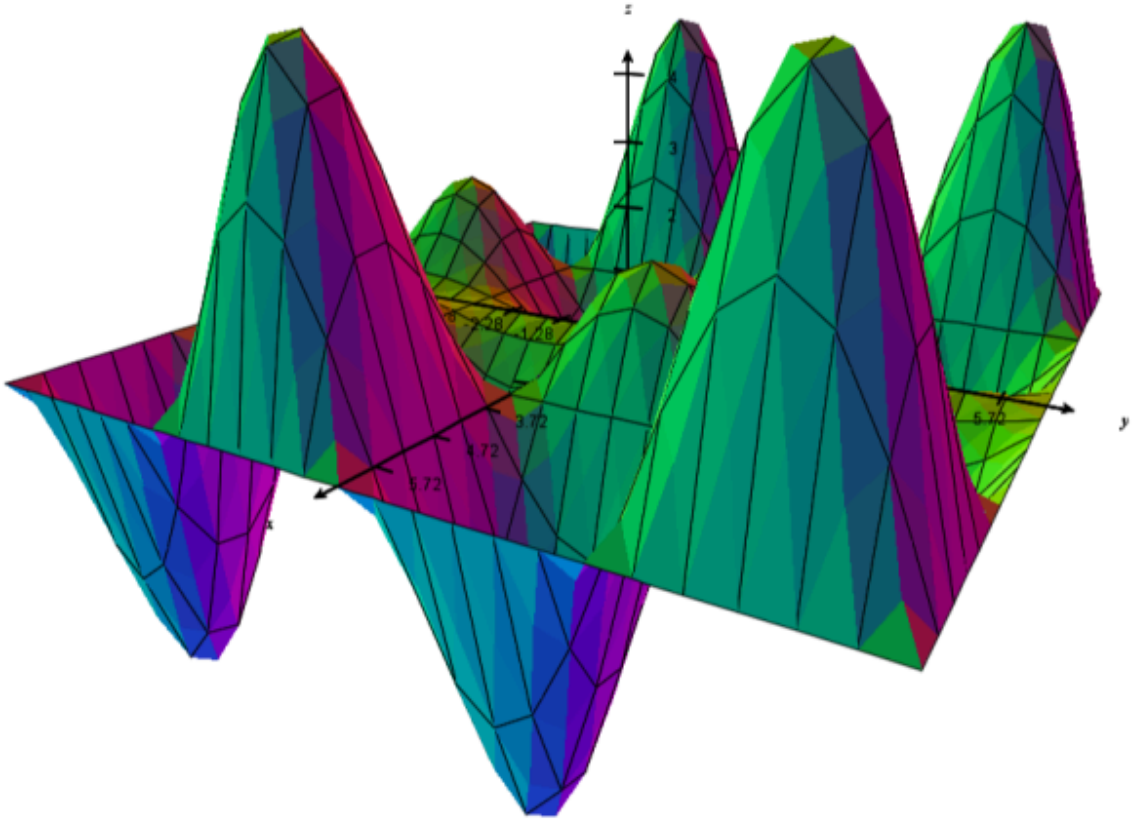


MultiVariable Calculus

Project Title: Analysis of BnB Demand and Strategies for Increasing Demand

Section: E

Maimoona Imran, 23i-0653

Fatima Ishtiaq, 23i-0696

Eshaal Malik, 23i-0732

Table of content

Objective of the Problem

The objective of this project is to analyze the demand for the product BnB and identify factors influencing its demand. Specifically, we aim to construct a multivariable function for the demand of BnB, analyze the effects of price changes on BnB demand using automatic differentiation, and propose strategies to increase the demand for BnB.

By Hand Solution

Calculus Project

Task 1:

x = price of BnB

y = price of A

z = price of B

After an increase, multiply by 1.2 for prices

$$D(x,y,z) = 10{,}000 - 2.5(1.2x)^2 + 3(1.2y) + 1.5(1.2z)$$

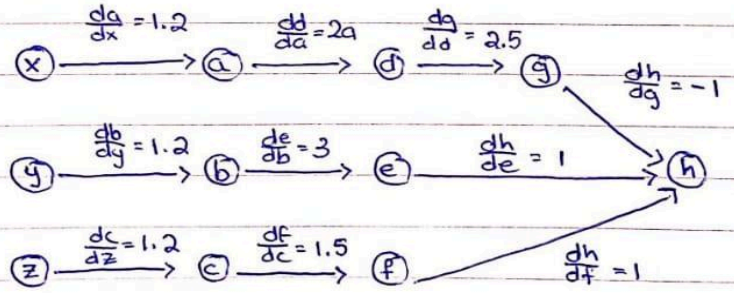
Before an increase takes place:

$$D(100,100,100) = -14550$$

$a = 1.2*x$ $\quad b = 1.2*y$ $\quad c = 1.2*z$

$d = a*a$ $\quad e = 3*b$ $\quad f = 1.5*c$

$g = 2.5*d$ $\quad h = 10{,}000 - g + e + f$



Task 2: $1.2*2*(1.2*x)*2.5*-1 = -7.2x$

$$\frac{dD}{dx} = -2.5*2(1.2x)*1.2 = -7.2x$$

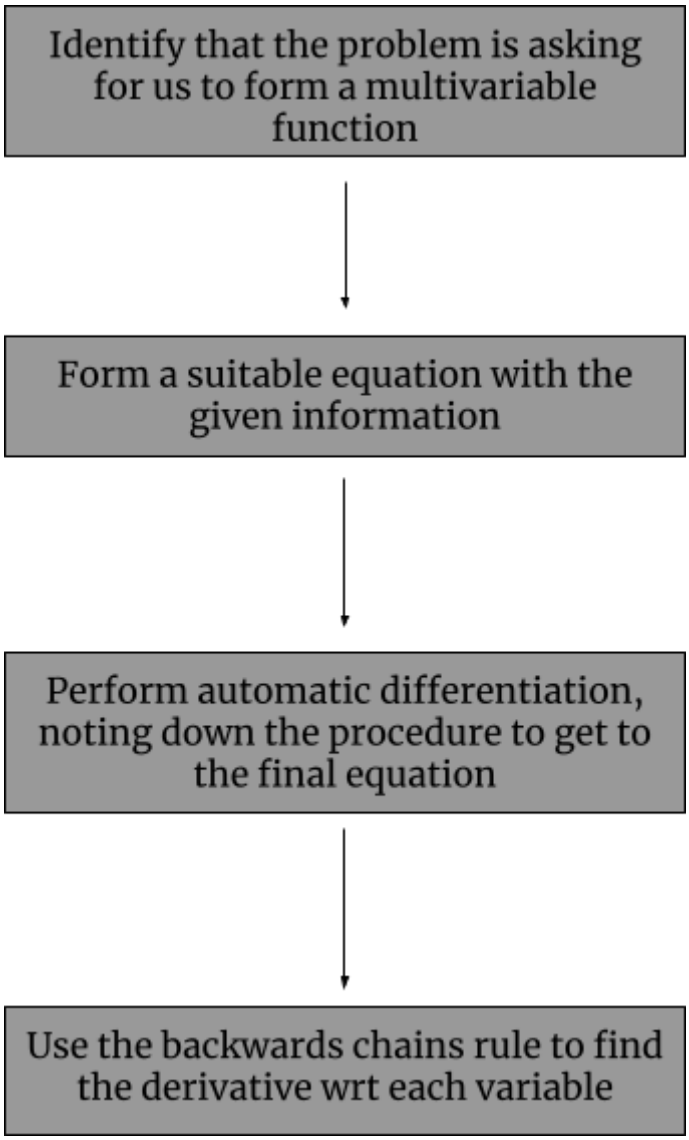
Task 3: $1.2*3*1 = 3.6$

$$\frac{dD}{dy} = 3*1.2 = 3.6$$

Task 4

Some solutions may include **reducing the BnB price** as the negative impact of price on demand suggests lowering the price of BnB. Also, we should **monitor competitor prices** as an increase in competitor A's price benefits BnB so keeping an eye on competitor pricing strategies could be valuable. In addition, **product Improvement** could be useful. Analyze if there's room to improve BnB's features or quality to make it more attractive to consumers even at its current price point.

Flowchart or Code Flow Diagram



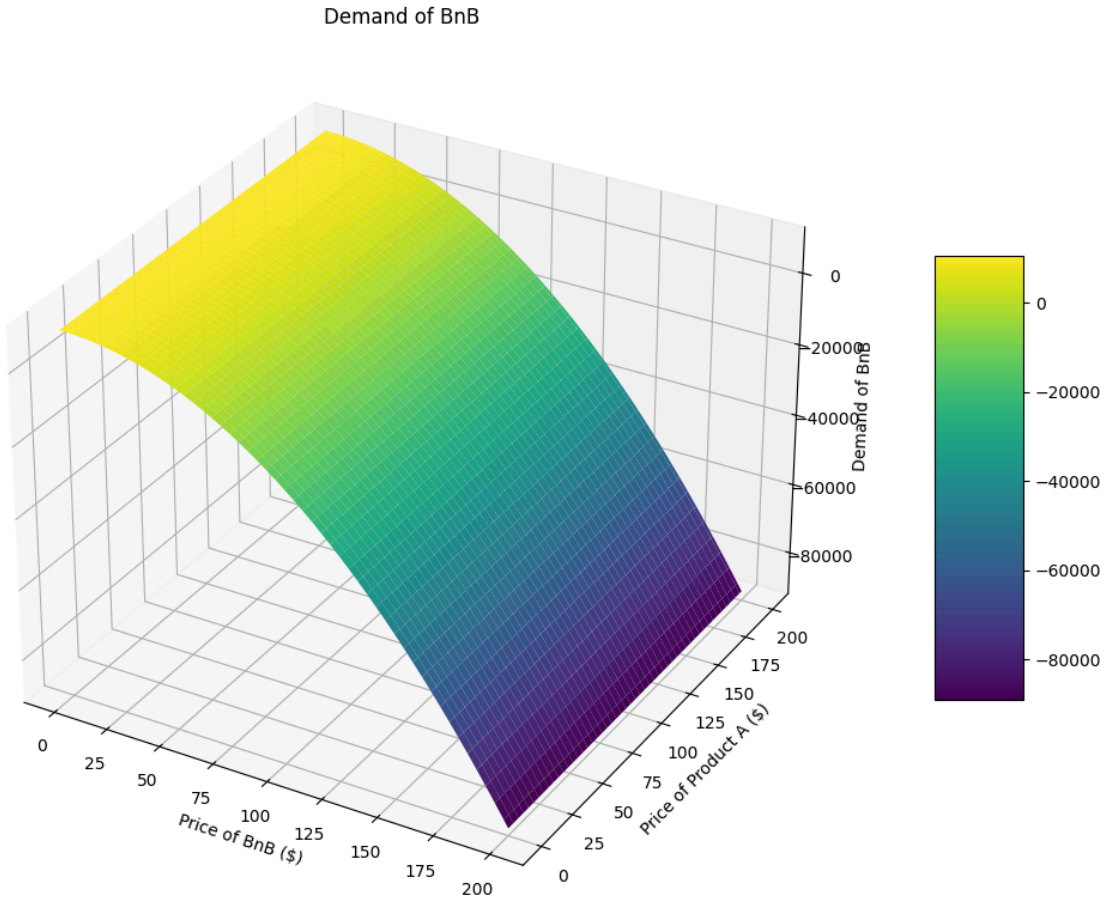
Explanation of Major MATLAB/Software Commands Used

- print(): This command is used to display output to the console. It takes strings or variables as arguments and prints them to the console.
- input(): This command takes user input from the console. It displays a prompt (if provided) and waits for the user to enter some input. In the code, input() is used to pause the program execution until the user presses any key to continue.
- def: This keyword is used to define a function in Python. Functions are blocks of reusable code that perform a specific task. In this code, two functions are defined: demand_bnb() and demand_bnb_after().
- return: This keyword is used inside a function to return a value back to the caller. In the functions demand_bnb() and demand_bnb_after(), return is used to return the calculated demand of BnB.
- while True:: This creates an infinite loop that continues until it's broken by a break statement. It's used here to repeatedly execute the tasks until the user chooses to terminate the program.
- Variable assignments: Lines like P_B = P_A = P_C = 100 are used to initialize multiple variables with the same value.
- Function Calls: Functions are called using their names followed by parentheses containing arguments. For example, demand_bnb(P_B, P_A, P_C) and derivative_bnb_wrt_price_B(P_B) are function calls.
- print() within tasks: Each task is delineated by print() statements providing information about what the task is doing, what it's displaying, or what action it's prompting.
- input() for user choice: The input() command is used to get user input regarding whether they wish to continue running the program or not.
- if statement: It checks the condition provided and executes the code block inside it if the condition is true. In this code, if choice == 'n': is used to check if the user chooses not to run another query and terminates the program accordingly using break.

Example Run and Detailed Results

```
maimoona@maimoona-HP-Laptop-15-dy2xxx:~$ python3 mvcal1.py
Programming Team:
1. 23i-0653
2. 23i-0696
3. 23i-0732
Press any key to continue
k

Task 1:
Demand of BnB when all prices are $100 each: -14550.0

Task 2:
Derivative of demand of BnB with respect to price of BnB: -7.2 P_B

Task 3:
Derivative of demand of BnB with respect to price of product A: 3.6

Task 4:
To increase demand of BnB, the company should consider reducing the price of BnB.
Additionally, improving product features or increasing advertising might help in increasing demand.

Do you wish to run another query? (Y/N): n
Program terminated.
maimoona@maimoona-HP-Laptop-15-dy2xxx:~$
```

2D or Other Plots



Conclusions and Analysis

From our analysis, we can conclude that there is price sensitivity meaning that the negative demand value (-14550 units/day) indicates a high sensitivity of demand to price. The current price point (all products at $100) likely discourages consumers, leading to a significant decrease in demand compared to the initial level (10000 units/day).

Also, this model is a simplification, and other factors like marketing efforts, consumer preferences, and economic conditions will most definitely influence demand. It's crucial to consider these factors for a more comprehensive picture which will enable us to make more strategic plans to improve the product's sales.

Contribution Section

Our team held regular meetings where we discussed various aspects of the project. In these sessions, every team member actively participated and contributed ideas, ensuring that all perspectives were considered. Through collaborative discussions and sharing of ideas, we were able to analyze the demand function and provide recommendations for increasing the demand of BnB. Throughout the project, each member put in dedicated effort, working together on every question and task.

Difficulties Faced and Overcoming Them

- **Programming Errors**: Debugging errors in the code was time-consuming and frustrating. We tackled this by using debugging tools provided by the programming environment.
- **Time Management**: Balancing the demands of the project with so many more projects was indeed a challenge. To manage our time effectively, we created a detailed project schedule, prioritized tasks based on their urgency, and delegated responsibilities among team members to distribute the workload evenly.

Complete and Well-Commented Program (Annexure A)

Code for main tasks

```
# Display team information
print("Programming Team:\n1. 23i-0653\n2. 23i-0696\n3. 23i-0732\nPress any key to continue")
input()

# Function to calculate demand of BnB
def demand_bnb(P_B, P_A, P_C):
    # Calculate demand of BnB using given formula
    return round((10000 - 2.5 * P_B**2 + 3 * P_A + 1.5 * P_C), 2)

# Function to calculate demand of BnB after a price increase
def demand_bnb_after(P_B, P_A, P_C):
    # Calculate demand of BnB after a price increase using given formula
    return round((10000 - 2.5*(P_B*1.2)**2 + 3*1.2*P_A + 1.5*1.2*P_C), 2)

# Loop for continuous execution of the program
while True:
    # Task 1: Displaying initial demand of BnB
    print("\nTask 1:")
    P_B = P_A = P_C = 100  # Prices of all products are initially $100 each
```

```
print("Demand of BnB when all prices are $100 each:", demand_bnb(P_B, P_A, P_C))

# Task 2: Calculating derivative of demand of BnB with respect to price of BnB
print("\nTask 2:")
def derivative_bnb_wrt_price_B(P_B):
    # Calculate the derivative of demand of BnB with respect to price of BnB
    return round((-2.5*1.2 *2*1.2), 2)
        print("Derivative of demand of BnB with respect to price of BnB:", derivative_bnb_wrt_price_B(P_B), "P_B")

# Task 3: Calculating derivative of demand of BnB with respect to price of product A
print("\nTask 3:")
def derivative_bnb_wrt_price_A(P_A):
    # Calculate the derivative of demand of BnB with respect to price of product A
    return round((3*1.2), 2)
        print("Derivative of demand of BnB with respect to price of product A:", derivative_bnb_wrt_price_A(P_A))

# Task 4: Suggestions to increase demand of BnB
print("\nTask 4:\nTo increase demand of BnB, the company should consider reducing the price of BnB.")
    print("Additionally, improving product features or increasing advertising might help in increasing demand.")

# Program termination or continuation based on user input
choice = input("\nDo you wish to run another query? (Y/N): ").strip().lower()
if choice == 'n':
    # If user chooses not to run another query, terminate the program
    print("Program terminated.")
    break
```

Code for plotting graph

```
import numpy as np
import matplotlib.pyplot as plt
from mpl_toolkits.mplot3d import Axes3D

# Function to calculate demand of BnB
def demand_bnb(P_B, P_A, P_C):
    # Calculate demand of BnB using the given formula
    demand = 10000 - 2.5 * P_B**2 + 3 * P_A + 1.5 * P_C
    return demand

# Generating price values
P_B_values = np.linspace(0, 200, 100)  # Generate 100 equally spaced values from 0 to 200 for the price of BnB
P_A_values = np.linspace(0, 200, 100)  # Generate 100 equally spaced values from 0 to 200 for the price of product A
P_C_values = np.linspace(0, 200, 100)  # Generate 100 equally spaced values from 0 to 200 for the price of product C

# Creating meshgrid
# Meshgrid creates a grid of points for each combination of the provided values
P_B_grid, P_A_grid, P_C_grid = np.meshgrid(P_B_values, P_A_values, P_C_values, indexing='ij')

# Calculating demand for each combination of prices
demand_grid = demand_bnb(P_B_grid, P_A_grid, P_C_grid)

# Plotting
fig = plt.figure()  # Create a new figure
ax = fig.add_subplot(111, projection='3d')  # Add a 3D subplot to the figure

# Plot surface
# Plot the surface plot using the calculated demand grid
surf = ax.plot_surface(P_B_grid[:,:,0], P_A_grid[:,:,0], demand_grid[:,:,0], cmap='viridis')
# Set labels for axes
ax.set_xlabel('Price of BnB ($)')  # Set label for x-axis
ax.set_ylabel('Price of Product A ($)')  # Set label for y-axis
ax.set_zlabel('Demand of BnB')  # Set label for z-axis
ax.set_title('Demand of BnB')  # Set title for the plot
```

```
# Add a color bar which maps values to colors
fig.colorbar(surf, shrink=0.5, aspect=5)  # Add a colorbar to the plot

plt.show()  # Display the plot
```