# BassModel

Milena Bazoyan

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## An Immortal Battery

The Oppo Zero-Power Tag, chosen for the innovation, addresses the challenge of powering IoT devices sustainably. It takes energy from ambient radio frequencies, eliminating the need for batteries and reducing waste.

## Look-alike innovation from the past (crystal radios)

The Oppo Zero-Power Tag, with its innovative approach to energy harvesting from ambient radio frequencies for powering devices, closely mirrors the concept of crystal radios from the early 20th century. Both innovations share a fundamental principle: using the energy around us to work without needing regular power like batteries. Crystal radios were remarkable for their ability to receive radio broadcasts without an external power supply, using the energy of radio waves themselves to produce sound.

The Oppo Zero-Power Tag updates an old idea. It uses energy from radio waves around us not just to pick up signals but to power gadgets too. This shows a new way to use energy that's just floating in the air. This link between past and present technology reminds us that old ideas can help solve new problems, leading to devices that are better for the planet and work on their own.

## Finding a time series that approximates the look-alike innovation

Time series data on IoT device adoption, battery technology advancements, or wireless energy trends can indirectly reflect the impact of innovations like the Oppo Zero-Power Tag, highlighting a shift towards more sustainable and efficient energy use in technology. These trends offer insights into the evolving market dynamics and the growing importance of technologies that harness ambient energy, underscoring efforts to enhance sustainability and efficiency.

## Estimate Bass model parameters for the look-alike innovation.

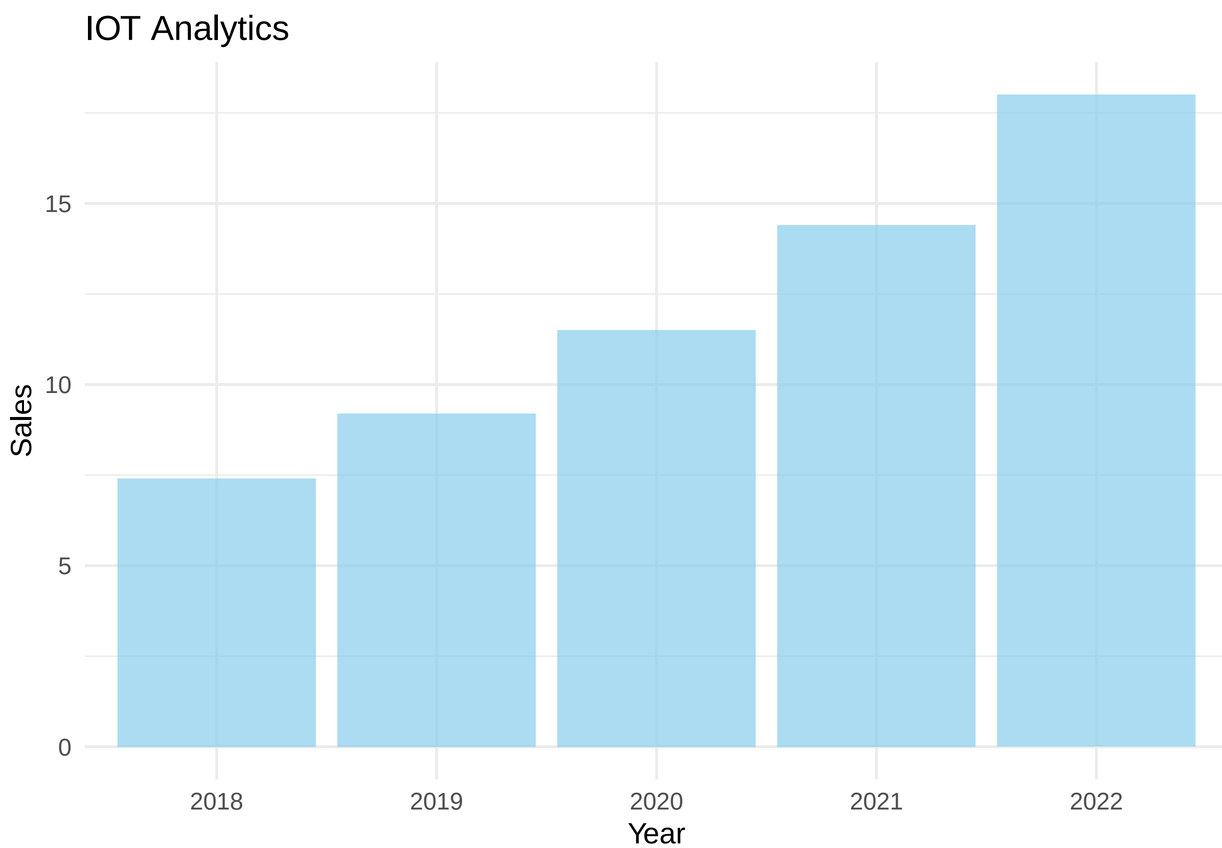
```r
iot <- read_excel("iot-analytics_2018-2022.xlsx")
iot
```

```
## # A tibble: 5 x 2
##   year  sales
##   <chr> <dbl>
```

```
## 1 2018    7.4
## 2 2019    9.2
## 3 2020   11.5
## 4 2021   14.4
## 5 2022   18
```

```
sm_sales <- ggplot(data = iot, aes(x = factor(year), y = sales)) +
  geom_bar(stat = 'identity', fill = 'skyblue', alpha = 0.7) +
  labs(title = 'IOT Analytics') +
  theme_minimal() +
  xlab("Year") +
  ylab("Sales")

sm_sales
```



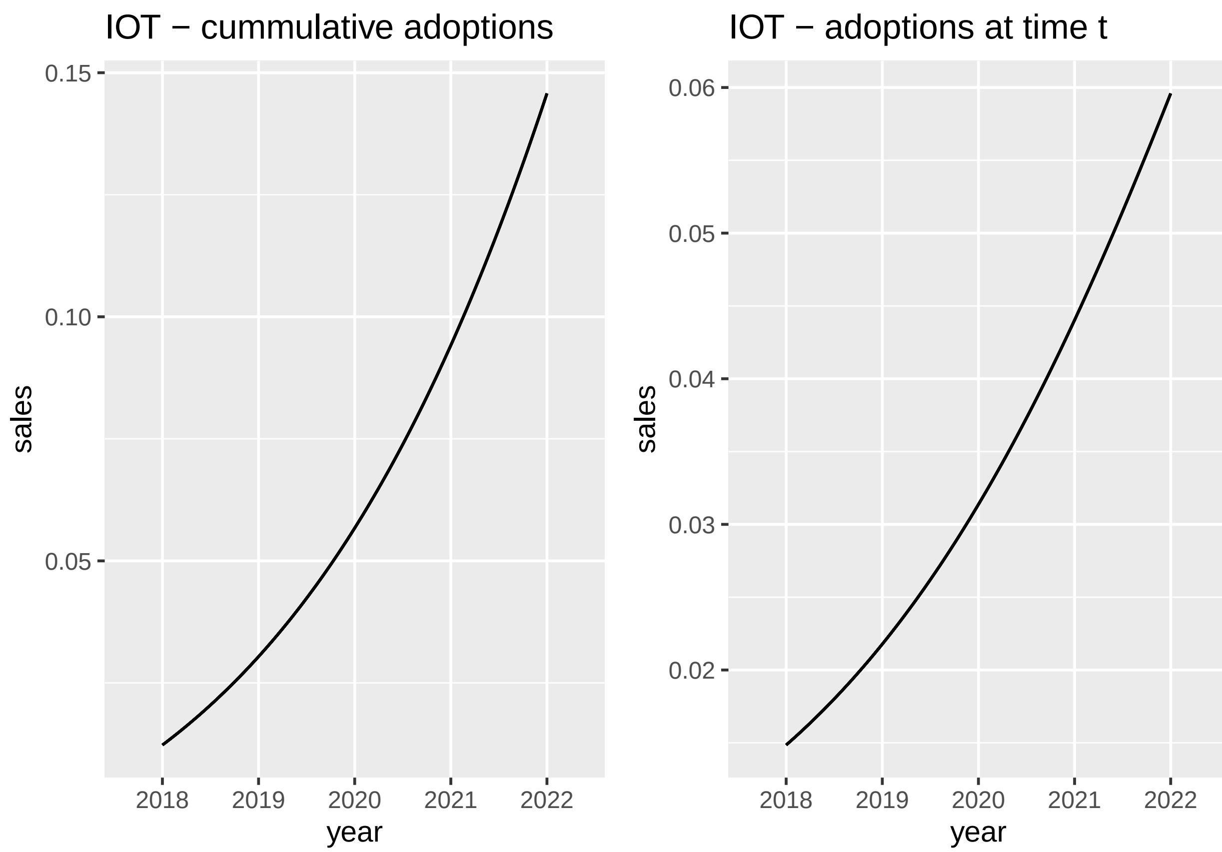

```
bass.f <- function(t,p,q){
((p+q)^2/p)*exp(-(p+q)*t)/
(1+(q/p)*exp(-(p+q)*t))^2
}

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

```
cumm_ad = ggplot(data = iot, aes(x = year, y = sales)) +
stat_function(fun = bass.F, args = c(p=0.01, q=0.41)) +
labs(title = 'IOT - cummulative adoptions')

time_ad = ggplot(data = iot, aes(x = year, y = sales)) +
stat_function(fun = bass.f, args = c(p=0.01, q=0.41)) +
labs(title = 'IOT - adoptions at time t')


suppressWarnings({ggarrange(cumm_ad, time_ad)})
```




## Make predictions of the diffusion

```
diff_m = diffusion(iot$sales)
p=round(diff_m$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  10.6139      NA
## q - Coefficient of imitation    0.0000      NA
## m - Market potential           30.9846      NA
##
## sigma: 16.152
```

Final parameter estimates: m p q 3.323186e+04 8.196280e-05 2.217740e-01

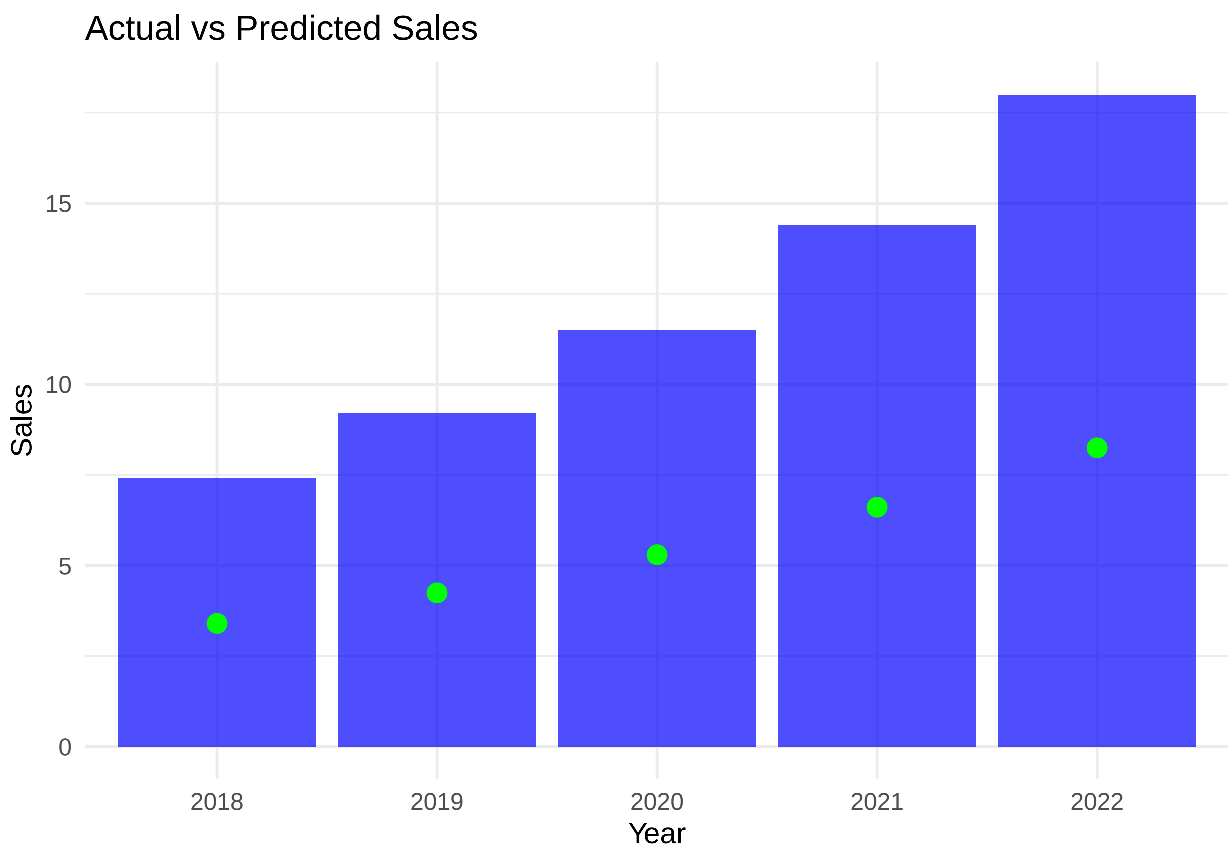
```
t <- 1:length(iot$year)

iot$pred_sales <- bass.f(t, p = 8.196e-05, q = 2.218e-01) * 3.323e+04

ggplot(data = iot, aes(x = year)) +
  geom_bar(aes(y = sales), stat = 'identity', fill = "blue", alpha = 0.7) +  # Actual sales
  geom_line(aes(y = pred_sales), color = 'green', size = 1) +  # Predicted sales
  geom_point(aes(y = pred_sales), color = 'green', size = 3) +  # Predicted sales points
  labs(x = "Year", y = "Sales", title = "Actual vs Predicted Sales") +
  theme_minimal()
```

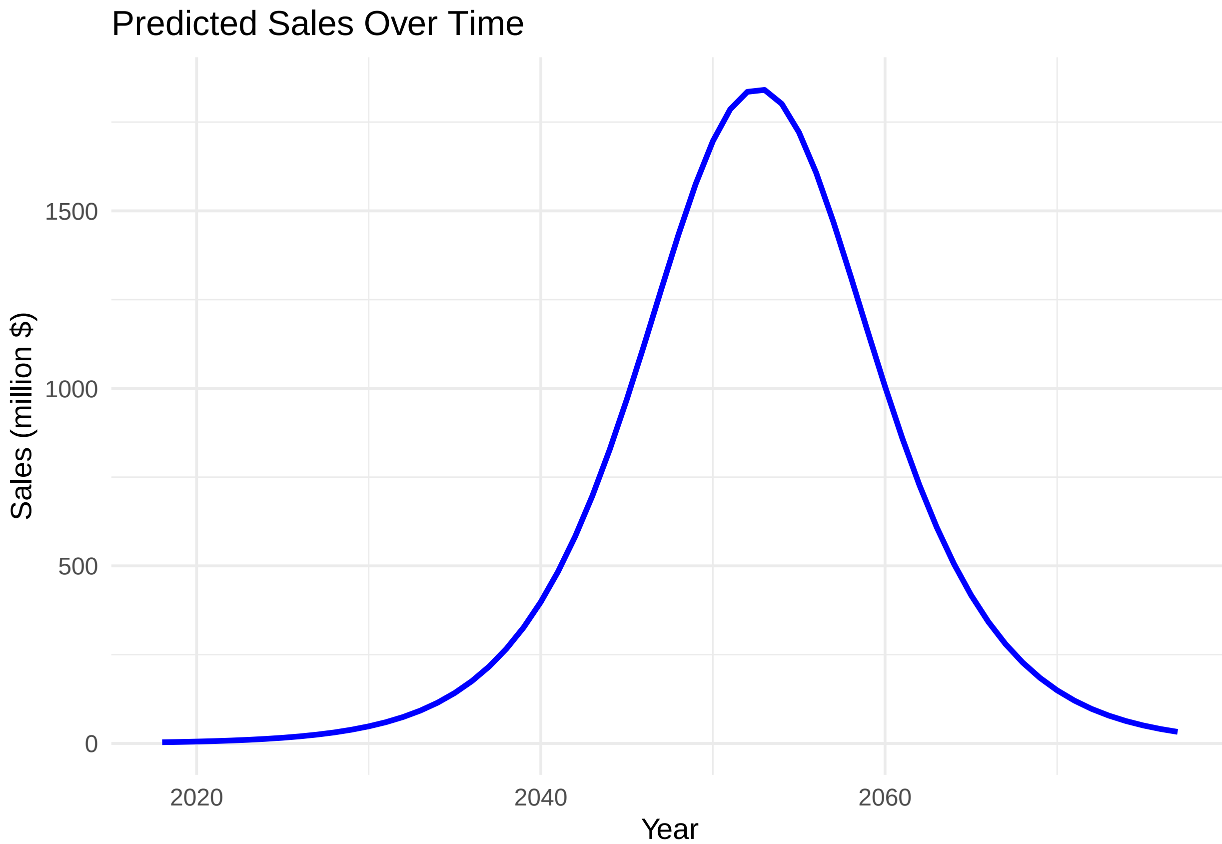
```
## Warning: Using 'size' aesthetic for lines was deprecated in ggplot2 3.4.0.
## i Please use 'linewidth' instead.
## This warning is displayed once every 8 hours.
## Call 'lifecycle::last_lifecycle_warnings()' to see where this warning was
## generated.
```

```
## 'geom_line()': Each group consists of only one observation.
## i Do you need to adjust the group aesthetic?
```




```r
innovation_pred <- bass.f(1:60, p = 8.196e-05, q = 2.218e-01) * 3.323e+04
years <- seq(from = 2018, to = 2022 + 55, by = 1)
innovation_data <- data.frame(Year = years, Sales = innovation_pred)
```

```r
ggplot(data = innovation_data, aes(x = Year, y = Sales)) +
  geom_line(color = 'blue', size = 1) +
  ylab("Sales (million $)") +
  ggtitle("Predicted Sales Over Time") +
  theme_minimal()
```




The predictions are made from the year 2018 to 55 years later (until 2073). The graph shows a classic diffusion curve, starting with lower sales in the early years, then rising to a peak as the product gains popularity and the rate of adoption increases due to both innovators and imitators. After reaching the peak, the sales gradually decline as the market becomes saturated.

## Estimate the number of adopters by period

```
p <- 8.196e-05
q <- 2.218e-01
M <- 3.323e+04
time_periods <- 1:60
adopters_by_period <- numeric(length(time_periods))
cumulative_adopters <- 0

for (t in time_periods) {
  new_adopters <- (p + (q * cumulative_adopters / M)) * (M - cumulative_adopters)
  adopters_by_period[t] <- new_adopters
  cumulative_adopters <- cumulative_adopters + new_adopters
}
```

```
percentage_of_market <- adopters_by_period / M * 100

years <- seq(from = 2018, to = 2018 + length(time_periods) - 1)
```

```r
adoption_data <- data.frame(Year = years, New_Adopters = adopters_by_period, Market_Percentage = percen
adoption_data
```

```
##    Year New_Adopters Market_Percentage
## 1  2018     2.723531        0.00819600
## 2  2019     3.327337        0.01001305
## 3  2020     4.064873        0.01223254
## 4  2021     4.965690        0.01494339
## 5  2022     6.065838        0.01825410
## 6  2023     7.409277        0.02229695
## 7  2024     9.049589        0.02723319
## 8  2025    11.052050        0.03325925
## 9  2026    13.496125        0.04061428
## 10 2027    16.478477        0.04958916
## 11 2028    20.116568        0.06053737
## 12 2029    24.552956        0.07388792
## 13 2030    29.960399        0.09016070
## 14 2031    36.547854        0.10998451
## 15 2032    44.567481        0.13411821
## 16 2033    54.322710        0.16347490
## 17 2034    66.177374        0.19914948
## 18 2035    80.565814        0.24244903
## 19 2036    98.003711        0.29492540
## 20 2037   119.099106        0.35840838
## 21 2038   144.562720        0.43503678
## 22 2039   175.216093        0.52728286
## 23 2040   211.995284        0.63796354
## 24 2041   255.946802        0.77022811
## 25 2042   308.211067        0.92750848
## 26 2043   369.987088        1.11341284
## 27 2044   442.470288        1.33153863
## 28 2045   526.754009        1.58517607
## 29 2046   623.684754        1.87687257
## 30 2047   733.663065        2.20783348
## 31 2048   856.387655        2.57715214
## 32 2049   990.552259        2.98089756
## 33 2050  1133.524262        3.41114734
## 34 2051  1281.061617        3.85513577
## 35 2052  1427.155776        4.29478115
## 36 2053  1564.112724        4.70692965
## 37 2054  1682.983987        5.06465238
## 38 2055  1774.413434        5.33979366
## 39 2056  1829.861611        5.50665547
## 40 2057  1843.020717        5.54625554
## 41 2058  1811.092143        5.45017196
## 42 2059  1735.544027        5.22282283
## 43 2060  1622.062316        4.88131904
## 44 2061  1479.648797        4.45274991
## 45 2062  1319.105755        3.96962310
## 46 2063  1151.339777        3.46476009
## 47 2064   985.925571        2.96697433
## 48 2065   830.211792        2.49838035
```

```
## 49 2066   689.026967         2.07350878
## 50 2067   564.864822         1.69986404
## 51 2068   458.349056         1.37932307
## 52 2069   368.788461         1.10980578
## 53 2070   294.691808         0.88682458
## 54 2071   234.177539         0.70471724
## 55 2072   185.263077         0.55751753
## 56 2073   146.047085         0.43950372
## 57 2074   114.809261         0.34549883
## 58 2075    90.052957         0.27099897
## 59 2076    70.511714         0.21219294
## 60 2077    55.135298         0.16592025
```

# Reference:

Statista. (2023, September 7). IoT analytics: global market size 2018-2022. https://www.statista.com/statistics/830549/worldwide-iot-analytics-market-size/#statisticContainer