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Prediction Cost on Media Campaigns

Murat Yazici
Department of Statistics and Probability, Faculty of Informatics and Statistics, Prague University of Business and Economics, Czech Republic
E-mail: asiscrus.muratyazici@gmail.com

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Abstract

The cost function illustrates the different levels of cost at which production is carried out. It assists companies in deciding how to best utilize their resources in order to produce the most amount of product. This paper includes the cost function's theoretical background and a study on the prediction of cost for acquiring customers on media campaigns.

Keywords: Cost function, short and long run cost curves, average and marginal costs
Jel codes: D20, D4

1. Introduction

The study of the relationship between the production of goods and services and the expenses involved is a core principle in the field of microeconomics, known as the cost function. Companies rely on cost functions to make well-informed decisions regarding production. These decisions encompass finding the most efficient production levels, formulating pricing strategies, and effectively allocating resources. The primary objective of utilizing a cost function is to minimize expenses and maximize a company's profitability.

This paper provides a theoretical foundation for the cost function and explores related concepts such as the average cost function and the marginal cost function. Average cost is determined by dividing the total cost by the total number of units produced, while marginal cost represents the increase in total cost for each additional unit produced. Furthermore, this article presents a study that determines the costs associated with acquiring customers through media campaigns.

The remainder of the paper is organized as follows. The section 2 starts the cost function including average and marginal costs. At the end of the section 2, the focus is on the short-run, long-run cost curves, and the concavity of the cost function. Then, the section 3 includes the prediction cost on media campaigns study. Finally, the conclusion part, the section 4, draws conclusions based on the results of the study.

2. The Cost Function

The minimum cost of producing a specific output level, given fixed factor prices, is quantified by the cost function. By this way, it provides a concise overview of the available technological options for firms. It turns out that the behavior of the cost function can tell us a lot about the nature of the firm's technology (Varian, 1992).

Utilizing the cost function as the foundation for model development in econometric applications ensures compatibility with the competitive cost reduction premise while avoiding the challenge of constructively deriving demand systems from production possibilities. Moreover, the simplified form of the model is defined by the cost function and its derivatives under certain econometric assumptions of company behavior. Properties of the cost function can also be used generalize and simplify the qualitative implications of cost minimization (McFadden, 1978).

The average cost is determined by dividing the entire cost by the total out-put. Making or manufacturing one more unit results in a change in overall production costs, which is known as the marginal cost. The marginal cost may be computed by dividing the variation in production costs by the amount changed. A short-run cost can be defined as the minimum time period during which there is at least one input item is fixed and cannot be altered. On the other hand, long-run costs represent a scenario in which all variables are malleable and subject to change. In the next sub-two sections, average and marginal costs which are related the cost function, and the short-run and long-run curves are examined, respectively.

2.1. Average and Marginal Costs

The average cost provides insights into the cost per unit of output. Busi-nesses rely on average cost analysis to identify the production level that minimizes the cost per unit. It is calculated by dividing the total cost by the quantity of output produced. Conversely, the concept of marginal cost refers to the extra expenses incurred when producing an additional unit of a good or service. It is determined by dividing the change in total cost by the change in quantity produced. Businesses consider the marginal cost when determining the optimal production quantity. The formulation of average cost (AC) and marginal cost (MC) are as Equation 1 and 2, respectively.

$$AC = \frac{TC}{Q} \tag{1}$$

where AC = average cost, TC = total cost, and Q = number of units of a good produced.

$$MC = \frac{\Delta C}{\Delta Q} \tag{2}$$

where MC = marginal cost, ΔC = change in cost, and ΔQ = change in quantity.

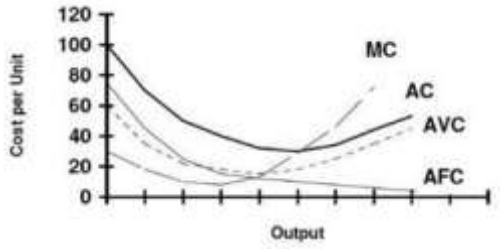

Figure 1. Average and Marginal cost curves

Source: https://commons.wikimedia.org/wiki/File:Shortruncostcurves.jpg

Figure 1 represents an example of marginal cost (MC) curve and average cost (AC) including AVC and AFC curves where AVC and AFC indicate average variable cost and average fixed cost, respectively. When average

cost does not change, it is considered constant. At the point where marginal cost equals average cost, MC = AC, the average cost is constant, and the decreasing average cost curve reaches its minimum point.

Table 1. The relation between Marginal Cost (MC) and Average Cost (AC)

1. When MC <AC: AC is decreasing.
2. When MC = AC: AC is constant.
3. When MC >AC: AC is increasing.

Table 1 indicates the relation between Marginal Cost (MC) and Average Cost (AC). As seen in the table, when marginal cost is less than average cost, average cost is decreasing. When marginal cost equals to average cost, average cost is constant. When marginal cost is greater than average cost, average cost increasing.

The average cost curve experiences a decline initially due to decreasing fixed costs, followed by an increase due to rising average variable costs.

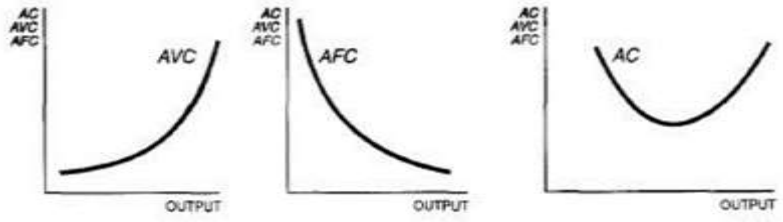

Figure 2. Average cost curves

Source: Varian, 1992

The Figure 2 shows the average cost curves. The average variable cost curve (AVC) will increase if output rises. The average fixed cost curve (AFC) will decrease if output rises, oppositely. The combination of these curves creates a *U*-shaped average cost curve (AC).

The total variable cost per unit of generated amount is equal to the average variable cost (AVC). In a similar manner, it is necessary to divide the total variable cost by the overall quantity to obtain the average variable cost.

$$AVC = \frac{VC}{Q} \quad (3)$$

where AVC = average variable cost, VC = total variable cost, and Q = quantity of output. For every unit, the average fixed cost (AFC) displays the entire fixed cost. Divide the entire fixed cost by the total amount to find the average fixed cost:

$$AFC = \frac{FC}{Q} \quad (4)$$

where AFC = average fixed cost, FC = total fixed cost, and Q = quantity of output.

2.2. Long-run and Short-run Cost Curves

The long-run cost curve considers both economies and diseconomies of scale, while the short-term cost curve indicates the extent of increasing or decreasing returns to scale. Additionally, both the long-run and short-run cost curves exhibit a *U*-shaped pattern.

The short-run cost and long-run cost functions can be written as following equations (Varian, 1992);

$$c(\mathbf{w}, y, \mathbf{x}_f) = \mathbf{w}_v \mathbf{x}_v(\mathbf{w}, y, \mathbf{x}_f) + \mathbf{w}_f \mathbf{x}_f \quad (5)$$

$c(\mathbf{w}, y, \mathbf{x}_f)$ represents the short-run total cost. The term $\mathbf{w}_v \mathbf{x}_v(\mathbf{w}, y, \mathbf{x}_f)$ indicates short-run variable cost (SVC), and the term $\mathbf{w}_f \mathbf{x}_f$ represents fixed cost (FC).

(i) STC = $\mathbf{w}_v \mathbf{x}_v(\mathbf{w}, y, \mathbf{x}_f) + \mathbf{w}_f \mathbf{x}_f$ // Short-run total cost

(ii) SAC = $\frac{c(\mathbf{w}, y, \mathbf{x}_f)}{y}$ // Short-run average cost

(iii) SAVC = $\frac{\mathbf{w}_v \mathbf{x}_v(\mathbf{w}, y, \mathbf{x}_f)}{y}$ // Short-run average variable cost

(iv) SAFC = $\frac{\mathbf{w}_f \mathbf{x}_f}{y}$ // Short-run average fixed cost

(v) SMC = $\frac{\partial c(\mathbf{w}, y, \mathbf{x}_f)}{\partial y}$ // Short-run marginal cost

The long-run cost function can be written as the following equations.

$$c(\mathbf{w}, y) = \mathbf{w}_v \mathbf{x}_v(\mathbf{w}, y) + \mathbf{w}_f \mathbf{x}_f = c(\mathbf{w}, y, \mathbf{x}_f(\mathbf{w}, y)) \quad (6)$$

LAC = $\frac{c(\mathbf{w}, y)}{y}$ // Long-run average cost

(i) LMC = $\frac{\partial c(\mathbf{w}, y)}{\partial y}$ // Long-run marginal cost

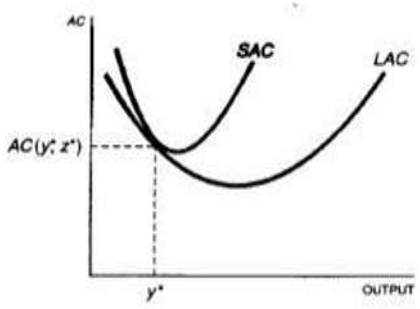

Figure 3. Long-run and short-run average cost curves

Source: Varian, 1992

The Figure 3 indicates the long-run average cost (LAC) and short-run average cost (SAC) curves. They must be tangent. The tangent point represents that the long-run and short-run marginal costs must be equal.

2.2.1. Relation between short-run and long-run average cost curves

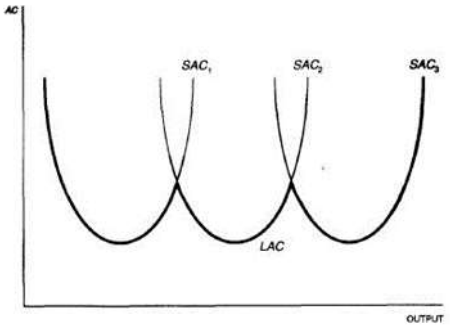

Figure 4. Long-run average cost curve

Source: Varian, 1992

In the Figure 4, it is seen that the long-run average cost curve, LAC, is the lower envelope of the short-run average cost curves, SAC1, SAC2, and SAC3.

2.3. Concavity of the cost function

Concavity of a function indicates the direction of its bend, with concave up indicating upward bends and concave down indicating downward bends.

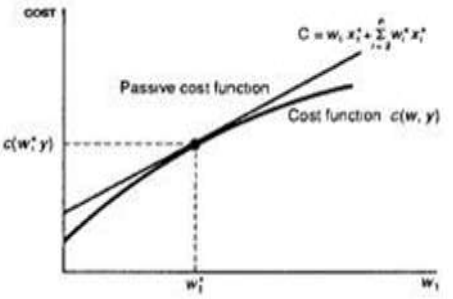

Figure 5. Concavity of the cost function

Source: Varian, 1992

As it is seen in figure 5 that with input prices w_1^*, total costs of producing y are $c(w^*, y)$. If the firm does not change its input, costs of producing y would follow the straight line. With input substitution, actual costs $c(w, y)$ will fall below this line, and hence the cost function is concave up at w_1^*.

3. Prediction cost on Media campaigns study

The study uses data from Convenient Food Mart (CFM) to calculate pre-diction cost to acquire a customer on media camping. For this aim, average and marginal costs are calculated via data including all media camping types in first. Secondly, they are determined for each media camping separately to see their effects on the cost. Table 2 represents variables of CFM Data.

Table 2. Variables of the CFM Data

Dependent variable:
Cost: The cost of acquiring a customer in dollars
Independent variables:
food category: Breakfast Foods, Jams, and Jellies etc.
food department: Frozen Foods, Baking Goods etc.
food family: Food, Drink etc.
store sales: as millions
store cost: as millions
unit sales: as millions, 1, 2, 3, 4 etc.
promotion name: Bag Stuffers, Cash Register Lottery, High Roller Savings etc.
sales country: USA, Canada, Mexico etc.
marital status: Married, Single.
gender: Female, Male.
Total children: 0, 1, 2, 3, 4, 5.
education: Partial High School, Bachelor's Degree, Graduate Degree etc.
member card: Normal, Bronze, Golden, Silver.
occupation: Professional, Management, Skilled Manual etc.
houseowner: Yes, No.
avg cars at home (approx): 0, 1, 2, 3, 4.
avg yearly income: $10K -$30K, $30K - $50K, $50K - $70K etc.
num children at home: 0, 1, 2, 3, 4, 5.
brand name: Carrington, Imagine, Golden etc.
SRP: Suggested Retail Price.
gross weight
net weight
recyclable package: 0, 1.
low fat: 0, 1.
units per case: 17, 25, 29 etc.
store type: Supermarket, Deluxe Supermarket, Gourmet Supermarket etc.
store city: Salem, Tacoma, Seattle etc.
store state: OR, WA, CA etc.
store sqft: Store square footage: 13305, 21215, 22123 etc.
grocery sqft: Grocery square footage: 13305, 22123, 26354 etc.
frozen sqft: Frozen square footage: 4746, 5415, 7041 etc.
meat sqft: Meat square footage: 3164, 3610, 4694 etc.
coffee bar: 0, 1.
video store: 0, 1.
salad bar: 0, 1.
prepared food: 0, 1.
florist: 0, 1.
media type: TV, Radio, In Store Coupon, Product Attachment etc.

Some extra explanations for the variables (features) are as, the Cost dependent variable provides information on the cost incurred on acquiring a customer in dollars. The store sales and unit sales, provide information on the sales generated by the store and the quantity of items sold in the store, respectively. The total children and num children at home provide information on the number of children in the household. The avg cars at home(approx) provides information on the approximate number of cars owned by the customer. The gross weight provides

information on the weight of the food item. The recyclable package and low fat provide information on the packaging type and whether the food item is a low-fat option or not. The units per case provides information on the number of units available in each case on the store shelves. The coffee bar, video store, salad bar, prepared food and florist provide information on the facilities available in the store.

3.1. Experimental results

3.1.1. Description of CFM Data

In this part, some descriptive statistics are performed on the data. The results are obtained by using the Python programming language via Jupyter Notebook. According to the variance analysis, some features are found to be not statistically significant on the acquire a customer cost.

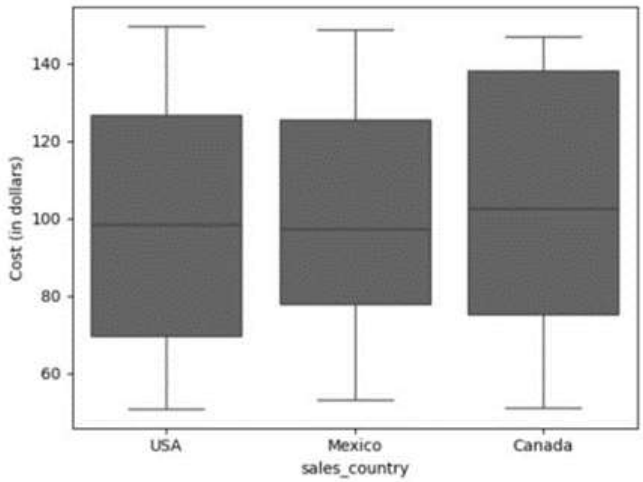

Figure 6. Cost of media campaigns by country

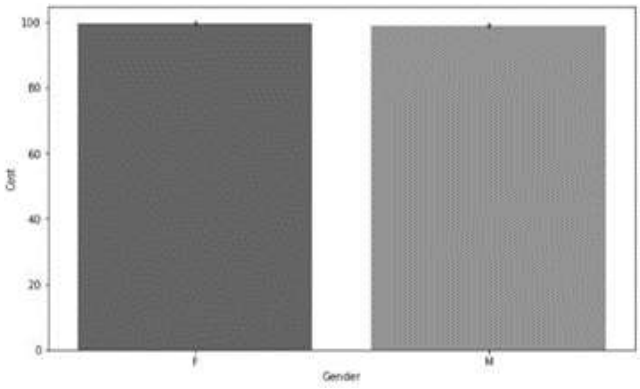

Figure 7. Cost of media campaigns by gender

Figure 6 and 7 represents cost of media campaigns by country and gender, respectively. It is seen that Canada has more cost at median point and cost of media campaigns by gender nearly same however female has a little bit more. Considering the size of the boxes, it can be said that while the least data is distributed in Mexico, the most data is distributed in Canada. The minimum costs are seen on USA and Canada. They are nearly same. However, the maximum cost is seen on USA.

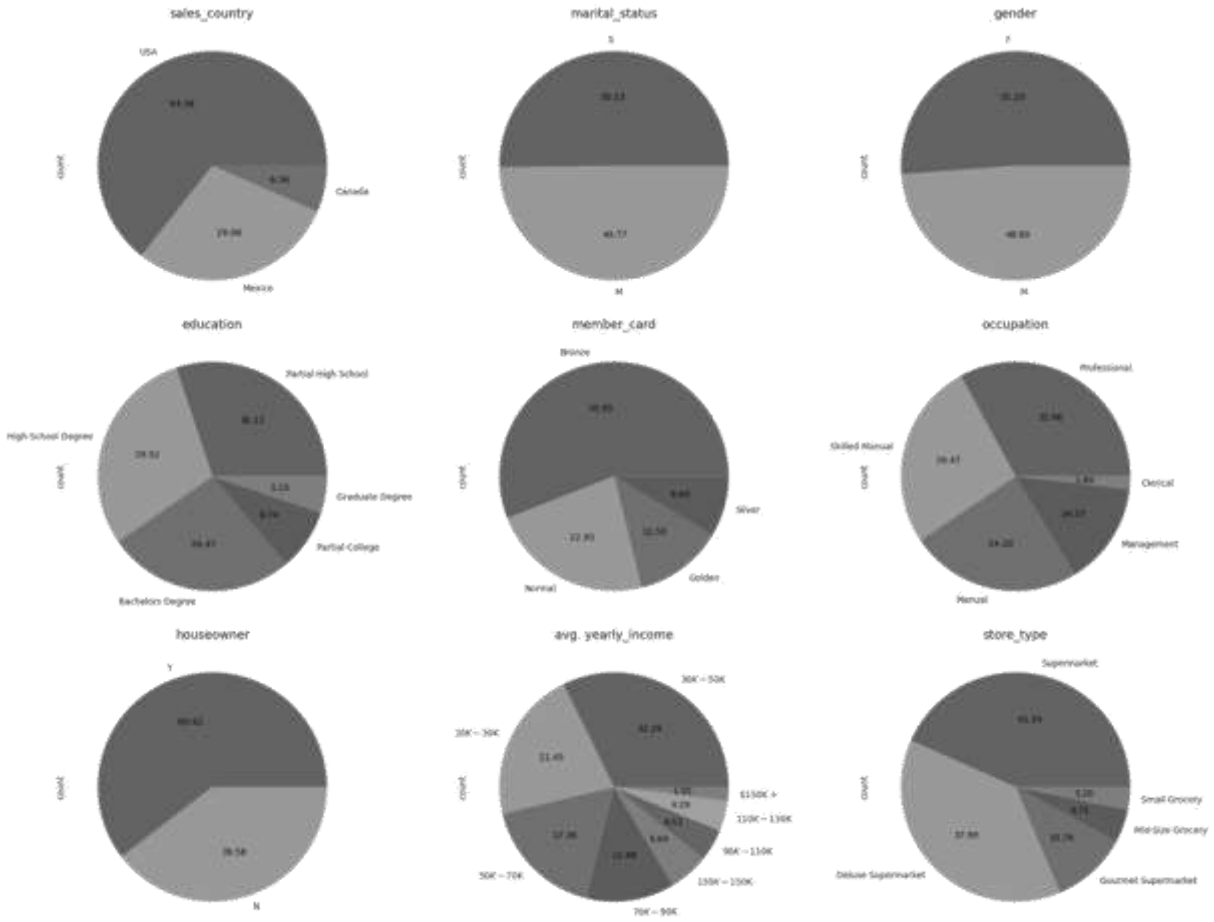

Figure 8. Some features in the CFM Data

According to analysis of variance (ANOVA), it is determined that some features do not have a statistically significant effect on the cost. These features are like as average cars at home, net weight, meat sqft, salad bar, food category, food department, food family, sales country, marital status, education, member card, houseowner, and brand name. These features have more than 0.05 p-values.

3.1.2. Average and marginal cost curves

In this part, average and marginal cost curves are drawn for both full CFM Data and each media campaign data, separately. It is important to note that average and marginal cost curves have not *U*-shapes because the CFM data has not fixed cost. Thus, it can be said that average cost (AC) equals to average variable cost (AVC). In addition, the short-run cost cannot be calculated because there is not at least one constant variable.

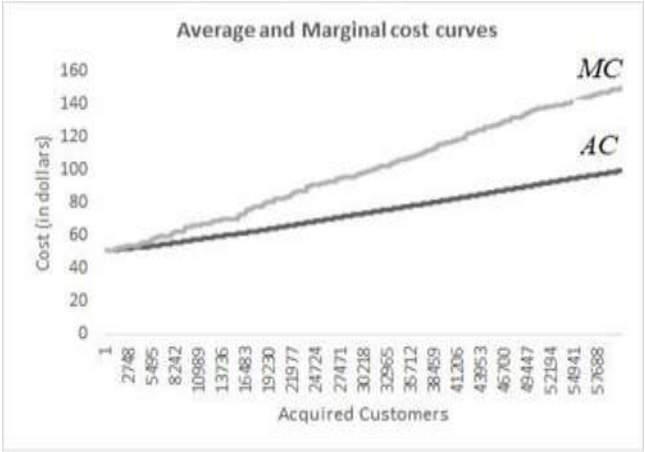

Figure 9. Average and marginal cost curves for the CFM Data

Figure 9 indicates average and marginal cost curves for the CFM Data. It is seen that AC is increasing because of MC>AC. It is not decreasing at the beginning because there are not any fixed costs on the CFM Data. In the figure, MC tends to move further away from AC while the count of acquire a customer is increasing.

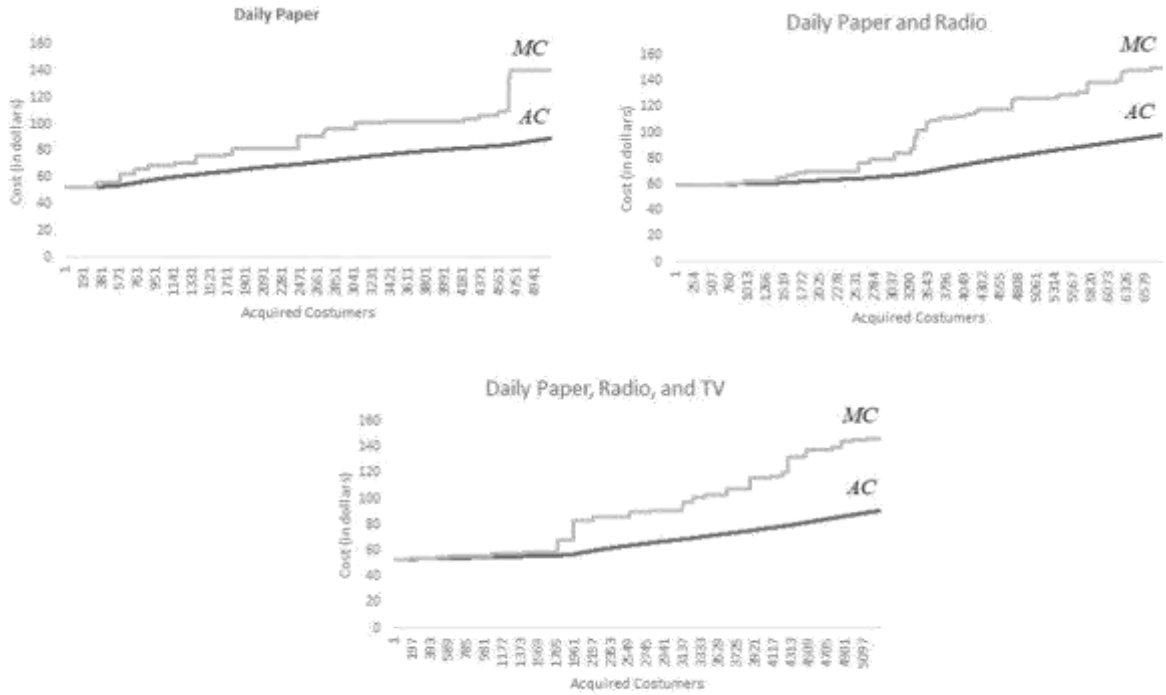

Figure 10. Average and marginal cost curves for Daily paper, Daily paper and Radio, and Daily paper, Radio and TV

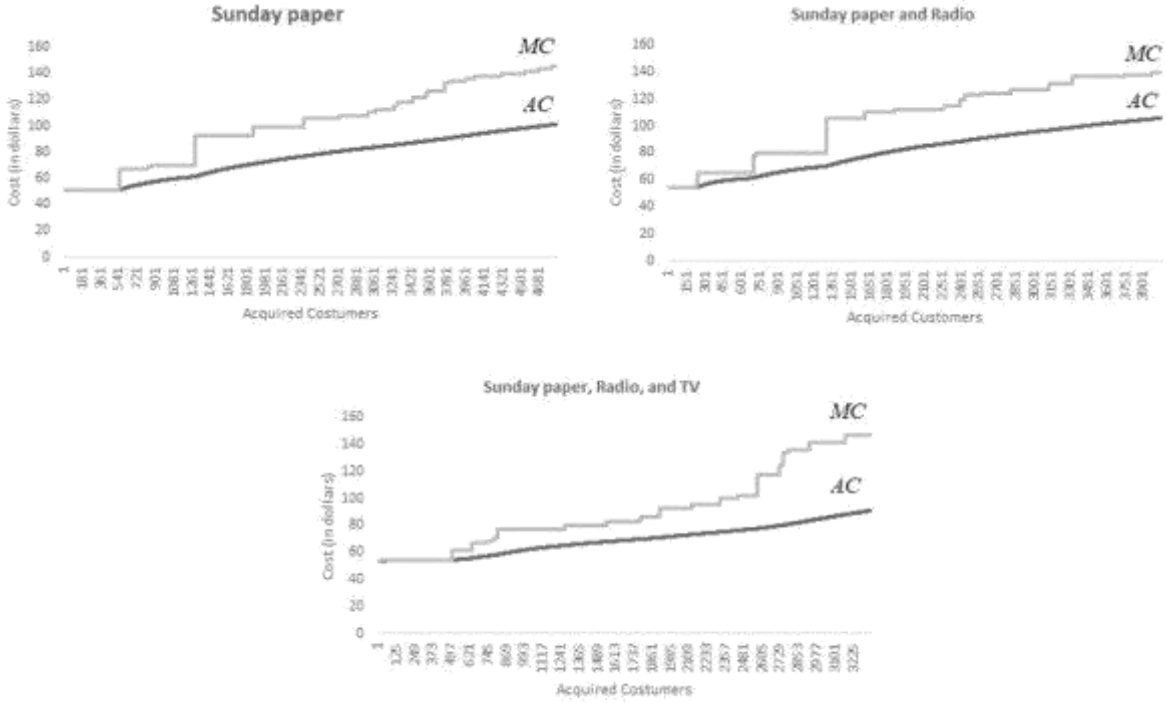

Figure 11. Average and marginal cost curves for Sunday paper, Sunday paper and Radio, and Sunday paper, Radio and TV

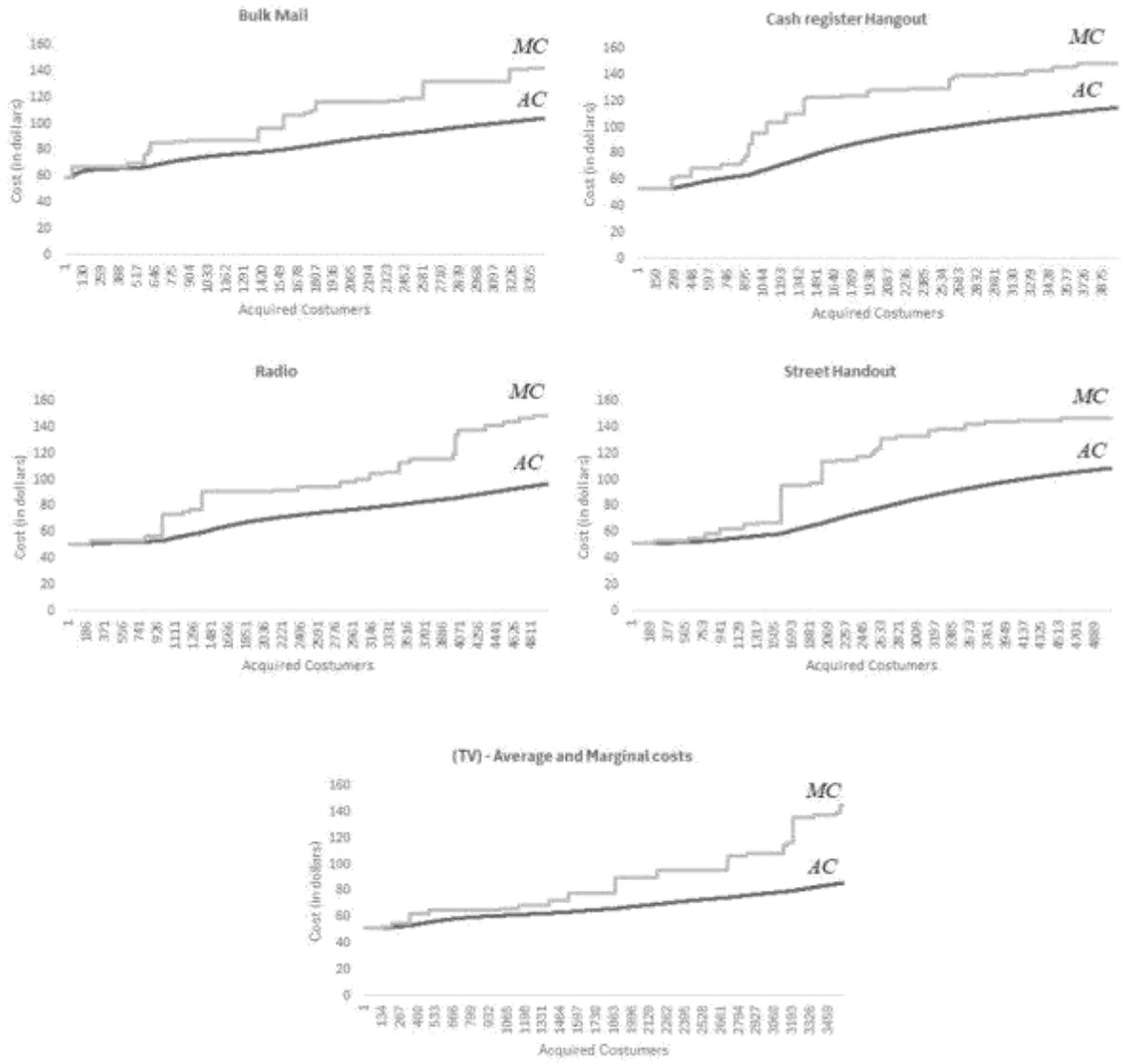

Figure 12. Average and marginal cost curves for Bulk mail, Cash register hangout, Radio, Street handout, and TV

4. Conclusion

Cost functions play a crucial role in the decision-making process for businesses. They assist in identifying optimal production levels, formulating effective pricing strategies, and efficiently allocating resources. The primary objective of utilizing a cost function is to minimize expenses and enhance a company's overall profitability.

In this paper, a theoretical foundation is provided for the cost function, along with an exploration of related concepts including the average cost function and the marginal cost function. It also included a study on the prediction costs to acquiring customers via media campaigns.

According to the results, because CFM Data does not have fixed cost in its feature, average cost (AC) did not show decreasing at the beginning of its curve. At the point having AC equals to marginal cost (AC = MC),

average cost is a constant and it has its minimum value. In addition, it is seen that AC is increasing because of MC>AC.

The study also showed average and marginal cost curves for all media campaign strategies, separately. In this way, when the firm wants to acquire *i*-th customer, it can compare the curves for all media campaigns.

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