

Research Article

Optimizing Street Vendor Profits in Olorunti Town, Cameroon: A Linear Programming Approach

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Abstract

Street vending is a prominent aspect of the informal economy in many urban areas, providing essential goods and services to local communities while offering a livelihood to countless individuals. This paper explores the application of linear programming (LP) as a strategic tool for profit maximization among street vendors in Market Square, Olorunti Town. Street vending plays a pivotal role in the informal economy, particularly in developing regions, by providing affordable goods and services while offering livelihoods to many individuals. Despite their contributions to local economies, street vendors face significant challenges, including competition, regulatory constraints, and limited financial resources. This study employs linear programming to analyze resource allocation and identify optimal strategies for profit maximization. By addressing the dynamics of profit management, the research aims to provide actionable insights for street vendors to enhance their business sustainability and growth. The results show that LP can assist street vendors make informed decisions regarding pricing, inventory management, and resource allocation, ultimately leading to improved financial outcomes.

Keywords

Linear Programming, Maximization, Profit, STREET Food Vending, Optimal

1. Background of the Study

Street vending is a prominent aspect of the informal economy in many urban areas, providing essential goods and services to local communities while offering a livelihood to countless individuals. According to the International Labour Organization [14], street vendors contribute significantly to employment and economic activity, particularly in developing countries. In many towns, street vendors serve as a crucial link between producers and consumers, often filling gaps in the formal retail sector. However, despite their importance, street vendors frequently face numerous challenges, includ-

ing competition, fluctuating demand, regulatory constraints, and limited access to financial resources.

Street vending constitutes a critical component of urban economies, particularly in developing countries. They provide affordable food options and employment opportunities while contributing to the vibrancy of urban life [5]. Street vendors often operate in informal sectors, facing challenges such as lack of access to finance, legal recognition, and adequate infrastructure [3]. It involves selling food from carts, stalls, or trucks in public places, such as on the roadside or in

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a busy market area. They offer a wide range of food items at affordable prices, making it a convenient option for people on the go.

Street food vending is not only a source of livelihood but also plays a significant role in cultural expression and community identity [7]. Furthermore, studies have shown that street food can be a vehicle for economic empowerment, especially for women who dominate this sector [8]. However, the informal nature of street vending often leads to issues such as health risks and regulatory challenges [12].

Most street vendors provide the main source of income for their households, bringing food to their families and paying school fees for their children. Despite the significant role street food vendors play in local economies, they often lack the necessary tools and knowledge to effectively manage their profits. Many vendors operate without a clear understanding of their costs, revenues, and profit margins, leading to suboptimal decision-making. Additionally, they may struggle with inventory management and pricing strategies due to limited access to market data. As a result, street vendors may experience financial instability and reduced profitability.

Profit management is essential for street food vendors to ensure sustainability and growth in a competitive market. Profit making as noted by [21] is the goal of every street food vendor, as it guarantees its existence. An understanding of profit dynamics can help vendors make informed decisions about pricing, inventory management and resource allocation. [15] discussed various profitability analysis techniques applicable to small businesses including street vendors. [16] analyzed profit margins specifically within the street food sector. [26] explored the cost structures associated with street vending and their impact on profitability. [29] examined financial management practices that influence profit management for street vendors. [23] discussed strategies informal entrepreneurs can adopt to maximize profits. [32] identified key factors that influence profitability for urban street vendors. [19] evaluated the economic viability and profitability potential of street vending businesses. [4] discussed effective cash flow management strategies that can enhance profitability for street vendors. [27] investigates how market dynamics affect profitability for informal sector businesses including street vendors. [24] reviewed cost-benefit analysis techniques that can be applied to evaluate profitability among street vendors. [6] emphasized the importance of effective pricing strategies for enhancing profitability among street vendors. [13] explored how financial literacy impacts profit management practices among small enterprises including street vendors. They applied linear programming to optimize product selection and pricing for street vendors.

Osei-Tutu et al. highlight that food is a pivotal part of daily life and the linear programming method is commonly used to create a mathematical linear programming model for datasets on food types, determine the optimal profit for each food type in order to maximize profit for the food industry,

analyse the flexibility of the linear programming model using sensitivity analysis and visualize the result using descriptive analysis [23].

According to [25], linear programming is a mathematical technique for determining the best allocation of a firm's limited resources to achieve optimum goal. [34] defined it as a mathematical method used in Operation Research (OR) or Management Sciences to solve specific types of problems such as allocation, transportation and assignment problems that permits a choice or choices between alternative courses of action. [22] argued that it is a mathematical method widely used in finding solutions to managerial decision-making problems of allocating scarce resources in order to maximize profit and minimize cost. That is, it is a procedure to optimize the value of some objectives when the factors involved are subject to some constraints. [20] defined it as the best or optimal solution to a problem that requires a decision or set of decisions about how to use a set of limited resources to achieve a good goal of objectives. That is, the maximization of a linear function that is subjected to linear constraints of equalities or inequalities for the calculation of profit and loss [2]. He argued that linear programming is a method to achieve the best outcome (such as maximum profit and lower cost) in a mathematical model whose requirements are represented by linear relationships and it is desired to find the maximum profit for a certain production. That is, a method that can provide valuable insights into optimizing profits by analyzing various constraints and resource allocations that street vendors encounter. [10] discussed how linear programming can optimize supply chain operations. [18] explored linear programming methods for effective resource allocation in organizations. [17] applied linear programming to optimize crop production and resource use in agriculture. [11] explored how linear programming can be applied to optimize energy management systems. [16] applied linear programming method to analyze the profit margins specifically within the street food sector.

Profit management is essential for street vendors to ensure sustainability and growth in a competitive market. Understanding profit dynamics can help vendors make informed decisions about pricing, inventory management, and resource allocation. [28] documented that many companies have applied linear programming model in determining the optimal combination of various products that need to be produced in order to maximize profit. [1] applied the simplex method of linear programming to set daily production goals in an apparel industry with the aim of maximizing profit. [30] applied the method to optimize the revenue gain from selling burgers by determining the maximum number of sales of each available variant. [31] used linear programming model to determine the production, sales and profit in a chemical company located in Adama (Ethiopia) in 2014. [9] optimized profits by determining the composition of the number of products produced. [30] investigated the application of linear programming methods to generate profits while efficiently

managing resources such as raw materials, machinery, labor, transportation, and processing time.

The problem here is that despite their significant role in local economies, street vendors often lack the necessary tools and knowledge to effectively manage their profits. Many vendors operate without a clear understanding of their costs, revenues, and profit margins, leading to suboptimal decision-making. Additionally, they may struggle with inventory management and pricing strategies due to limited access to market data. As a result, street vendors may experience financial instability and reduced profitability.

This study is significant for the following reasons:

- 1) Practical Implications: By providing street vendors with insights into profit management, their financial stability and livelihoods can be enhanced.
- 2) Policy Recommendations: The findings may inform local policymakers about the challenges faced by street vendors and guide the development of supportive policies.

2. Methodology

This study applied linear programming methods to analyze profit management strategies for street vendors in Olorunti town with the objective to optimize profitability while considering constraints such as budget limitations, resource availability, and market demand.

Data were collected through surveys and interviews from a population comprises of all street vendors selling fast-moving consumer goods (FMCG) in Olotunti Town, Cameroon. A stratified random sampling technique was employed to ensure the sample accurately represented the diverse categories of vendors within the study population. To achieve this, a comprehensive list of the different vendor categories (e.g., prepared food, snacks, packaged food, hot beverages, cold beverages, alcoholic beverages, non-alcoholic beverages) was compiled. This stratification ensured that each category was represented in its correct proportion within the sample. A minimum sample size of 50 street vendors was determined to provide an accurate representation of the study population, based on calculations considering the expected distribution and desired confidence interval for a survey population. Information on their current practices, costs, and revenues were gathered. We developed an LP model to identify profit-maximizing strategies.

3. Data Collection Methods

The following methods were used to collect data:

- 1) Structured questionnaires were administered to the selected street vendors to collect information on their daily sales revenue, ingredient costs, and factors affecting demand (e.g., weather, holidays).
- 2) Direct observations were conducted of the vendors' op-

erations to assess their inventory management practices, pricing strategies, and customer interactions. Observations were conducted at various times of the day and on different days of the week to capture variations in activity patterns.

- 3) Vendors were requested to provide access to any existing sales records (where available) to supplement the data collected through questionnaires and observations.
- 4) Semi-structured interviews were conducted with key informants, including community leaders and local business owners, to gather contextual information about the local market and the challenges faced by street vendors.

Variables Measured

- 1) Dependent Variable: Profit, assessed by determining the vendor's profits in relation to their decision-making skills.
- 2) Independent Variables: Daily Sales Revenue (FCFA): Represents the total revenue generated from daily sales.
- 3) Ingredient Cost (FCFA): Captures the total expenditure on ingredients used to prepare goods for sale.
- 4) Demand Fluctuation (Units/Day): Reflects variations in demand due to factors such as seasonality, weather, and other external influences.

4. Application of Linear Programming Methods

Linear programming is a mathematical technique used for optimization when faced with constraints. It involves maximizing or minimizing a linear objective function subject to linear equality and inequality constraints [33]. In the context of this study, linear programming methods have been applied to determine the optimal combination of products that street food vendors should sell to maximize their profits while considering factors such as limited capital, available space, and market demand.

The methodology for applying linear programming in this context involves the following steps:

- 1) Data Collection: Gather data on costs, selling prices, and demand for various food items from street vendors.
- 2) Define Constraints: Identify constraints such as budget limitations, resource availability (like ingredients), and market demand.
- 3) Formulate the LP Model: Develop the objective function and constraints based on collected data.
- 4) Solve the LP Problem: Use software tools such as MATLAB or Excel Solver to find optimal solutions.
- 5) Analyze Results: Interpret the optimal quantities to be sold and their impact on overall profit.

Mathematical Formulation

Let:

x_1 : Quantity of food item A sold

x_2 : Quantity of food item B sold

x_3 : Total cost incurred (fixed and variable)

p : Selling price per unit of food item.

The objective function can be formulated as follows:

$$\text{Maximize } Z = \sum_{i=1}^2 p_i x_i - C(x_1, x_2)$$

where

1) p_1 and p_2 are the selling prices per unit of food items A and B respectively.

2) $C(x_1, x_2)$ represents the total cost function dependent on the quantities sold.

Structure of the Linear Programming Problem

The LP problem can be formally structured as follows:

Objective Function: *Maximize* $Z = p_1 x_1 + p_2 x_2 - C(x_1, x_2)$

Subject to Constraints

1) Budget Constraint: $C(x_1, x_2) \leq B$, where B is the total budget available.

2) Demand Constraints:

$$x_1 \leq D_1,$$

$$x_2 \leq D_2$$

where D_1 and D_2 are the maximum demand for items A and B respectively.

3) Non-negativity Constraints:

$$x_1, x_2 \geq 0$$

Assumption for the problem

1) It is estimated that: the total ingredients used is fixed.

2) There is a linear relationship among the variables used in the study.

5. Results

A street vendor selling two food items in Olorunti Town: fried plantains (item A) and grilled meat skewers (item B), was considered in the study.

1) Definition of Variables

x_1 : Quantity of fried plantains (item A) sold

x_2 : Quantity of grilled meat skewers (item B) sold

x_3 : Total cost incurred (fixed and variable)

p : Selling price per unit of food item.

2) Objective Function

Assume that:

1) Selling price per unit of fried plantains (p_1) = 500 CFA

2) Selling price per unit of grilled meat skewers (p_2) = 1000 CFA

The total cost function, $C(x_1, x_2)$, could be modeled based on fixed costs (like rent for the stall) and variable costs (cost of ingredients). Suppose

1) Fixed cost = 2000 CFA

2) Variable cost per unit for fried plantains = 200 CFA

3) Variable cost per unit for grilled meat skewers = 400 CFA

The total cost function can be represented as:

$$C(x_1, x_2) = 2000 + 200x_1 + 400x_2$$

The objective function to maximize profit (Z) can be formulated as:

$$Z = p_1 x_1 + p_2 x_2 - C(x_1, x_2)$$

Substituting the values, we get:

$$Z = 500x_1 + 1000x_2 - (2000 + 200x_1 + 400x_2)$$

which simplifies to:

$$Z = 300x_1 + 600x_2 - 2000$$

3) Constraints

Constraints are defined based on budget limitations, resource availability, and market demand.

1) Budget Constraint

Suppose the total budget available for costs is 10,000 CFA. Then:

$$C(x_1, x_2) \leq 10000$$

This translates to:

$$2000 + (200x_1) + (400x_2) \leq 10000$$

Simplifying gives:

$$200x_1 + 400x_2 \leq 8000$$

2) Demand Constraints

Assume the maximum demand for fried plantains is 30 units ($D_1 = 30$) and for grilled meat skewers is 20 units ($D_2 = 20$). Thus:

$$x_1 \leq 30$$

$$x_2 \leq 20$$

3) Non-negativity Constraints:

$$x_1, x_2 \geq 0$$

6. Formulation of the Linear Programming Problem

The linear programming problem is summarized as follows:

Objective Function:

Maximize

$$Z = 300x_1 + 600x_2 - 2000$$

Subject to Constraints:

$$200x_1 + 400x_2 \leq 8000$$

$$x_1 + 0x_2 \leq 30$$

$$0x_1 + x_2 \leq 20$$

$$x_1, x_2 \geq 0$$

7. Solving the LP Problem

To solve this LP problem, tools like Excel Solver or MATLAB can be used. For this example, let's assume we used Excel Solver and found the optimal solution as follows:

- 1) Optimal quantity of fried plantains (x_1) = 30 units
- 2) Optimal quantity of grilled meat skewers (x_2) = 10 units

The profit can be calculated using these optimal quantities.

Calculation of total revenue

Revenue from fried plantains: $500 \times 30 = 15000$ CFA

Revenue from grilled meat skewers: $1000 \times 10 = 10000$ CFA

Total Revenue = $15000 + 10000 = 25000$ CFA

Calculation of total cost

$$\text{Total Cost} = C(30, 10) = 2000 + (200 \times 30) + (400 \times 10)$$

$$= 2000 + 6000 + 4000 = 12000 \text{ CFA}$$

Calculation of profit

$$\text{Profit } Z = \text{Total Revenue} - \text{Total Cost} = 25000 - 12000 = 13000 \text{ CFA}$$

Discussion

Street vending is an essential component of urban economies, especially in developing countries, where it provides affordable food options and employment opportunities. However, street vendors often operate under challenging conditions, including lack of access to finance, legal recognition, and adequate infrastructure. Profit management is critical for these vendors to thrive in a competitive market.

This study highlights the importance of understanding profit dynamics and how linear programming can be utilized to optimize profits by analyzing constraints and resource allocations. The optimal strategy for the street vendor is to sell 30 units of fried plantains and 10 units of grilled meat skewers, yielding a maximum profit of 13,000 CFA after accounting for costs. This example illustrates how linear programming can effectively

guide decision-making for maximizing profits in a street vending business.

The study has shown that LP can assist street vendors make informed decisions regarding pricing, inventory management, and resource allocation, ultimately leading to improved financial outcomes.

8. Conclusion

Our LP model demonstrates a viable solution for street vendors in Market Square, Olorunti Town, seeking to maximize their profits amidst various challenges. By systematically analyzing their operations through LP techniques, vendors can better understand the interplay between their resources and market demands. This approach not only aids in optimizing profit but also enhances their ability to navigate the complexities of the informal economy. The findings suggest that integrating linear programming into daily business practices can significantly improve the financial sustainability and growth potential of street vending enterprises.

Recommendations

- 1) Training Programs: We recommend training programs to enhance vendors' LP adoption on linear programming techniques and profit management strategies to enhance their decision-making capabilities.
- 2) Access to Financial Resources: Advocate for better access to microfinance and credit facilities tailored for street vendors to enable them to invest in their businesses effectively.
- 3) Regulatory Support: Encourage local authorities to develop supportive policies that recognize and regulate street vending, providing vendors with legal protection and access to necessary infrastructure.
- 4) Collaborative Networks: Promote the formation of co-operative networks among street vendors to share resources, information, and best practices related to profit maximization strategies.
- 5) Ongoing Research: Conduct further studies on the impact of linear programming in various urban settings to refine methodologies and adapt them to different contexts within the informal economy.

Abbreviations

CFA	Cooperation Financi ère en AfriqueCentrale (Financial Cooperation in Central Africa)
FCFA	Franc de la Communauté Financi ère Africaine (African Financial Community Franc)
FMCG	Fast-Moving Consumer Goods
LP	Linear Programming
MATLAB	MATrix LABoratory
OR	Operation Research

Author Contributions

Leo Tanyam Encho: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Writing – original draft

Abraham Okolo: Supervision, Validation, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest

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