Bass Model Homework

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1. Introduction

This report analyzes the diffusion of Samsung's Neo QLED 8K TV, one of TIME's 2024 Best Innovations, using the Bass Diffusion Model. The Bass model helps describe how new technologies spread in a market, distinguishing between adoption driven by innovation (external influence, like advertising) and imitation (social influence, like word-of-mouth).

To estimate the parameters of the model, we use historical OLED/LCD TV shipment data from 2016 to 2023 as a look-alike product. This approach assumes that the adoption of Samsung's Neo QLED 8K will follow a similar pattern to that of previous high-end display technologies.

Similarity Between OLED TVs and Samsung Neo QLED 8K TVs

The OLED TV is an appropriate look-alike innovation for Samsung's Neo QLED 8K TV because both represent major advances in flat-panel display technology targeting the premium television market. Each innovation improves picture quality, color accuracy, and viewing experience through enhanced panel design and light-emission control. OLED technology introduced self-emissive pixels, eliminating the need for back-lighting and offering perfect blacks and high contrast ratios. Similarly, Samsung's Neo QLED 8K TV builds on these improvements by using mini-LED backlighting and quantum-dot filtering to achieve comparable color depth and brightness while increasing resolution to 8K. Functionally, both serve the same consumer purpose—high-end home entertainment systems that emphasize superior visual performance—and both rely on similar market drivers such as technological innovation, early-adopter enthusiasm, and social imitation effects. For this reason, historical OLED adoption patterns provide a credible basis for forecasting the diffusion of Neo QLED 8K TVs using the Bass model.

2. Data Description

The dataset contains yearly global shipments (in millions of units) of OLED TVs from 2016 to 2023, taken from Statista and other market research sources. These values represent total worldwide adoption and serve as a proxy for historical TV innovation diffusion.

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

```
## Warning: package 'diffusion' was built under R version 4.4.3
```

```r
library(readxl)
```

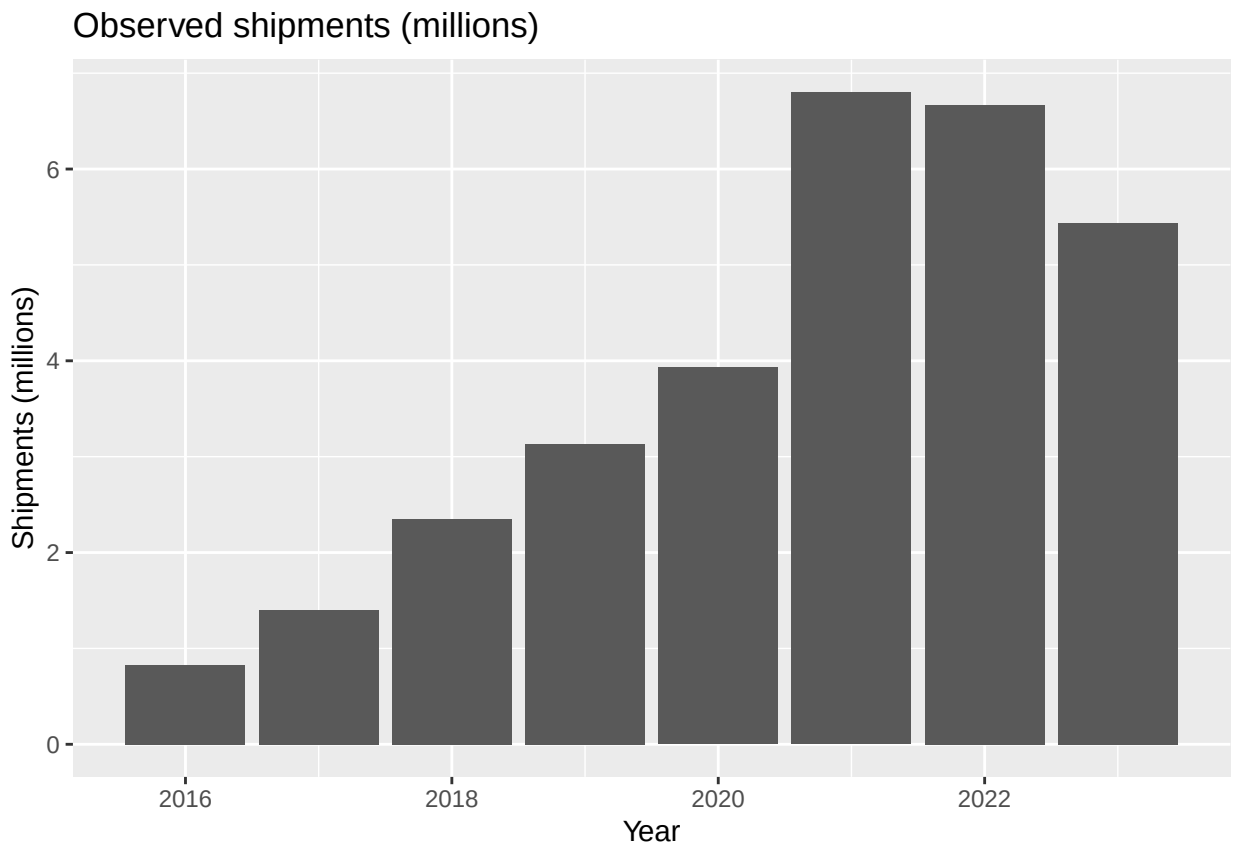
```
## Warning: package 'readxl' was built under R version 4.4.3
```

```r
df <- read_excel("dataset1.xlsx") #sales are in millions here
df
```

```
## # A tibble: 8 x 2
##    year sales
##   <dbl> <dbl>
## 1  2016  0.83
## 2  2017  1.4
## 3  2018  2.35
## 4  2019  3.13
## 5  2020  3.93
## 6  2021  6.8
## 7  2022  6.67
## 8  2023  5.44
```

A quick visualization shows the overall trend in OLED TV shipments.

```r
ggplot(df, aes(x = year, y = sales)) +
  geom_bar(stat = 'identity') +
  ggtitle('Observed shipments (millions)') +
  ylab('Shipments (millions)') + xlab('Year')
```



The sales show steady growth until 2021, followed by a slight decline — typical of an innovation nearing market saturation.

3. Methodology

The Bass model defines adoption at time t as:

$$f(t) = \frac{(p+q)^2}{p} \cdot \frac{e^{-(p+q)t}}{\left(1 + \frac{q}{p} e^{-(p+q)t}\right)^2}$$

where:

- p = coefficient of innovation (influence of external sources)
- q = coefficient of imitation (influence of prior adopters)
- M = total market potential (maximum possible adopters)

The model is fitted using non-linear least squares (NLS) to estimate p, q, and M.

```
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))
}
```

```
sales <- df$sales
t <- 1:length(sales)

start_m <- sum(sales)*3
start_p <- 0.01
start_q <- 0.4
```

```
bass_nls <- nls(sales ~ m * (((p+q)^2/p) * exp(-(p+q)*t)) /
                (1 + (q/p) * exp(-(p+q)*t))^2,
                start = list(m = start_m, p = start_p, q = start_q),
                control = nls.control(maxiter = 200, warnOnly = TRUE))

summary(bass_nls)
```

```
##
## 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 40.606991   3.940935  10.304 0.000148 ***
## p  0.008241   0.002506   3.289 0.021740 *
## q  0.630386   0.077508   8.133 0.000456 ***
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5541 on 5 degrees of freedom
##
## Number of iterations to convergence: 8
## Achieved convergence tolerance: 4.049e-06
```

4. Results and Discussion

The estimated parameters of the Bass model are:

```
params <- coef(bass_nls)
m_est <- params["m"]
p_est <- params["p"]
q_est <- params["q"]

cat("Estimated parameters (nls):\n")
```

```
## Estimated parameters (nls):
```

```
print(params)
```

```
##            m            p            q
## 40.606990537  0.008241127  0.630386203
```

Interpretation:

The p (innovation coefficient) is relatively low, suggesting adoption was mainly driven by word-of-mouth rather than advertising.

The q (imitation coefficient) is higher, which indicates a strong social contagion effect — consumers adopt after seeing others do so.

The market potential M represents the estimated total number of units that can be adopted worldwide.

Predicted Adoption Path

Using the fitted parameters, the predicted number of adopters and cumulative adoption from 2016 to 2030 are:

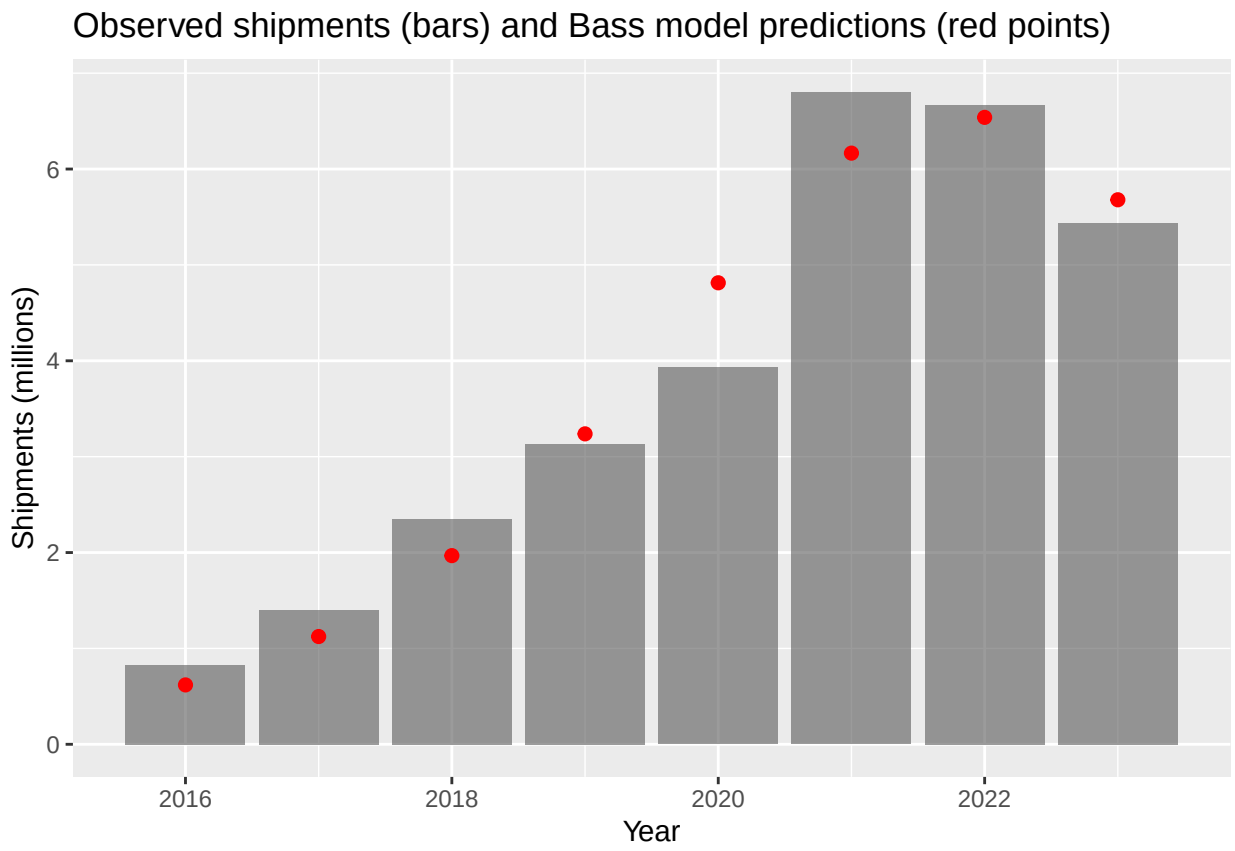
```
t_fore <- 1:15 # 2016..2030
years_fore <- 2016 + (t_fore - 1)
pred_fore <- m_est * bass.f(t_fore, p_est, q_est)
cum_fore <- cumsum(pred_fore)

pred_df <- data.frame(year = years_fore,
                      pred = pred_fore,
                      cum = cum_fore)
knitr::kable(round(pred_df,3), caption = "Predicted adopters (millions) and cumulative adopters")
```

Table 1: Predicted adopters (millions) and cumulative adopters

year	pred	cum
2016	0.619	0.619
2017	1.124	1.743
2018	1.968	3.711
2019	3.238	6.949
2020	4.813	11.763
2021	6.166	17.928
2022	6.539	24.467
2023	5.679	30.147
2024	4.143	34.289
2025	2.657	36.946
2026	1.567	38.513
2027	0.879	39.392
2028	0.480	39.872
2029	0.258	40.130
2030	0.137	40.268

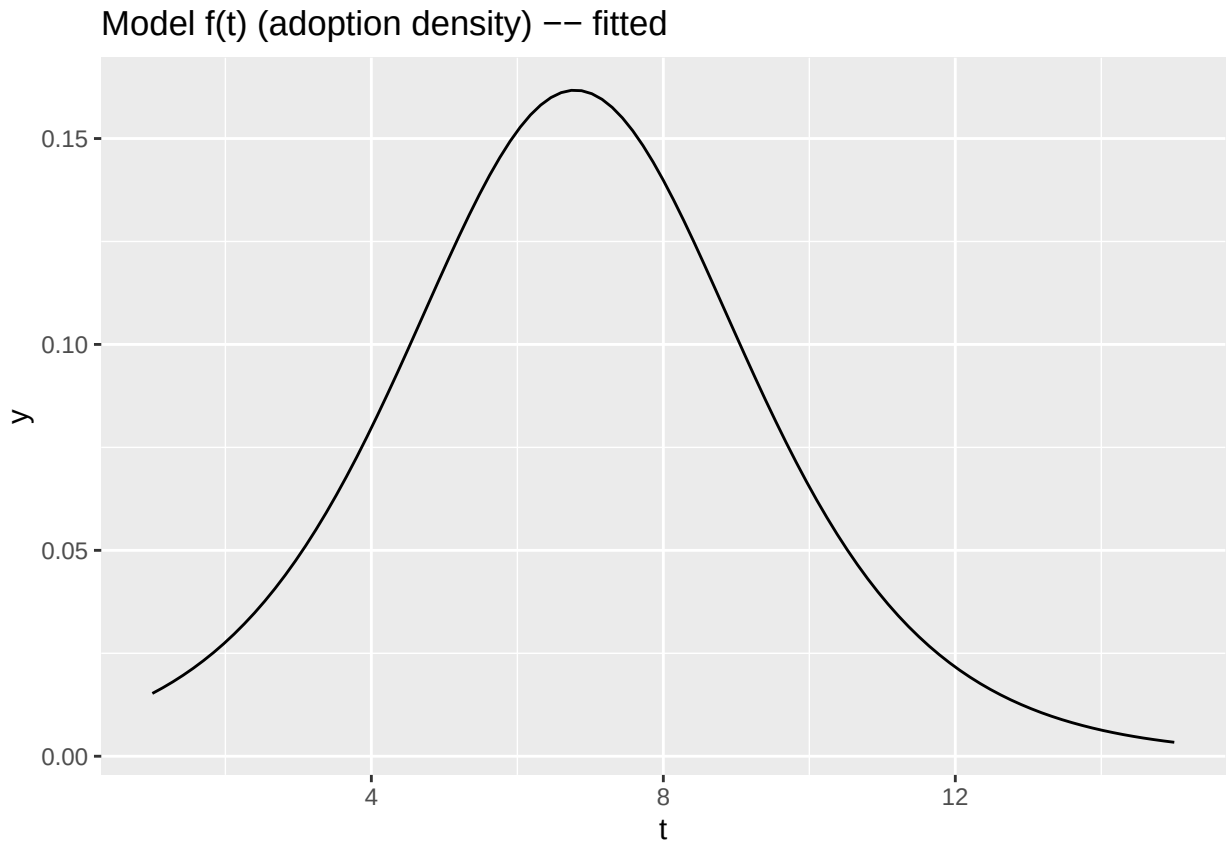
Model Fit and Visualization

```
df$pred_in_sample <- pred_df$pred[1:nrow(df)]
ggplot() +
  geom_bar(data = df, aes(x = year, y = sales), stat = 'identity', alpha = 0.6) +
  geom_point(data = df, aes(x = year, y = pred_in_sample), color = 'red', size = 2) +
  ggtitle("Observed shipments (bars) and Bass model predictions (red points)") +
  ylab('Shipments (millions)') + xlab('Year')
```



Adoption Density Function

```
ggplot(data.frame(t = 1:15), aes(t)) +
  stat_function(fun = function(x) bass.f(x, p_est, q_est), geom='line') +
  ggtitle("Model f(t) (adoption density) -- fitted")
```




```
t_star <- log(q_est / p_est) / (p_est + q_est)
cat(sprintf("Peak adoption at t* = %.2f years after 2016 → year approx = %.2f\n",
            t_star, 2016 + t_star))
```

```
## Peak adoption at t* = 6.79 years after 2016 → year approx = 2022.79
```

```
dir.create("img", showWarnings = FALSE)
ggsave("img/observed_vs_pred.png", width = 8, height = 5)

write.csv(pred_df, "predicted_adopters_2016_2030.csv", row.names = FALSE)

knitr::kable(data.frame(parameter = c("m","p","q"),
                        estimate = c(m_est, p_est, q_est)),
             caption = "Fitted Bass parameters")
```

Table 2: Fitted Bass parameters

	parameter	estimate
m	m	40.6069905
p	p	0.0082411
q	q	0.6303862

5. Conclusion

The Bass model effectively describes the diffusion of high-end display technologies. For the OLED TV data, the estimated parameters indicate that the adoption peak occurred around 2022, followed by a gradual slowdown as the market matured.

Assuming the Neo QLED 8K follows a similar pattern, its diffusion is expected to reach peak adoption within several years of launch, driven primarily by social influence rather than pure innovation.

This model can support future forecasting, production planning, and marketing strategy design for similar technology products.

6. References

Bass, F. M. (1969). A New Product Growth Model for Consumer Durables. Management Science, 15(5), 215–227.

Statista (2024). Global OLED TV Shipments from 2016 to 2023 (in millions).

Samsung Electronics. (2024). Neo QLED 8K Product Information.