

Levon Gevorgyan MA Homework 1

2025-09-25

Tasks

1. Choose an Innovation from the List.

For the link to the innovation from the “Innovations’ List” *click here* (the first innovation on the list). For the actual product profile, *click here*.

2. Identify a Similar Innovation from the Past.

Apple Vision Pro and the look-alike Oculus/Meta Quest

In this homework, I will be analyzing the ***Apple Vision Pro***. as one of the significant innovations from Apple, a leading company in the mobile market. This product is a headset that gives users the opportunity to see and use apps, videos, and games in a 3D space. A similar innovation from the past is the ***Oculus/Meta Quest***, which is a virtual reality headset that also allows users to create digital environments. In comparison to the Apple Vision Pro, Oculus/Meta Quest headsets focus mainly on gaming and entertainment, while the Apple Vision Pro is better suited for work and communication.

Libraries

```
library(readxl)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##   filter, lag

## The following objects are masked from 'package:base':
##
##   intersect, setdiff, setequal, union
```

```
library(ggplot2)
```

3. Find Historical Data.

Time Series data on Meta/Oculus Quest Headsets

```
df <- read_excel("../data/data.xlsx", sheet = "Data", skip = 4, col_names = FALSE)
```

```
## New names:
## * ' -> '...1'
## * ' -> '...2'
## * ' -> '...3'
## * ' -> '...4'
## * ' -> '...5'
## * ' -> '...6'
## * ' -> '...7'
## * ' -> '...8'
## * ' -> '...9'
## * ' -> '...10'
## * ' -> '...11'
```

```
head(df)
```

```
## # A tibble: 6 x 11
##   ...1    ...2    ...3    ...4    ...5    ...6    ...7    ...8    ...9    ...10 ...11
##   <chr>   <chr> <chr> <chr> <chr>   <chr> <chr> <chr> <chr> <chr> <chr>
## 1 <NA>    Meta  Sony  Apple ByteDance Xreal Others HTC  Vitore TLC   <NA>
## 2 Q1 2023 47.8  -    -      6.1    1.3  43.4  1.4  -    -    in %
## 3 Q2 2023 50.1  27.2 -    9.6    2.5  10.6  -    -    -    in %
## 4 Q3 2023 54.8  23.3 -    6.4    4.2  11.3  -    -    -    in %
## 5 Q4 2023 61.6  15.9 -    6.4    4.7  11.4  -    -    -    in %
## 6 Q1 2024 36.2  2.5   16.5  11.5   9.1  19.6  -    2    2.6  in %
```

```
colnames(df) <- df[1, ]
df <- df[-1, ]

meta_vec <- df$Meta
meta_numeric <- as.numeric(gsub(",", ".", meta_vec))
meta_numeric <- meta_numeric[!is.na(meta_numeric)]

meta_ts <- ts(meta_numeric, start = c(2023, 1), frequency = 4)

# -----
# Plot of the Sales Volume on Historical Data
# -----

n_periods <- length(meta_ts)
years <- 2023 + ((0:(n_periods - 1)) %/% 4)
quarters <- ((0:(n_periods - 1)) %% 4) + 1
labels <- paste0(years, " Q", quarters)

x_positions <- time(meta_ts)
```

```

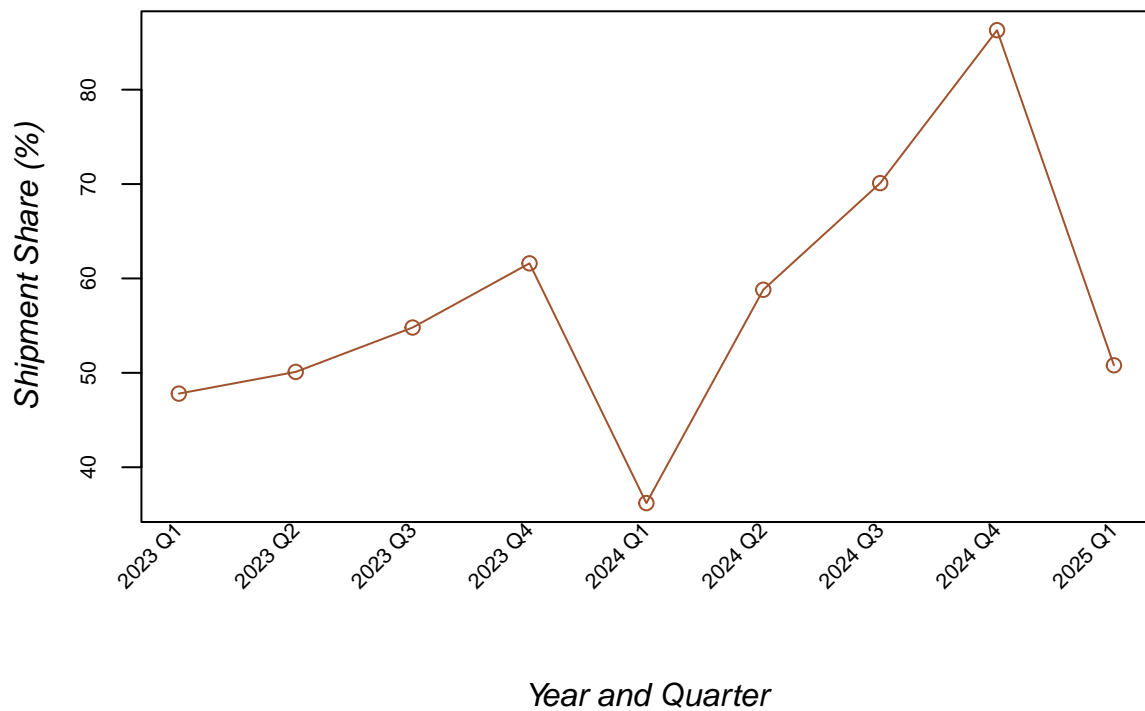
plot(meta_ts, type = "o",
     col = "#A0522D",
     xlab = "",
     ylab = "",
     main = "AR/VR Headset Companies Shipment Share (Meta)",
     col.main = "#800000",
     font.main = 4,
     xaxt = "n", yaxt = "n")

axis(2, cex.axis = 0.7)
x_positions <- time(meta_ts)
labels <- paste0(years, " Q", quarters)
text(x = x_positions, y = par("usr")[3] - 0.5, #
     labels = labels, srt = 45, adj = 1, xpd = TRUE, cex = 0.7)

mtext("Year and Quarter", side = 1, line = 4, font = 3)
mtext("Shipment Share (%)", side = 2, line = 2.5, font = 3)

```

AR/VR Headset Companies Shipment Share (Meta)



The graph shows that Meta's headset shipment share fluctuated between 2023 and 2025, with a general upward trend and a sharp peak in late 2024, though periods of steep decline reveal that its dominance is unstable and strongly influenced by competition, product cycles, and seasonal demand.

4. Estimate Bass Model Parameters.

```
meta_frac <- meta_ts / 100

cum_adopt <- cumsum(meta_frac)

time <- 1:length(cum_adopt)

start_vals <- list(
  p = 0.02,
  q = 0.4,
  M = max(cum_adopt)
)

bass_model <- nls(
  cum_adopt ~ M * ((1 - exp(-(p+q)*time)) / (1 + (q/p) * exp(-(p+q)*time))),
  start = start_vals,
  algorithm = "port",
  lower = c(0, 0, 0),
  upper = c(1, 1, 10),
  control = list(maxiter = 500)
)

params <- coef(bass_model)
p <- params["p"]
q <- params["q"]
M <- params["M"]

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

```
## Estimated Bass parameters:
```

```
cat("p (innovation) =", p, "\n")
```

```
## p (innovation) = 0.04087809
```

```
cat("q (imitation) =", q, "\n")
```

```
## q (imitation) = 0.1631384
```

```
cat("M (market potential) =", M, "\n")
```

```
## M (market potential) = 10
```

```
# -----
# Plot of Observed vs Fitted Cumulative Adoption
# -----
```

```
fitted_cum <- predict(bass_model)
```

```

years <- rep(2023:2025, each = 4)
quarters <- rep(c("Q1","Q2","Q3","Q4"), times = 3)
labels <- paste0(quarters, " ", years)[1:length(cum_adopt)]

plot(time, cum_adopt, type = "o",
     col = "#A0522D",
     ylab = "Cumulative Adoption",
     xlab = "Quarter",
     xaxt = "n", yaxt = "n",
     main = "Bass Model Fit",
     col.main = "#8B0000",
     font.main = 4,
     font.lab = 3)

lines(time, fitted_cum, col = "#D2691E", lwd = 2)

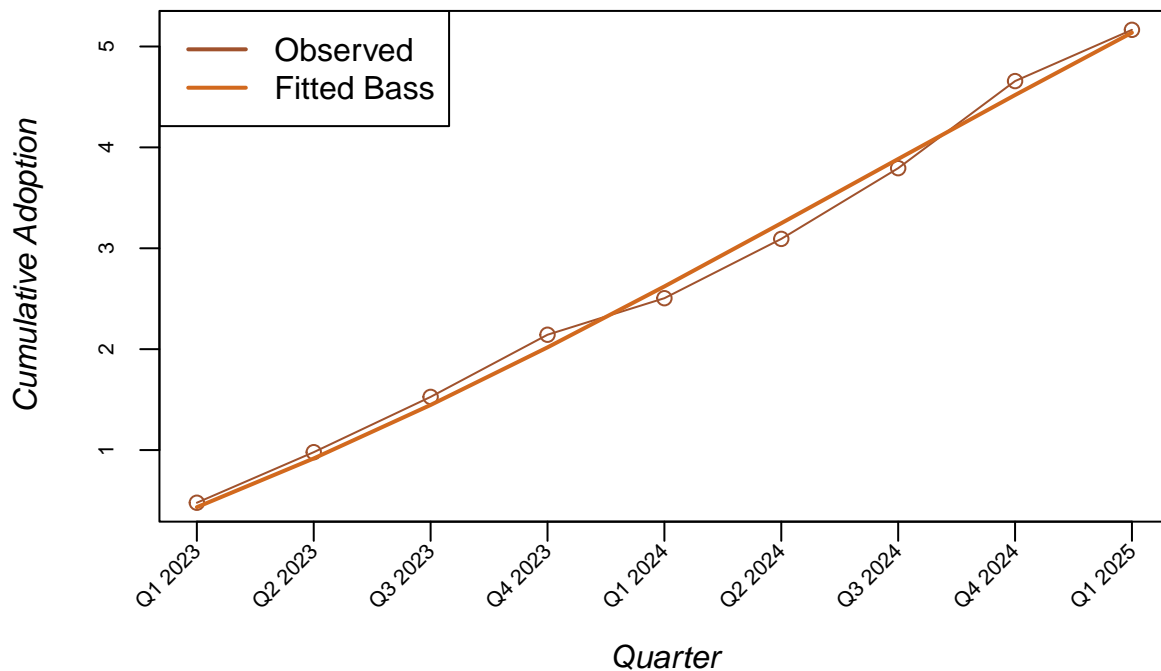
axis(2, cex.axis = 0.7)

axis(1, at = time, labels = FALSE)
text(x = time, y = par("usr")[3] - 0.05*diff(par("usr")[3:4]),
     labels = labels, srt = 45, adj = 1, xpd = TRUE, cex = 0.7)

legend("topleft", legend = c("Observed", "Fitted Bass"),
     col = c("#A0522D", "#D2691E"), lty = 1, lwd = 2)

```

Bass Model Fit



Here, the Bass model provides a very close fit to the observed cumulative adoption of Meta's headsets over

time, with the fitted curve almost overlapping the actual data points, which suggests that the diffusion of adoption can be well explained by a mix of innovation and imitation effects, and that the estimated market potential captures the observed growth quite accurately.

5. Predict the Diffusion of the Innovation.

```
future_periods <- 8
total_periods <- length(cum_adopt) + future_periods
future_time <- 1:total_periods

bass_predict <- function(t, p, q, M) {
  M * ((1 - exp(-(p + q) * t)) / (1 + (q / p) * exp(-(p + q) * t)))
}

predicted_cum <- bass_predict(future_time, p, q, M)
predicted_cum_percent <- predicted_cum * 100

# -----
# Plot of the Predicted Diffusion
# -----

start_year <- 2023
start_quarter <- 1

years <- start_year + ((0:(total_periods - 1)) + (start_quarter - 1)) %/% 4
quarters <- ((start_quarter - 1 + 0:(total_periods - 1)) %% 4) + 1
labels <- paste0(years, " Q", quarters)

y_ticks <- pretty(predicted_cum_percent, n = 6)

plot(future_time, predicted_cum_percent, type = "l", col = "#FF8C00", lwd = 2,
     ylab = "", xlab = "", xaxt = "n", yaxt = "n",
     main = "Predicted Diffusion of Apple Vision Pro (Bass Model)",
     col.main = "#8B0000", font.main = 4)

points(1:length(cum_adopt), cum_adopt * 100, type = "o", col = "#8B4513", pch = 16)

axis(2, at = y_ticks, labels = y_ticks, cex.axis = 0.7)
axis(1, at = future_time, labels = FALSE)

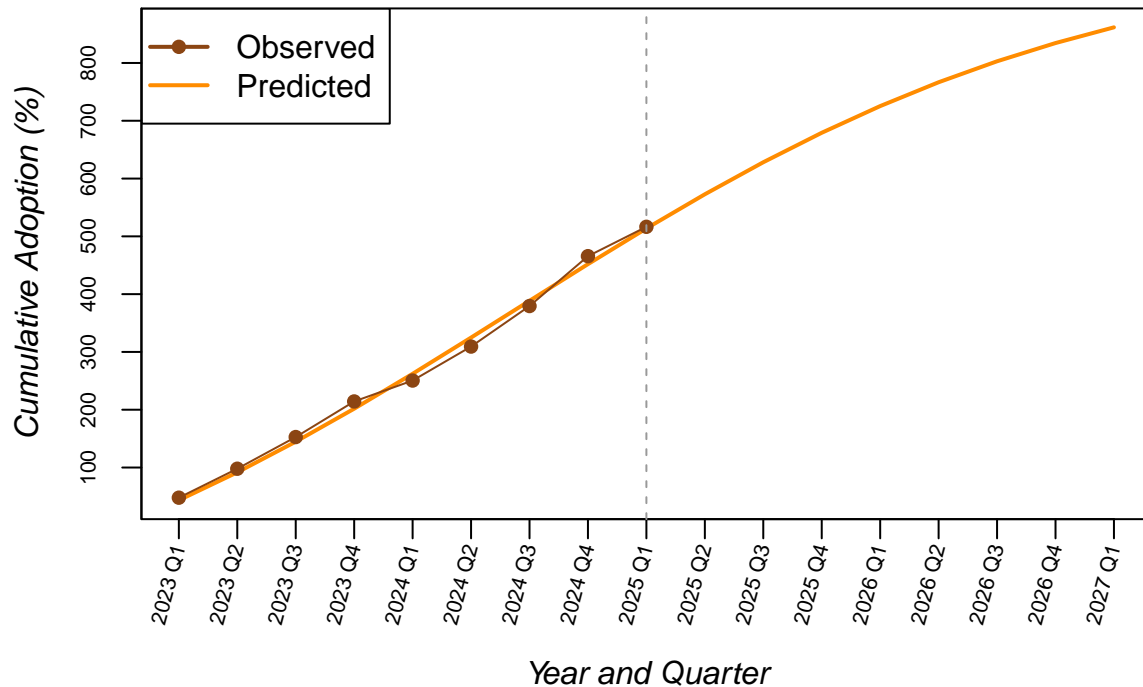
text(x = future_time,
     y = par("usr")[3] - 0.05 * diff(par("usr")[3:4]),
     labels = labels, srt = 75, adj = 1, xpd = TRUE, cex = 0.7)

mtext("Year and Quarter", side = 1, line = 3.5, font = 3)
mtext("Cumulative Adoption (%)", side = 2, line = 2.5, font = 3)

legend("topleft", legend = c("Observed", "Predicted"),
     col = c("#8B4513", "#FF8C00"), lty = 1, lwd = 2, pch = c(16, NA))

abline(v = length(cum_adopt), lty = 2, col = "gray60")
```

Predicted Diffusion of Apple Vision Pro (Bass Model)



Here I applied the Bass model to the adoption of Apple Vision Pro, where the observed values closely follow the fitted curve in the initial quarters, and the prediction suggests that cumulative adoption will continue increasing but at a decreasing rate as the market moves toward saturation.

6. Choose a Scope.

For the **Apple Vision Pro** diffusion analysis, we focus on a *global scope* because Apple sells its products *worldwide almost at the same time*, and early adopters are present in many regions. Looking only at one country may hide how adoption in one market can affect another. In the same way, **Meta's Oculus** has also spread on a *global level*, with users in North America, Europe, and Asia, not just in one place. Since both Apple and Meta work in very international markets, a *global view* gives a clearer picture of how these devices spread and compete.

7. Estimate the number of Adopters by Period.

```
future_periods <- 7                                # number of future quarters to predict
                                                    # (as we predict for 2025-2026 -> 2 years)

total_periods <- length(cum_adopt) + future_periods
future_time <- 1:total_periods

bass_predict <- function(t, p, q, M){
  M * ((1 - exp(-(p + q) * t)) / (1 + (q / p) * exp(-(p + q) * t)))
}
```

```

}

predicted_cum <- bass_predict(future_time, p, q, M)
adopters_per_period <- c(predicted_cum[1], diff(predicted_cum))
adopters_percent <- adopters_per_period * 100

M_estimate <- 1e7 # 10 million potential adopters
adopters_units <- adopters_per_period * M_estimate

# -----
# Plot of the Predicted Number of Adopters
# -----

start_year <- 2023
start_quarter <- 1

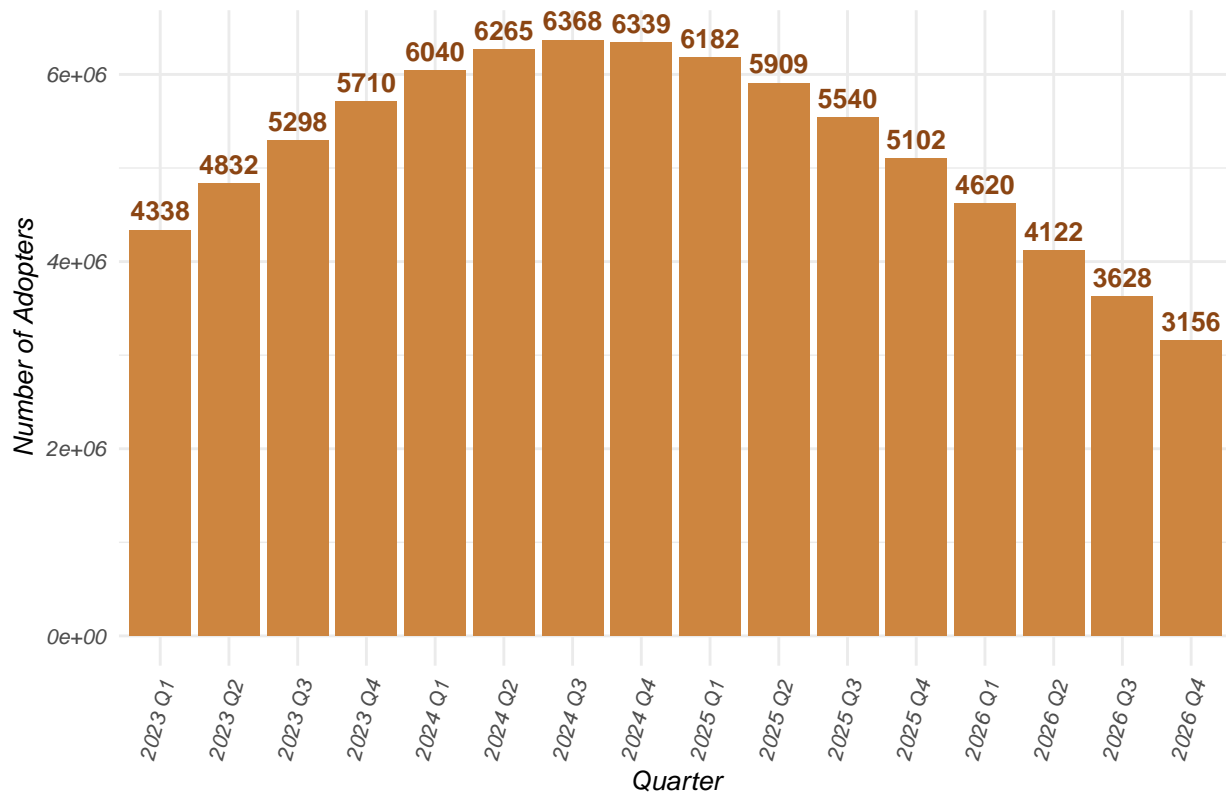
years <- start_year + ((0:(total_periods - 1)) + (start_quarter - 1)) %/% 4
quarters <- ((start_quarter - 1 + 0:(total_periods - 1)) %% 4) + 1
quarter_labels <- paste0(years, " Q", quarters)

plot_data <- data.frame(
  Quarter = factor(quarter_labels, levels = quarter_labels),
  Adopters = adopters_units
)

ggplot(plot_data, aes(x = Quarter, y = Adopters)) +
  geom_bar(stat = "identity", fill = "#CD853F") +
  geom_text(aes(label = round(Adopters / 1000)),
    vjust = -0.5, size = 3.5, color = "#8B4513", fontface = "bold") +
  theme_minimal() +
  theme(
    axis.text.x = element_text(angle = 75, hjust = 1, size = 8, face = "italic"),
    axis.text.y = element_text(size = 8, face = "italic"),
    axis.title.x = element_text(face = "italic", size = 10),
    axis.title.y = element_text(face = "italic", size = 10),
    plot.title = element_text(face = "bold.italic", color = "#8B0000", size = 14)
  ) +
  labs(
    title = "Estimated Number of Apple Vision Pro Adopters per Quarter",
    x = "Quarter",
    y = "Number of Adopters"
  )

```


Estimated Number of Apple Vision Pro Adopters per Quarter



The bar chart above presents the *estimated quarterly adoption of the Apple Vision Pro*, predicted using the Bass diffusion model with a market potential of 10 million adopters. The forecast indicates that adoption rises from about *4.34 million* in Q1 2023, reaching peaks of over *6.3 million* adopters per quarter by 2024. After this surge, adoption gradually tapers off through 2025–2026, ending near *3.16 million* in Q4 2026. This trend follows the typical *S-shaped diffusion pattern*, where early growth is driven by innovators and imitators, before slowing down as the market approaches saturation.

Reference: Statista — “AR/VR headset companies shipment share worldwide 2023–2025, by quarter.” [Click here for the link](#)