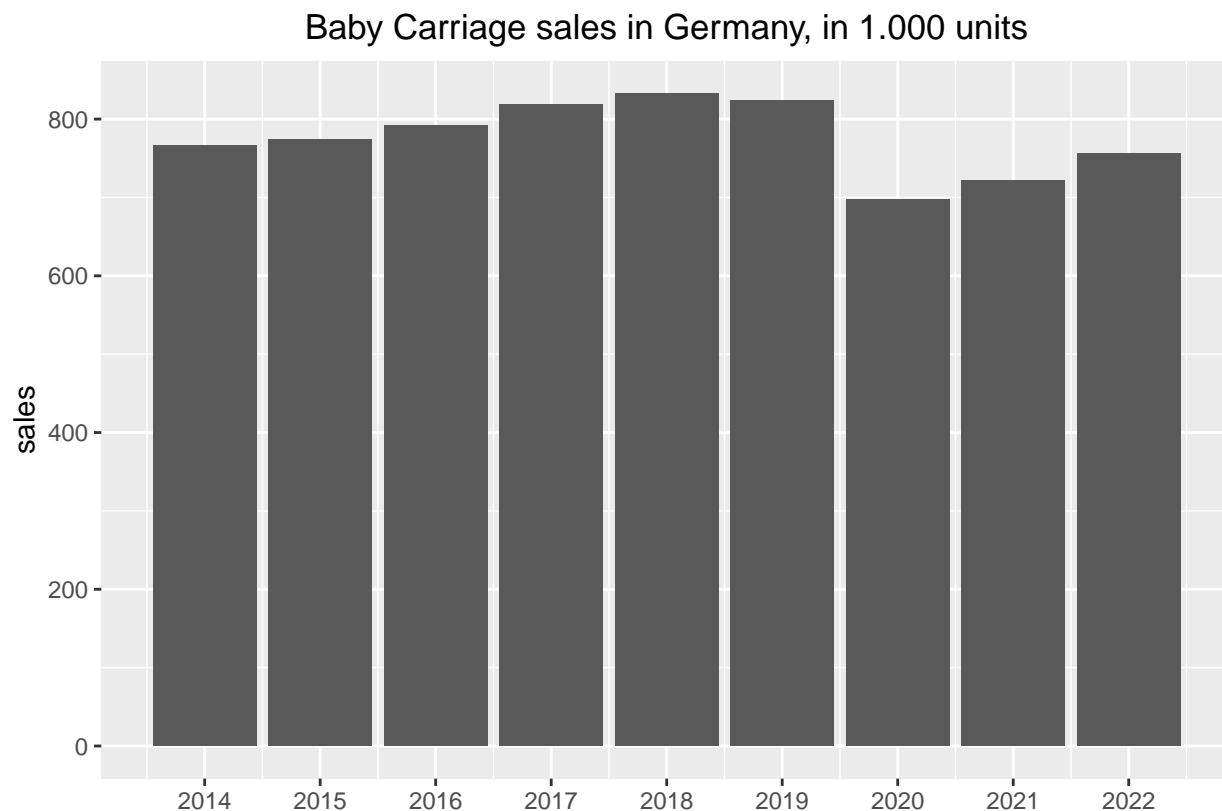
Manipulating the data to keep only useful information.

```
df<- data[3:11, ]
colnames(df) <- c("Year", "Car Seats", "Carriages")
df$Year[9] <- "2022"
df$Year <- as.integer(df$Year)
df$Carriages <- as.integer(df$Carriages)
df
```

```
## # A tibble: 9 x 3
##   Year `Car Seats` Carriages
##   <int> <chr>         <int>
## 1  2014 2164           766
## 2  2015 2257           774
## 3  2016 2331           792
## 4  2017 2470           819
## 5  2018 2513           832
## 6  2019 2523           824
## 7  2020 2182           698
## 8  2021 2240           721
## 9  2022 2316           756
```

Visualizing the sales of baby carriages from 2014 to 2022

```
ggplot(data = df, aes(x = Year, y = Carriages)) + geom_bar(stat = 'identity')+
  labs(title = 'Baby Carriage sales in Germany, in 1.000 units', x= ' ', y = 'sales')+
  scale_x_continuous(breaks = 2014:2022, labels = 2014:2022)+
  theme(plot.title = element_text(hjust = 0.5))
```



Bass model parameters for the traditional baby carriage

Defining $f(t)$ and $F(t)$ functions. $bass.f$ - the fraction of the total market that adopts at time t ;

$bass.F$ - the fraction of the total market that has adopted up to and including time t ;

p - innovation rate;

q - imitation rate

```
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))
}
```

Model Summary and Parameter Estimation

```
sales = df$Carriages
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)))

summary(bass_m)
```

```
##
## Formula: sales ~ m * (((p + q)^2/p) * exp(-(p + q) * t))/(1 + (q/p) *
##      exp(-(p + q) * t))^2
```

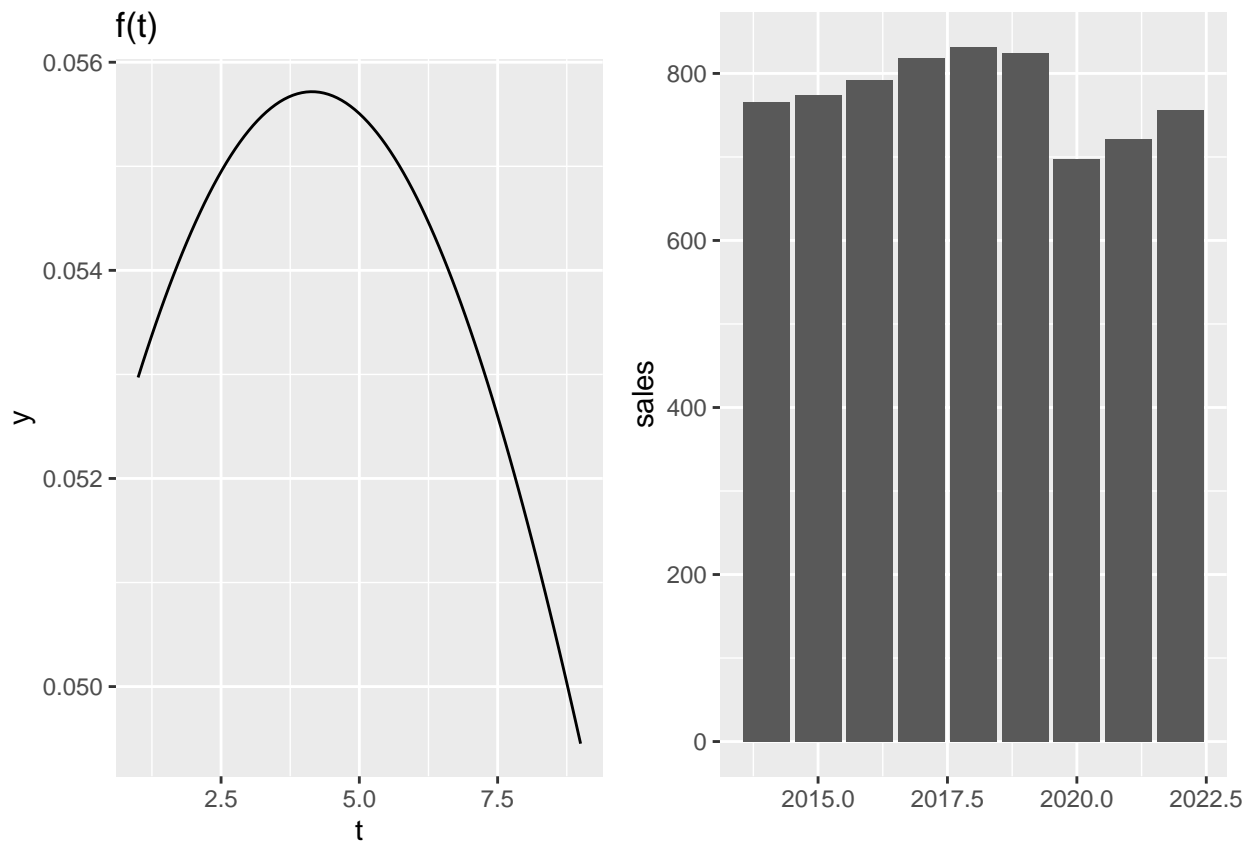
```
##
## Parameters:
##   Estimate Std. Error t value Pr(>|t|)
## m 1.445e+04  2.935e+03   4.922 0.002651 **
## p 5.106e-02  8.101e-03   6.304 0.000743 ***
## q 9.259e-02  3.694e-02   2.507 0.046106 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 41.33 on 6 degrees of freedom
##
## Number of iterations to convergence: 6
## Achieved convergence tolerance: 9.739e-06
```

From the summary, we can see that the values for innovation rate, imitation rate and market potential are 0.05106, 0.09259 and 14450 respectively. We take these values and plot the $f(t)$ on the left side of the plot, and on the right side you can see the histogram of baby carriage sales in Germany, in 1.000 units.

```
time_ad <- ggplot(data.frame(t = c(1:9)), aes(t)) +
  stat_function(fun = bass.f, args = c(p=0.05106, q=0.09259)) +
  labs(title = 'f(t)')

carriage_sales <- ggplot(data = df, aes(x = Year, y = Carriages)) +
  geom_bar(stat = 'identity') + labs(x = " ", y = "sales")

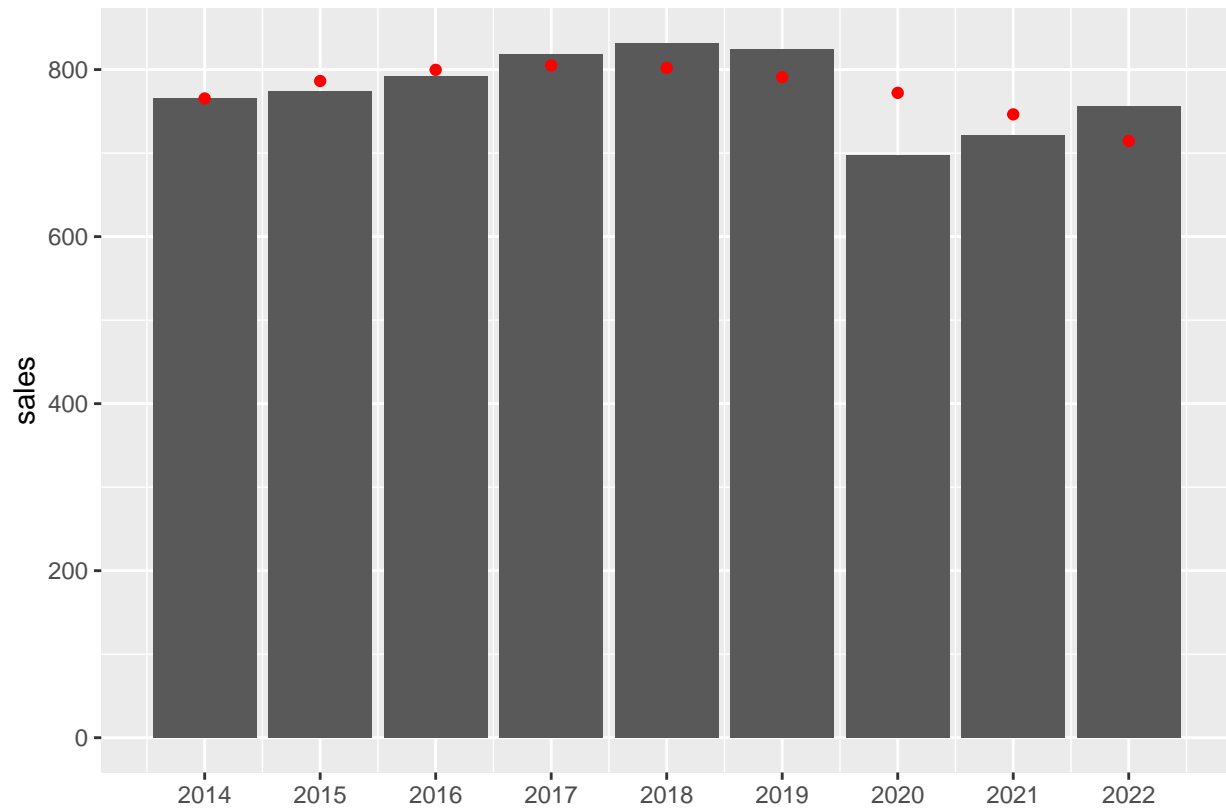
ggarrange(time_ad, carriage_sales)
```



Estimated number of adopters by time

We take the estimated $f(t)$ with the estimated rate of innovation and imitation and multiply it with the estimated market potential. These are plotted for different t -s on the plot as red dots.

```
df$pred_sales = bass.f(1:9, p = 0.05106, q = 0.09259)*14450
ggplot(data = df, aes(x = Year, y = Carriages)) +
  geom_bar(stat = 'identity') +
  geom_point(mapping = aes(x=Year, y=pred_sales), color = 'red')+
  labs( x= ' ', y = 'sales')+scale_x_continuous(breaks = 2014:2022, labels = 2014:2022)
```



Sources :

For the innovation:

<https://time.com/collection/best-inventions-2020/5911764/cybex-e-priam/>

For the definition of baby carriages:

McGregor , S. (2014, February). *A brief history of the baby stroller | best buy blog*.

Retrieved February 27, 2023, from

<https://blog.bestbuy.ca/home-furniture-kitchen/baby/a-brief-history-of-the-baby-stroller>

For the data:

<https://www.statista.com/>