Calculation of liters to be sold at a gas station to optimize profits using the simplex method for a correct decision- making

Cálculo de litros por vender en una gasolinera para optimizar las ganancias utilizando método simplex para una correcta toma de decisions

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Abstract

Measurements of monthly sales were made from January to June 2021 at a gas station in order to obtain historical information and based on it determine, applying the simplex method for decision making, the correct number of liters of gasoline of the Magna (green) and Premium (red) type and Diesel necessary to obtain a maximum profit based on a budget that the company has. The monthly observations and the calculation were made using the EXCEL software with pre-recorded formulas to apply the simplex method and were developed during the period from July 05 to 09, 2021. This research work takes advantage of the benefits of the simplex method to find and optimize the best cost-benefit relationship and find the maximum possible profit in the sale of gasoline at a given station. The fluctuation in the changes of the gasolines costs in the last three years was considered to carry out the calculations of this investigation.

Measurements, Optimize, Fluctuation

Resumen

Se realizaron mediciones de las ventas mensuales desde el mes de Enero al mes de Junio de 2021 en una estación de gasolina con el objeto de obtener información histórica y en base a ella determinar, aplicando el método símplex para toma decisiones, el correcto número de litros de gasolina del tipo Magna (verde), Premium (roja) y Diésel necesarios para obtener una ganancia máxima en base a un presupuesto con el que cuenta la empresa. Las observaciones mensuales y el cálculo se hizo utilizando el software EXCEL con fórmulas pregrabadas para aplicar el método símplex y fueron desarrolladas durante el periodo del 05 al 09 de Julio de 2021. Este trabajo de investigación aprovecha las bondades del método símplex para encontrar y optimizar la mejor relación de costo beneficio y encontrar la máxima ganancia posible en la venta de gasolinas en una determinada estación. Se consideró la fluctuación en los cambios de las gasolinas en los últimos tres años para realizar los cálculos de esta investigación.

Mediciones, Optimizar, Fluctuación

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Introduction

This research paper shows the results of the application of a decision-making method (simplex method) based on historical sales data of three products (magna gasoline, premium gasoline and diesel) offered by a gas station.

The main idea of it is to find a point of balance between the number of liters sold per month of each of the products and to obtain, based on this, an optimzation in sales, understood as optimization, the adequate number of each one of them to obtain the highest monthly profit and keep track of the liters sold of each of them.

1. Decision making

Decision making is a daily process in which many times the decisions that are made consciously or unconsciously. It is neccesary to define the concept as well as the identifiction of some elements that influence the decision making, such as experience, knowledge and intuition.

In the words of (Pérez Callejo, 2015) decision- making is a structured process of decomposition of the possible solution alternatives and is carried out based on one or several axiological criteria where each of that aletrnatives is assigned a specific weight.

Two of the elements to differentiate when a making decision is made are the states of nature and the alternatives or options. In the states of nature, the decision maker (who makes the decision doesn´t have any injerence in the decision due it is a situation out of his control while in the alternatives or options he has full control to select any of them).

Intuition in decision making can change the decision making toward the subjectivity since it’s based on what the decision maker feels, imagines or believes according to his criteria.

This subjectivist behavior must be replaced by objectivity based on concrete and hard facts provided by a mathematical model.

In the opinion of (Jiménez Lozano & Jiménez Muñoz, 2012) some models for decision making are decisions in certainty environments, decisions in risk environments, in uncertainty environments with experimental information. One of the main objectives that are sought with the correct decision making through any of the methods described above is for an optimization, which will be discussed in the next section.

2. Optimization

Many real-life problems are solved when the researcher manages to translate the observed problem into a mathematical model, that is, to identify variables, values and restrictons, as well as the relations of operations between them that are conducive to establishing an equation, and with it, finding an unique value that satisfies all the conditions established in the problem analysis stage.

However, it isn´t always a value that can satisfy all the conditons or restrictions, but it has been observed that a set of values can also satisfies them. Contrary to what could be thought of as a success, this sometimes represents a second problem because now it’s neccesary to identify which of this set of values is the one that gives us the best solution and this value is known as the optimal value.

It’s important to specify that optimization is generally understood as the fact of finding a greater profit and often the other sense of optimization, which consists of reducing costs (minimization), is left aside. That is why, when defining the problem, it must also be established whether the problem to be solved is one of maximization or minimization

For the present research work, we´ll work according to the logic of maximization, since what is intended is to find the greatest possible profit from the sales of the products at a gas station. In optimization problems, it’s desired to achieve a set of objectives with a maximum benefit or a minimum cost, adjusting the problem to the reality through a set of restrictions as well as the inclusion of a goal called the objective function (Santisteban Urquiza, 2012). Many of these types of existing problems are solved by applying inexact methods and it’s precisely in the type of exact methods where the simplex method is located, which we’ll address in the next section.

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3. Simplex method

The simplex method is a method that works based on cycles or repetitions of operations. Each time a loop is performed, a better solution is found.

In real life, the first cycle will not give an optimal solution since it's assumed that it can always be improved. In many cases, this first solution is 0 with negative values in the first row as a sign that the system should be improved through a second iteration.

Each cycle or iteration will find a better solution, that is, the third solution impoves the second one and the fourth one improves the third one and so on.

The loop ends when there are no more negative values (all positive or 0) in the first row of the simplex table and at that moment the best possible solution has been found.

The simplex method has the added value with respect to its predecessor, the graphical method, in that it works for n variables and m number of restrictions, which makes it more versatile.

The problem to solve consists of finding the optimal combination of liters sold of the three products that are sold at the gas station to get the maximum profit and thus keep track of the liters that are sold in the sense of prioritizing in the sale of liters according to the results of the application of the simplex method.

The simplex method is also known as the self- directed optimization method (Ahumada & Guerrero, 2010), which is based on measuring the effects that produce changes in the variables and deducing from the results what must be done in the succesive changes to get improvements in the behavior of the phenomenon being studied.

Regarding the simple sequential optimization method, the following steps are established (García Soto, Rodríguez Niño, & Trujillo, 2013)

– The vertex that has the worst response is reflected over the centroid of the remaining k vertices ($\alpha = 1$).
– If the response of the new vertex is better than that obtained in previous vertices, an expansion of this new vertex is applied ($\gamma = 2$, expansion coefficient) to extend the movement in the direction of reflection.
– If the new vertex response is better than the previous worst vertex, but not better than the resulting vertices, $0 < \beta < 1$ is applied to reduce the step size for the new cycle.

4. Operation of gas stations

Regarding the operations of gasoline outlets, they are conceived as a point of sale of gasoline for the supply of motor vehicles and is made up of several gasoline vending machines, storage tanks for diferente types of gasoline, and space for the service an supply of gasoline to vehicles. (Ramírez, Patete, & Javier, 2011).

However, regarding the fluctuations of gasoline prices in Mexico (Ibarra Salazar & Sotres Cervantes, 2008), it's known that these are regulated by the federal government through the Ministry of Finance and Public Credit (SHCP) and are mainly based on the fiscal aspect, the uniform price policy per volumen unit throughout the country and differential prices policies in the northern and southern regions of the country It's a fact that gasoline moves a country regardless of the new energies that are emerging or that are about to be released the reality is today, gasoline is the main input that moves the automobile and transport industry (land and air), both, in Mexico and in the world.

According to (Canobbio Rojas & Cárdenas Aragón, 2020), for the operation of gas stations in Mexico, it's necessary to point out that gas stations must belong to a mandatory scheme called SASISOPA (Industrial Safety and Environmental Protection Administration System), which was created to regulate the activities of the hydrocarbon sector (MX ASEA 2019).

5. Metodology to develop

The historical files in Excel that the company has were searched and based on this, the simplex method was applied with the following objective function of maximization and whose restrictions according to the needs of the gas station as follows:

- The variable *x1* will represent the number of liters of magna gasoline (green).
- The variable *x2* will represent the number of liters of premium gasoline (red).
- The variable *x3* will represent the number of liters of diesel (black).

The current prices of the products with their respective earnings are as follows (Juy, 2021). See Table 1.

Product	Cost per liter	Sale per liter (public)	Revenue
Magna gasoline	\$18.61	\$20.23	\$1.62
Premium gasoline	\$20.41	\$22.18	\$1.77
Diesel	\$19.62	\$21.39	\$1.77

Table 1 Current prices
Own Elaboration

In discussions with the managers of the gas station, it was established that the sum of the 3 products should not exceed 1,000,000 liters per month and that the profit from premium gasoline is expected to be at least double the sum of the liters of the other 2 products (magna and diesel).

Also, derived from saids talks, a monthly budget of \$19,453,000 was established, which should not be exceded at any time. With this information and with the individuals earnings of each one of the products specified in Table 1, the following mathematical model was establised:

Objective function (profit maximization)

$Max\ z = 1.62\ x1 + 1.77\ x2 + 1.77\ x3$

Restricted to:

$x1 + x2 + x3 \leq 1{,}000{,}000$
(not exceed 1,000,000 monthly liters)

$18.61\ x1 + 20.41\ x2 + 19.62\ x3 \leq \$19{,}453{,}000$
(never exceed the Budget of \$19,453,000)

$x2 \geq 2\ (x1 + x2)$
(premium profit at least double of the other two products)

$x1, x2, x3 \geq 0$
(conditions of non-negativity)

The mathematical model is summarized in the simplex table shown in Table 2, thus establishing the first solution.

Var	z	x1	x2	x3	h1	h2	h3	Revenue
Z	1	-1.62	-1.77	-1.77	0	0	0	0
h1	0	1	1	1	1	0	0	1,000,000
h2	0	18.61	20.41	19.62	0	1	0	19,453,000
h3	0	-2	1	-2	0	0	1	0

Table 2 Tabla Initial simplex table with the first solution
Own Elabration

This is a first solution, but obviously, it isn't the optimal one since there is no profit.

The most negative variable (greatest negative value) is chosen as the variable entering the system. In this case, it makes no difference to choose *x2* or *x3* since both have the same value,-1.77. The variable *x2* was chosen.

Once the variable that enters the system is determined, the variable that will leave the system is determined as follows.

The following operations are carried out to determine the variable that will leave the system, which will be the one with the lowest value in the OPERATIONS column, being the slack variable *h3*, see Table 3.

1,000,000 / 1 = 1,000,000
19,453,000 / 20.41 = 953,111.22
0 / 1 = 0

Var	z	x1	x2	x3	h1	h2	h3	Revenue	Operactions
z	1	-1.62	-1.77	-1.77	0	0	0	0	
h1	0	1	1	1	1	0	0	1,000,000	1,000,000
h2	0	18.61	20.41	19.62	0	1	0	19,453,000	953,111.22
h3	0	-2	1	-2	0	0	1	0	0

Table 3 Middle table
Own Elaboration

At the intersection of the variables *x2* and *h3* is the pivot with a value of 1. This pivot serves as the basis for searching for the appropriate operations and leaving the entire column of *x2* at zeros (0) with the operations that are included in the column of operations and Table 4 is obtained with the second solution.

Var	z	x1	x2	x3	h1	h2	h3	Revenue	Operations
z	1	-5.16	0	-5.31	0	0	1.77	0	
h1	0	3	0	3	1	0	-1	1,000,000	R1 + 1.77*R4
h2	0	59.43	0	60.44	0	1	-20.41	19,453,000	R2 – R4
x2	0	-2	1	-2	0	0	1	0	R3 – 20.4*R4

Table 4 Second solution
Own Elaboration

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This is a second solution, but again an earn of 0 is detected, which means that is not yet the solution. Since there are 2 negative values in the *x1* and *x3* columns, it's known that one more iteration must be performed to find a new solution.

For this new solution, the variable that will enter the system is chosen, being the most negative (*x3*). Now, to determine the variable that leaves the system the operations specified in the operations column are carried out and the one with the lowest value (321,856.39) is chosen, with the slack variable h2 as the variable that leaves and its place will be taken by the variable *x3*, see Table 5.

Var	z	x1	x2	x3	h1	h2	h3	Revenue	Operations
z	1	-5.16	0	-5.31	0	0	1.77	0	
h1	0	3	0	3	1	0	-1	1,000,000	1000000/3=333333
h2	0	59.43	0	**60.44**	0	1	-20.41	19,453,000	19453000/60.44=321856
x2	0	-2	1	-2	0	0	1	0	0/-2=0 (se ignora)

Table 5 Middle table
Own Elaboration

Now, at the crossroads of the variables x3 and h2 is the pivot with a value of 60.44, which is why all of that line (R3) is divided by 60.44 to transform it into a value of 1. Once the pivot has been established as 1, we proceed to leave the entire column of x3 in zeros (0) relying on the formulas established in the operations column.

In this case, all the values of the first line are positive or greater than or equal to zero, which is interpreted as the optimal solution with a profit of $1,709,057.41, see Table 6.

Var	z	x1	x2	x3	h1	h2	h3	Revenue	Operations
z	1	0.06	0	0	0	0.087	-0.02	1709057.4	R1+5.31*R3
h1	0	0.05	0	0	1	-0.049	0.01	34430.84	R2-(3*R3)
x3	0	0.98	0	**1**	0	0.016	-0.33	321856.39	R3/60.44
x2	0	-0.033	1	0	0	0.033	0.36	643712.77	R4+(2*R3)

Table 6 Calculated máximum gain.
Our Elaboration

Gratitude

We appreciate both the facilities and the information provided by the gasoline sales service station in Ebano, S.L.P., Mexico.

To the Polytechnic University of Altamira and the Academix Body in Consolidation UPALT- CA6- "Quality and Productivity".

Conclusions

To obtain the máximum profit it's necessary to sell the following quantities in liters of each of the 3 products:

X1 = 34,432 magna gasoline liters X2 = 643,712 premium gasoline liters X3 = 321,856 diesel liters To get a monthly earn of $1,709, 057.41

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