

# Profit Maximization for Small Medium-Sized Import Vehicle Company Using Linear Programming Approach

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## Abstract

In the highly competitive automotive industry, maximizing profit while balancing costs and revenues, poses a significant challenge. This study explores the use of linear programming to enhance profit optimization strategies for small and medium-sized import vehicle company. Through the development of a mathematical model, the aim is to maximize profit by determining the most efficient number of vehicle import services to accept. The problem is solved using the simplex method's linear programming approach, and this methodology is implemented efficiently through Excel Solver. Focusing on service provision rather than vehicle ownership, the research formulates constraints related to customer demand, time constraints, workforce limitations, and financial considerations. The results are obtained through the utilization of the linear programming solution and its subsequent sensitivity analysis. Numerous companies have used the linear programming approach to determine the most profitable outcomes, leading to the selection of small and medium-sized import vehicle company as the case of study for this profit maximization investigation. According to the results, the potential maximum profit the company could achieve amounts to RM56,000.00. This study will expose the organization to the linear programming method for strategic decision-making, specifically focusing on maximizing profits for import and export companies, particularly within the context of Malaysia.

## 1. Introduction

In any business, whether small or large company, having a clear mission and vision helps employees understand their responsibilities. Leaders who create, explain, own, and passionately drive this vision forward, contribute to their company's success [1]. Every organization aims for specific goals, usually centered around making a profit. However, in today's world with changing politics, economies, technology, and intense competition, achieving these goals has become more challenging. Especially for Small Medium-sized Enterprises (SMEs). The majority of businesses worldwide are composed of SMEs [2]. Different countries have different ways of defining SMEs. In general, SMEs are identified by their size, profits, and employees. Size can be categorized into three categories which are micro, small, and medium. For micro, sales turnover less than RM 300,000 or employees less than 5, while for small, sales turnover from RM 300,00 to less than RM 3 million or employees from 5 to less than 30 [3]. As mentioned, SMEs make up the majority of business in numerous countries. To paint a picture, 98.5% of businesses in the country are SMEs, and in 2018, they contributed over RM500 billions of Malaysia's gross domestic product (GDP) [4]. Around 89.2% of SMEs in Malaysia are engaged in the services sector [5]. The company in this study is classified as a small and medium-sized import vehicle company as its services turnover

is not more than RM 3 million but not less than RM 300,000. While the number of employees is not more than 30. This small and medium-sized import vehicle company is an international logistics company serving as an agent for import and export customs clearance. Exporting involves selling goods and services from one's home country to a foreign nation, while importing entails buying foreign products and bringing them into one's home country [6]. However, it's important to note that this study exclusively focuses on the import service aspect, considering that it constitutes the foremost service provided by the company. As an SMEs company it is undoubtedly difficult to compete with large businesses that have been in business for over 30 years and have their loyal customers. Similar to these small and medium-sized i. It measures a company's success and efficiency in generating income. It measures a company's success and efficiency in generating income. It measures a company's success and efficiency in generating income. It measures a company's success and efficiency in generating income. Import vehicle company, they encounter challenges like market competition, staff limitations, storage issues, customer demand, time constraints and finance considerations, which will be discussed in the methodology. This is where the linear programming model steps in—it's a method that helps companies find the best ways to increase sales and income, ultimately maximizing profits or minimizing costs.

Linear programming, initially explored by mathematicians and economists Kantorovich and Leontief in the 1930s for manufacturing schedules and economics, faced initial disregard [7]. However, during World War II, it became pivotal for transportation, planning, and resource distribution. George Dantzig's introduction of the simplex method in 1947 simplified solving linear programming problems, leading to its widespread use across industries (8). It made solving linear programming issues much simpler. The simplex method was then published by George Dantzig. This resulted in the generalization of linear programming [9]. In 1947 "Programming" was a common phrase for "planning". Since the moment, linear programming has been used in a variety of industries, including business and the management of natural resources. A mathematical technique called linear programming (LP) aims to maximize performance in terms of resource combinations [10]. The primary purpose of linear programming is to maximize or minimize an objective function while satisfying a set of linear constraints. The process utilizes linear equations to represent relationships between decision variables, an objective function that needs to be optimized, and constraints that restrict the allowable solutions. This optimization method is widely applied in many industries to support decision-making in the areas of resource allocation, supply chain management, production planning, and financial portfolio optimization. Linear programming offers an organized method for solving problems, which enables companies to make effective decisions that lead to enhanced operational efficiency and strategic decision-making.

This study focuses on three objectives, to develop a mathematical model using linear programming, determining the optimal solution of profit maximization for the company using Excel Solver and analyze sensitivity analysis to see how adjusting different factors can impact the best profit outcomes. Consistent profits are vital for a business's long-term survival. It measures a company's success and efficiency in generating income. Therefore, in this study Linear Programming is implemented in solving the model and it will help this small and medium-sized import vehicle company overcome the hurdles and compete effectively in the business landscape.

## 2. Methodology

### 2.1 Modelling of Linear Programming

In this section, we construct a linear programming model to maximize the profit. In order to construct a linear programming model to maximize the profit, the decision variables, objective function and constraint must be defined. The data was collected based on a personal interview with the manager of this Small Medium-Sized Import Vehicle Company. Data used in this study is gathered by collecting the invoice that contain service fees for a month, in May 2023, as this study only focused on the import service taken for three different types of vehicles, which are sedans, SUVs, and caravans. Some other data collected are the financial cost, import capacity, customer demand, time, workforce, and market demand. There are a few steps that must be completed to maximize the profit to accomplish the goal of this study. By gaining all the data, we get to define the decision variables, construct objective function, and identify constraints that can lead to develop a linear programming model and analyse the data by using Excel Spreadsheet Solver.

#### 2.1.1 Decision variables

Three data sets of different types of vehicles which are Sedans, SUVs and Caravans are gathered for this study. The purpose of this study is to determine how many import services should be taken, which led to the following definition of decision variables.

- $x_1$  = number of import service should be taken for Sedans,
- $x_2$  = number of import service should be taken for SUVs,
- $x_3$  = number of import service should be taken for Caravans.

Decision variables values greater than or equal to zero.

### 2.1.2 Objective function

The objective function is to maximize the profit for this Small Medium-Sized Import Vehicle Company per month. Calculating profit in this study involves determining the total service revenue and subtracting the total costs associated with offering import service. Here's a formula for profit calculation in this study.

$$\text{Profit} = \text{Total Service Revenue} - \text{Total Cost Associated with Service Provision} \quad (1)$$

Total service revenue is the total income generated from providing import service. Including fees charges for facilitating importation process, handling customs clearance and paperwork.

$$\text{Total Service Revenue (RM)} = 1500x_1 + 1900x_2 + 2400x_3 \quad (2)$$

The total cost is a sum up expenses directly related to offering import services.

$$\text{Total Cost (RM)} = 500x_1 + 700x_2 + 900x_3 \quad (3)$$

Therefore, the profit calculation is,

$$\text{Maximize profit, } Z = 1000x_1 + 1200x_2 + 1500x_3 \quad (4)$$

### 2.1.3 Constraints

In this study, twelve constraints have been identified. All the constraints are shown as below:

Constraint based on import capacity (in units),

$$x_1 + x_2 + x_3 \leq 65 \quad (5)$$

Constraint based on customer demand (in units),

$$x_1 \geq 20 \quad (6)$$

$$x_2 \leq 20 \quad (7)$$

$$x_3 \leq 10 \quad (8)$$

$$x_1 + x_2 + x_3 \leq 50 \quad (9)$$

Constraint based on time (3 weeks),

$$3x_1 + 3x_2 + 3x_3 \leq 160 \quad (10)$$

Constraint based on financial constraint,

$$500x_1 + 700x_2 + 900x_3 \leq 30000 \quad (11)$$

Constraint based on market demand (in units)

$$x_1 \leq 40 \quad (12)$$

$$x_2 \leq 25 \quad (13)$$

$$x_3 \leq 15 \quad (14)$$

Constraint based on workforce (10 shipment per worker)

$$(x_1/10) + (x_2/10) + (x_3/10) \quad (15)$$

Non negativity constraint

$$x_1 \geq 0 \quad (16)$$

$$x_2 \geq 0 \quad (17)$$

$$x_3 \geq 0 \quad (18)$$

## 3. Results and Discussion

In this section, it delved into the optimal result and sensitivity analysis. To solve the model designed, Excel Spreadsheet Solver is used to attain the optimal result, which will be elaborated upon in this results and discussion section. From the optimal result it will help to shows current production output of this Small Medium-Sized Import Vehicle Company per month and the profit earned. Additionally, it will be discussed about how sensitivity analysis affects the final results.

### 3.1 Optimal Result

Table 1 explained the optimal result in this case study, where the recommended optimal import service taken for each vehicle model and the corresponding profit are obtained. The data for original import service taken are gathered from this Small Medium-Sized Import Vehicle Company by the invoice collected for each vehicle model in a month which is in May 2023.

**Table 1** Optimal profit

Types of Vehicles	Sedans	SUVs	Caravans	Total Profit (RM)
Original Import Service Taken	40	7	3	52900
Recommended Optimal Import Service Taken	35	5	10	56000

Based on Table 1, currently, the average number of import services taken for Sedan's is 40. While the average number of import service taken for SUVs is 7 and average number of import service taken for Caravans is 3. By taking this amount of service per month, the company are able to earn RM 52,900.00 per month. However, by using linear programming solution, it is suggested that the company to take 35 Import service of Sedans and 5 Import service taken of SUVs and increase the number of import service taken for Caravans to 10 in order to get an optimum profit of RM 56,000.00 per month. The total profit comparison between recommended optimal import service taken which is RM 56,000.00 with original import service taken, RM 52,900.00. It reveals a profit increase of RM 3,100.00.

### 3.2 Sensitivity Analysis

Sensitivity analysis is a useful method for determining how adjustments to limitations impact the most effective import plan. It highlights which constraints significantly influence the quantity of vehicles to import and the resulting profit. By being aware of these effects, it aids in making informed decisions, identifying flexible constraints without jeopardizing the overall import plan. Moreover, sensitivity analysis helps foresee potential issues and suggests improvements to refine the import strategy, ensuring adaptability to changes and enhancing the overall effectiveness of decision-making in the importation process.

Table 2 and Table 3 provide the sensitivity analysis for the study which align with the third objective of this study, analyzing sensitivity analysis to see how adjusting different factors can impact the best profit outcomes.

**Table 2** Sensitivity analysis result of variable cells

Decision Variables	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$x_1$	35	0	1000	200	100
$x_2$	5	0	1200	50	200
$x_3$	10	0	1500	Infinity	100

As shown in Table 2, sensitivity analysis for result variables cells. The optimum values for every decision variable are represented by the final value. Objective coefficient is the coefficient for each variable or can call it as a profit. Reduced cost is the amount by which the coefficient of a decision variable in the objective function could be increased without changing optimal solution. As shown all the reduced cost are zero which means the variable at its optimal value. If any of the final value is zero, adjustment made to the profit. The allowable increase refers to max amount by which the coefficient of a decision variable in the objective function can be increase while still maintaining the current optimal solution. Likewise for allowable decrease refers to the maximum reduction permissible in coefficients of the objective function while retaining the optimal solution.

For  $x_1$ , the final value service should be taken is 35 and objective coefficient is 1000. The allowable increase shows the potential for profit growth, allowing the objective coefficient to reach up to 1200 while still maintaining the current final value. The allowable decrease indicates the level of profit reduction, in this case, it can be decrease by 100, reaching 900 before impacting the optimal solution.

Essentially, the final value suggests exact quantities of each vehicle type for maximum profit, and the allowable increase and decrease show the profit's flexible range without altering the optimal solution.

**Table 3** Sensitivity analysis result of constraints

Constraints	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
5	50	0	65	Infinity	15
6	35	0	20	15	Infinity
7	5	0	20	Infinity	15
8	10	100	10	2	7
9	50	500	50	1	4
10	150	0	160	Infinity	10
11	30000	1	30000	3000	1000
12	35	0	40	Infinity	5
13	5	0	25	Infinity	20
14	10	0	15	Infinity	5
15	5	0	15	Infinity	10
16	35	0	0	35	Infinity
17	5	0	0	5	Infinity
18	10	0	0	10	Infinity

For constraints, final value or we call solution is an actual value that a decision variable takes in the optimized solution. Constraint R.H. Side (Right-Hand Side) is a limitation or an original value of constraint. Shadow price indicates how much objective coefficient will be affected if constraint R.H. side increase or decrease. Allowable Increase is a maximum amount by which the RHS values can be increase while maintain feasibility. While the allowable decrease is a vice versa.

As we can see from constraint 5, the final value import capacity is 50 unit as the constraint is less than 65. The shadow price is 0, hence objective coefficient will not be affected if constraint R.H. side increase or decrease.

For the allowable increase, maximum amount can be increased to the RHS up to no limit but can be decreased to 15 units while maintain the optimal solution. In constraint 9, final value for customer demand is 50 units, following to the condition of not exceeding 50. Since the shadow price is 500, an increase in the constraint RHS to 51, would result in a corresponding rise of 500 in the objective coefficient. The allowable increase and decrease for customer demand differ by a small margin, specifically by 1 and 4. Constraint 12 indicates that the optimal value for market demand is 35 units, with the constraint RHS being less than 40 units, representing a difference of 5. The shadow price is 0 while it can be increased infinitely without changing the optimal solution and can be decreased by a maximum of 5. In constraint 16,17 and 18, the final values are 35, 5, and 10. The maximum allowable increase is equal to the final value, allowing an increase in the RHS while maintaining feasibility.

Based on the third objectives in this study, which is to analyse sensitivity analysis to see how adjusting different factors can impact the best profit outcomes. From the sensitivity analysis results, we can draw insights into how changes in input parameters impact the solution and identify the key factors influencing the optimal outcome. This comprehension empowers strategic decision-making in potentially modifying various operational factors, aiming for the most effective solutions to enhance the company's operational efficiency and profitability.

#### 4. Conclusion

By formulating constraints related to customer demand, time limits, workforce availability, financial costs, and import capacity helped the model find the best solution. It made the most profit while following these rules. The sensitivity check showed how changing these rules affected the best solution, showing how flexible the strategy was and how much the rules affected it. The results obtained from the optimization model showcased the specific quantities of each vehicle type recommended for importation to achieve maximum profit, with the allowable increase and decrease values indicating the range within which profits could fluctuate without affecting the optimal solution.

This project demonstrates the practical application of linear programming in real-world scenarios, offering a structured approach to decision-making in vehicle importation. Additionally, the sensitivity analysis helps decision-makers understand how adaptable the import strategy is to changes in the market, which is useful for making informed decisions when the market fluctuates. Overall, this project helps us learn how optimization methods can be used to increase profits while dealing with various limitations in the vehicle import process. Furthermore, while this study offers actionable insights into maximizing profits, future research endeavours could delve deeper into refining these strategies, exploring additional constraints, and considering broader datasets encompassing both import and export activities. Ultimately, this study provides a steppingstone

towards operational excellence and financial growth for SMEs engaged in import service within the competitive automotive landscape.

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## Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

## Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design, data collection:** Nurathirah Camelia Binti Osman; **analysis and interpretation of results, draft manuscript preparation:** Nurathirah Camelia Binti Osman and Azila Md Sudin. All authors reviewed the results and approved the final version of the manuscript.

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