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DISTRIBUTION METHODOLOGY IN SMALL BREWERY COMPANY TO OBTAIN PROFITS IN SHORT TIME

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Abstract: This paper presents a methodology oriented to obtain profits in the short-term and is applied to the brewery industry for distributing goods. It is composed of two models of Operations Research (OR), the Knapsack Problem (KP), and the Traveling Salesman Problem (TSP). Also, the Greedy Algorithm is used. In the first step, the KP modified model is used in the choice of the product to give priority to products, which maximize the profit of the Company, making the load assignments for each route respecting the constraints of volume and weight of vehicle capacity. The volume of the vehicle considers full boxes, and its weight and profit are calculated in bottles. As a result, the product loaded is prioritized, where the highest profit product is delivered first and then the low-profit product. Subsequently, the TSP model was used to select the best route for the distribution of the products. Finally, with the Greedy Algorithm and results obtained previously, the customers to be visited are determined.

1 Introduction

In Mexico, 2014, the number of Micro, Small, and Medium Enterprises (SMEs) were more than four million, according to [1]. Moreover, according to [2], the SMEs are 99% of the businesses that exist in Mexico. The SMEs generate 80% of current jobs and more than 36% of Gross Domestic Product (GDP), for this reason, it is the economic sector that has one of the most significant social impacts. To accelerate and to improve their competitiveness, any federal programs support the entrepreneur, where they can obtain advice, services, and credits. The support offered focuses on solves economic problems or develops strategies to make the SMEs grow. Nevertheless, there are no programs to analyze the internal process of each one of the SMEs.

There are international studies that report problems to implement development projects and low success rates [3,4]. A good strategy that SMEs can use to obtain the analysis and the improvement of their processes is to interact with universities because, after all, education and research are keys in the formation of worldwide markets [5]. On the other hand, in Mexico, the universities, especially those that are offering postgraduate studies, are developing investigation [6] based on the case study method and using data from SMEs in order to develop the application of knowledge to real-world situations [7]. In this way, the case presented and improved is a result of this relationship.

Within the improvement to the brewing company, the knapsack Problem (KP), the Traveling Salesman Problem (TSP), and the Greedy Algorithm are used to solve the problem of distribution of goods to customers incurring in the lowest possible costs. The problem is tackled because the Company is not complying with the deliveries to customers promptly, and the priority of the Company is to attend the customers that represent more income. The current delivery of the company process consists of supplying the customers as soon as possible, which incurs unnecessary costs because they do not have a delivery plan.

The KP or also known as the Backpack Problem is a Combinatorial Optimization Problem (COP) and is used to define objects to fit into a backpack, so that optimizes the total value, without exceeding the weight and/or volume of the backpack [8] proposed a solution of 0-1 in the KP (non-viable - viable) while several processors run at the same time, it was a way to achieve better time solution of the problem of this nature for the NP-Hard solution. Besides, [9] proposes three levels of the knapsack algorithms that minimize the errors of the best solution for small problems. These algorithms are discarded and made a selection of the best solutions that were defined as Hyper-heuristics.

On the other hand, [10] propose a heuristic be able to generate a common knapsack problem considering that the products can do rotations in two and three dimensions. While the TSP model is approached from the street vendor, he wishes to visit exactly once each of a list of cities and return to origin.

Now, the importance of the TSP model is that it is representative of a larger class of problems known as COP too. It belongs to the class of problems known as NP-complete. Specifically, it is possible to find an efficient algorithm that can give the solution (i.e., that run in polynomial time). Also, the TSP model has practical implications for issues as seemingly diverse as drilling of printed circuit boards [11], x-ray crystallography [12], and the robotics assembly [13]. Some practical problems involving laser drilling of printed circuit boards [14] or movements in the manufacture of chips mean the TSP model up to a million nodes.

Nevertheless, as noted above, it has not discovered any effective algorithm that can find the optimal solution to the TSP model, and a guaranteed-search method exhaustive because it becomes more impractical as it increases the number of points (n). Increases the number of possible solutions to a TSP model (n - 1)! / 2 (if the direction of travel is ignored), so, to find all the possible solutions to a problem of 20 nodes, a computer-generated by, say, 100 solutions per second would require more than 19 million years [15].

Also, the application of the Greedy Algorithm was used to find the best solution for every step, with the hope that, at some point, to obtain a better solution. [16] defined that this algorithm seeks the best solution from a selection of possible solutions. [17], who defined an algorithm to optimize again to obtain the solution of Greedy Algorithm nature based on partial solutions and reach the best solution more quickly with fewer resources.

For a vast instance, the exact methods are inefficient regarding resolution times, and here is where the metaheuristics help us to solve them. It is possible to build an effective solution using the Greedy algorithm; some of the solutions reported with this algorithm have an error of 5% [18].

2 Background

This section is separated into two subsections: the first subsection is about the analysis of the companies according to their sizes, the number of employees and the entities as they are located, and the second subsection is about the beer companies in Mexico.

2.1 Companies in Mexico

According to the information of the National Institute of Statistics and Geography (INEGI) [19], the companies are classified into four types based on the number of employees and their sales expressed in US dollars with an exchange rate of 21.92.

1. ***Micro Industry***. This type of industry has a maximum of 15 employees, and their sales are a maximum of USD 1,387,808.10.
2. ***Small Industry***. This type of industry has a maximum of 100 employees, and their sales are a maximum of USD 18,504,108.03.
3. ***Medium Industry***. This type of industry has a maximum of 250 employees, and their sales are a maximum of USD 50,886,297.08.
4. ***Big Industry***. This type of industry has more than 250 employees, and their sales are more prominent than USD 50,886,297.08.

In Mexico, the manufacturing sector is considered the companies that make beer, the steel industry, the automotive industry, and others.

According to INEGI (2018)[20], the manufacturing sector generates 27 % of the national total, with 39% of total employees. It makes the manufacturing sector one of the most important for the country. These data are shown in Figure 1.

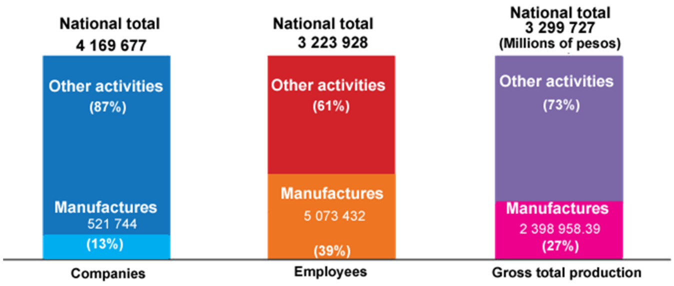

Figure 1 Importance of Manufactures in the Economy (source: INEGI, 2018)

There is not enough data to analyze the behavior of manufacturing companies by their size; for this reason, the INEGI 2014 data will be employed for the analysis. The manufacturing sector from 2008 to 2013 in the number of companies grow a 12.1% in total, but the strata that most grow was the micro with a 13.3% and the small decrease in 8.5%, while the medium and the big grew 4.5% and 9.7%. The decrease of 8.5% shows that small companies have trouble to survive and that is the reason to focus the present work to help in the improvement of one small Company. These data are presented in Table 1.

The indicator of increase or decrease in the number of companies needs to be accompanied by the analysis of evolution in the number of employees. It because although the companies show the evolution and the perception of economic growth, the number of employees shows the social impact of each one of the strata in the country.

Table 1 Evolution of companies by stratum 2008 and 2013 (source: economic census of INEGI, 2014)

Strata	**Companies**			**Percentage growth**
	2008	**2013**	**2018**	**2008-2013**
Total manufactures	**436 851**	**489 530**	**521 744**	**12.1**
Micro	404 156	458 096		13.3
Small	22 349	20 455		-8.5
Medium	7 113	7 431		4.5
Big	3 233	3 548		9.7

The total growth of employees in the manufacturing sector was 8.8 %. It is contrary to the growth observed in Table 1. In micro manufactures, the number of employees decreased by 2.2%. In the small strata, the decrease was 4.5%; in the medium strata, the growth was 6.7%, and the best strata were in big manufacturers with a growth of 17.4%. These data are shown in Table 2. Table 1 shows the growth of companies from 2008 to 2013 in quantity and percentage associate with this. While Table 2 shows the growth in quantity and percentage of employees affected directly with the growth (positive or negative) of the companies. In Table 1, the micro-companies grow 13.3% while in Table 2, the micro-companies decrease in 2.2%, one of the reasons for these data could be that to survive small companies are now micro-companies with fewer employees and fewer profits, and that could explain the growth of micro-companies. In comparison, other small companies conserved their profits but had fewer employees, that could explain that the percentage of micro-companies grew and the percentage of employees decreased. The reality that tables show is those small companies are a vulnerable sector that needs help, the rest are only assumptions, that need more in-depth analysis.

Table 2 Evolution on the number of employees by stratum 2008 and 2013. (source: economic census of INEGI, 2004)

Strata	**Employees**		**Percentage growth**
	2008	**2013**	**2008-2013**
Total manufactures	**4 661 062**	**5 073 432**	**8.8**
Micro	1 080 713	1 057 456	-2.2
Small	467 197	446 181	-4.5
Medium	797 907	851 506	6.7
Big	2 315 245	2 718 289	17.4

According to INEGI, Mexico (Country) is divided into five regions, South-southeast, Center-West, Center, Northeast, Northwest. Each one of these regions was analyzed by INEGI to know the number of Companies, Employees, and the Gross Total Production. The region of interest is the Region South-southwest, where Puebla located. This region contributes to the country with 36.9% of the Companies, 14.2% of the Employees, and 18.4% of the Gross Total Production. The percentage of each one of these regions in the Total National is presented in Table 3. Puebla is located in the south-southeast region, the region that brings more companies to the total Nacional (According to Table 3).

Table 3 Economic regions of Mexico. (Source: economic census of INEGI, 20014)

Regions	**Companies**	**Employees**	**Gross Total Production**
	Percentages		
Total nacional	**100.0**	**100.0**	**100.0**
South-southeast	36.9	14.2	18.4
Central-west	24.0	22.1	20.8
Center	24.5	24.9	26.6
Northeast	8.6	27.5	26.7
Northwest	6.0	11.3	7.5

Puebla is the City with the most quantity of companies in the Region south-southeast. With a grew total from 2008 to 2013 of 22.8%. The micro-companies grew 22.4%, small companies grew 38.6%, medium companies grew 46.4%, and big companies grew 38.2%, being Puebla, who grew more in the region. The input of each City in the region south-southeast is presented in Table 4.

The information about the contribution of Puebla in the economy of México is vital because the Company to be analyzed is a beer manufacturing company settled in Puebla. This Company is of small size because it has 32 employees. This Company is active in superstores, coffee shops, restaurants, and lodging houses.

Table 4 Companies by Entity according to their size, 2013. (source: economic census of INEGI, 2014)

Strata	Total		Micro		Small		Medium		Big	
	Absolute	%	Absolute	%	Absolute	%	Absolute	%	Absolute	%
South-southeast	**180 574**	**100.0**	**176 471**	**100.0**	**2 976**	**100.0**	**834**	**100.0**	**293**	**100.0**
Campeche	3 440	1.9	3 349	1.9	63	2.1	18	2.2	10	3.4
Chiapas	16 856	9.3	16 580	9.4	215	7.2	44	5.3	17	5.8
Guerrero	26 774	14.8	26 627	15.1	120	4.0	23	2.8	4	1.4
Oaxaca	36 964	20.5	36 712	20.8	210	7.1	29	3.5	13	4.4
Puebla	41 114	22.8	39 467	22.4	1 148	38.6	387	46.4	112	38.2
Quintana Roo	3 043	1.7	2 894	1.6	122	4.1	23	2.8	4	1.4
Tabasco	5 075	2.8	4 898	2.8	128	4.3	34	4.1	15	5.1
Veracruz	24 674	13.7	23 893	13.5	551	18.5	153	18.3	77	26.3
Yucatán	22 634	12.5	22 051	12.5	419	14.1	123	14.7	41	14.0

2.2 The beer industry in Mexico

There are two Mexican corporations in the beer-market, that dominate more than 97% of the market in Mexico Grupo Modelo and Cervecería Cuauhtémoc Moctezuma (CCM), part of Grupo Femsa. Grupo Modelo had a market share of 57%, while CCM had a market of 42% [21]. It left a very reduced market to other breweries in the national market. Also, it is necessary to take into account that foreign breweries corporations are interested in the national market; this makes harder the competition for small companies. The product of the Company to study is available in supermarkets, restaurants, and bars. These products share the market with a lot of different beer-brands, also with foreign beer-brands.

According to [22], there are 55 economic units in the country dedicated to brewing, which generate 1.2% of total gross production with a total gross production of 78,403 million Mexican pesos. In the brewery industry work 11,834 persons, of which 7.3% are women and 92.7%, are men. The brewery industry is number 14 in order of importance in Mexico, as can be seen in Table 5.

According to [22], the primary entities that produce beer are Zacatecas with 18%, Coahuila with 15%, DF with 12%, Nuevo Leon with 11%, Oaxaca with 11%, the other 33% is distributed among other entities.

Table 5 Position of the importance of Brewing Companies in Mexico (source: economic census of INEGI, 2015)

Position of importance	Industry
1	Petroleum refining
2	Truck and Tractor Truck Manufacturing
3	Manufacture of basic petrochemicals of natural gas and refined oil
4	Manufacture of cars and trucks
5	Manufacture of other parts for automotive vehicles
6	Preparation of soft drinks and other soft drinks
7	Pharmaceutical industry (Manufacture of pharmaceutical preparations)
8	Manufacture of electrical and electronic equipment and parts for motor vehicles
9	Steelmakers complexes
10	Manufacture of gasoline engines and their parts for automotive vehicles
11	Manufacture of other iron and steel products
12	Manufacture of interior seats and accessories for motor vehicles
13	Food processing for animals
14	**Brewing**

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Mexico ranks as the fourth largest beer-producing country in the world, after China, the United States of America and Brazil.

Since 2010, Mexico is the leading exporter of beer worldwide. Currently, one in five beers exported in the world is produced in Mexico.

The production of beer is essential in the beverage industry because brewing, according to gross production, is among the 14 most important activities of the country's manufacturing production, among a total of 291 activities, below oil refining, the manufacture of cars and trucks, among others.

Brewing represents 29.3% of the total gross production of the Beverage Industry, being the second most important economic activity within it, as is shown in Table 6.

Table 6 Importance of brewing in the beverage industry source: economic census of INEGI, 2015)

SCIAN Code	Economic activity	Economic units	Busy staff	Gross production
Branch 3121	Beverage industry	100	100	100
Class 312111	Preparation of sodas and other soft drinks	1.5	39.2	54.9
Class 312112	Water purification and bottling	89.9	40.1	4.8
Class 312113	Ice making	4.1	5.2	1.3
Class 312120	**Beer making**	**0.3**	**7.2**	**29.3**
Class 312131	Elaboration of alcoholic beverages based on grapes	0.3	1.3	1.8
Class 312141	Elaboration of rum and other distilled cane drinks	0.2	0.4	0.6
Class 312142	Elaboration of distilled agave drinks	2.9	5.9	7.2
	Other activities	0.8	0.7	0.1

According to the history, The Cuauhtémoc brewery group (Grupo Cuauhtémoc Moctezuma, 2012) emerges on November 8, 1890, in the City of Monterrey, Nuevo León and because of the needs of this group they start to create companies to provide them, like Vidriera Monterrey, Hylsa Factories Monterrey, Packaging Carton Titan, Grafo Regia, and Malta. With this history, it is easy to show how the born of new companies helps other companies to born or to grow, improving with this the economy of the country and also if any company broke other companies are affected.

3 Problem Description

Company A is a brewery company that serves local and national markets. The national market is served by courier service, while the local market is served directly by the Company, for which the Company has its transportation. The Company has the problem of not having a plan to optimize the distribution of their product at the local level, so this document focuses on solving this problem. The Company has 17 small local customers in the City of Puebla. The Company sells two types of beer, and there are two presentations for each one, bottles and barrels. The weekly customer's demand is 1364 bottles of beer type 1 and 2021 bottles of beer type 2, the content of the bottle is 350 ml, and are packed in groups of 12 in boxes.

On the other side, there is a demand for one of 19 liters' barrels of beer type 1 and demand of one of 29 liters' barrels of beer type 2. This Company supplies individually bottles of products type one (*y1*) and type (*y2*), but these bottles are carrying on boxes, even if there are less than 12 bottles. The mentioned data are shown in Table 7.

Table 7 Weekly demand per customer

Product	Customer																	Total	Units
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
y1	28	54	296	80	54	41	82	78	41	54	28	270	28	54	41	135	0	1364	Bottles
y2	54	108	1044	80	54	26	67	79	41	28	26	270	32	54	67	0	0	2021	Bottles
y3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	Barrels
Y4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	Barrels

In Table 8, four variables are used, where *y1*, *y3* represents beer type 1, with bottles and barrel presentations of 19 liters, respectively, while *y2*, *y4* represent the beer type 2 in bottles and 29-liters barrel presentations respectively. The same table shows the volume, the weight, and the profit obtained by the Company from its sale. In the case of *y1* and *y2*, the volume is per box, while the profit and the weight is per bottle.

Table 8 Volume, weight, and profit of each product

Variable	Volume	Weight	Profit	Units
y1	574	4.2	USD 1.4	Box
y2	574	4.2	USD 1.4	Box
y3	2215	24	USD 78.1	Barrel
y4	2286.3	38.1	USD 117.5	Barrel

4 Research Methodology

Because product distribution is required, and there is only one truck, planning the distribution as done in three steps, which are detailed below:

- The KP model was used to obtain the load of the truck, assigning first the products that provide more excellent utility to the Company, respecting the volume, and the weight that can stand the truck. The KP was used first because it considers the volume and weight of the products. It looks for first select products that grant higher profit to the Company, thereby ensuring that the first routes to provide more profit to the Company — after that, the Company will continue distributing the products with less profit, giving attention to all customers, but prioritizing to customers that have a more significant impact on the company profits.
- Then, the TSP model was used to find the optimal route that would minimize the distances, looking for fuel economy.
- Moreover, for last, the Greedy Algorithm was used to assign the product to the customers. According to the TSP model of the previous step, it was respecting the loads assigned with the KP.

5 Case study

The data necessary to solve the problem were the demand of the customers, the capacity of the vehicles, the distance from the warehouse to customers and between customers, the volume and the weights of the products, the cost of the fuel, the value associate to each one of the products. The case study was solved in three steps following the methodology of section 4.

5.1 Knapsack Problem (KP)

The KP model is a problem that searches for the best solution among a finite set of possible solutions to a problem. It models a situation like filling a backpack that can have constraints of weight or volume or both. Objects in the backpack will have their weight and specific volume and will be selected so that putting them in the backpack maximizes the total value, without exceeding the maximum weight or volume.

Since the standard Knapsack selecting from existing products, those that could be placed in the truck, not exceeding the volume and weight, the algorithm suggested place to *y1*, *y2*, *y3*, and *y4* product, (a part of each) which as we shall see, do not exceed the capabilities of the truck, since they are considered unique products. i.e., its amount is not considered, and if the total amount of each of the products is considered, the amount would not fit in the pickup truck in a single route.

Therefore, the KP model developed by [23] was modified according to the volume, weight, and profit of each of the presentations of the products chosen and the total of each product the truck should carry. The proposed model is presented below:

Objective Function:

$$Max \sum_{k=1}^{n} P_k Q_k \tag{1}$$

Constraints:

$$Q_k \le D_k \qquad k = 1,2,3 \tag{2}$$

$$B_k = \left\lceil \frac{Q_k}{T} \right\rceil \qquad k = 1 \tag{3}$$

$$B_k * 12 = Q_k \qquad k = 2,3 \tag{4}$$

$$\sum_{k=1}^{n} w_k Q_k \le W \tag{5}$$

$$\sum_{k=1}^{n} v_k B_k \le V \tag{6}$$

$$Q_k \in \mathbb{Z} \quad k = 1,\ldots,n \tag{7}$$

$$B_k \in \mathbb{Z} \quad k = 1,\ldots,n \tag{8}$$

Where:

k are the products that assume values from 1 to n.
n is the number of different types of products.
P_k is the value associated with each product.
T is the number of bottles per box (T=12).
w_k is the weight associated with each product k.
v_k is the volume associated with each product.
x_k acquires the value of 1 if the product k is chosen and 0 otherwise.
W is the total weight of the vehicle.
V is the volume that the vehicle supports.
D_k is the total quantity of the product k.

Q_k is the quantity of product (in bottles) k assigned to each route.

B_k is the quantity of product (in boxes) k assigned to each route.

The objective function (1) seeks to maximize the profit obtained from the selected products and their quantity. The constraint (2) allows selecting an amount of each product that does not exceed the total amount to be transported. The constraint (3) determines the number of boxes in integer numbers. The constraint (4) establishes the number of barrels in integer numbers. The constraint (5) verifies that the weight of the selected products does not exceed the weight limit that can be supported by the vehicle. The constraint (6) verifies that the quantity of products does not exceed the limits on the volume of the vehicle. The constraint (7) verifies that the variable Q_k for k=1, 2, 3 is an integer, to ensure that the bottles and the barrels are not considered on fractions. The constraint (8) verifies that the variable B_k is an integer, to ensure that boxes and barrels for the calculation of volume, are not considered on fractions.

However, since the program seeks to fill a vehicle each time optimally, some steps were cyclical, as shown in Figure 2.

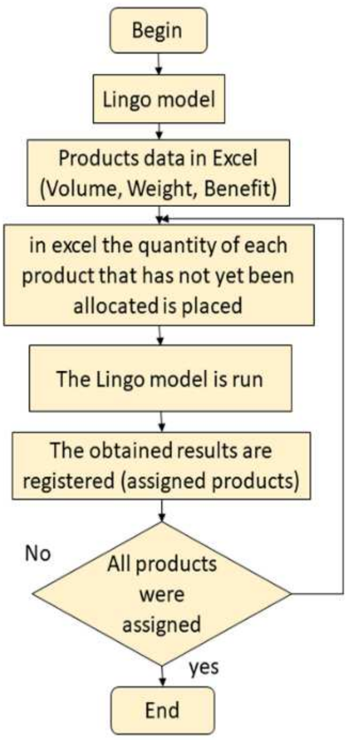


Figure 2 Flowchart of the process of assigning modified Knapsack

The modifications to the KP in Lingo model are shown in Appendix A; these modifications allowed the model to assign the maximum amount to be transported in the truck, respecting the constraints of volume and maximum weight that it can hold the truck in each route and they are considered complete boxes for the route, even if bottles are moved. Lingo code *QT* variable receives the full amount of each presentation of the product, while the variable *Q*, allows fewer of each product, to accomplish with the restrictions of weight and volume of the truck.

The *y1* and *y2* products were joined to obtain the Knapsack since they provide the same utility to the Company. In order to assign the products to the truck, there were three runs, where the KP respects the constraints of weight and maximum volume of the truck that was 1143 Kg and 57400 m^3, respectively. The volume, weight, and profit for each of the presentations of the beer can be seen in Table 6.

In Figure 8 for each product is shown the variables, where the variable *v* is the volume, *w* is the weight, *R* is the profit, *Q* is the quantity to calculate the cost and the weight of the products, *QT* is the total quantity to transport in all the three tours, *Q2* is the number of complete boxes (even if they are not full) and barrels to calculate the volume that the vehicles will transport.

Also, to hold the assignment to give priority to products that provide more profit, so that the first route was scheduled to carry the load that maximizes profit. Barrels (*y3*, *y4*) were assigned to the first route, and the rest of the space was assigned to boxes of beer type 1 and type 2 (*y1*, *y2*), with a weekly profit of USD 326.5; route two charges *y1* and *y2* with a weekly profit of USD 141. Furthermore, finally, route 3 comes with *y1* and *y2* with a weekly profit of USD 129.5. With three routes covering the total weekly demand, as is shown in Figure 3.

Global optimal solution found.			
Objective value:	7107.812	3066.667	2763.067
Extended solver steps:	5	0	0
Total solver iterations:	226	27	13
Variable	Value	Value	Value
V(1)	574.0000	574.0000	574.0000
V(2)	2215.000	2215.000	2215.000
V(3)	2286.300	2286.300	2286.300
W(1)	4.200000	4.200000	4.200000
W(2)	24.00000	24.00000	24.00000
W(3)	38.10000	38.10000	38.10000
R(1)	30.66667	30.66667	30.66667
R(2)	1711.315	1711.315	1711.315
R(3)	2575.164	2575.164	2575.164
X(1)	1.000000	1.000000	1.000000
X(2)	1.000000	0.000000	0.000000
X(3)	1.000000	0.000000	0.000000
Q(1)	92.00000	100.0000	90.10000
Q(2)	1.000000	0.000000	0.000000
Q(3)	1.000000	0.000000	0.000000
QT(1)	282.1000	190.1000	90.10000
QT(2)	1.000000	0.000000	0.000000
QT(3)	1.000000	0.000000	0.000000
Q2(1)	92.00000	100.0000	91.00000
Q2(2)	1.000000	0.000000	0.000000
Q2(3)	1.000000	0.000000	0.000000

variable for cost and weight

variable for volume

(a)

	Load distribution		
	Tour 1	Tour 2	Tour 3
y1,y2	92	100	90.1 / 91
y3	1	0	0
y4	1	0	0
Utility	326.5	141.0	129.5
Volume	57309.3	57400	52234
Weigth	448.5	420	378.42

(b)

Figure 3 (a) LINGO runs to assign cargo to 3 routes (b) Distribution of products per route

5.2 Traveling Salesman Problem (TSP)

Karl Menger conceived the idea of the TSP model in the 1930s. This model seeks to minimize the total distance of a route that connects all nodes of a network, visiting each node once and returning to the starting point. The TSP model is shown below:

Objective Function:

$$Min \sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij} x_{ij} \quad (10)$$

onstraints:

$$\sum_{i=1, i \neq j}^{n} x_{ij} = 1, \quad j = 1, \ldots, n \quad (11)$$

$$\sum_{j=1, j \neq i}^{n} x_{ij} = 1, \quad i = 1, \ldots, n \quad (12)$$

$$(n-1) x_{ij} + u_i - u_j \leq (n-2), \quad i, j = 2, 3, \ldots, n \quad (13)$$

$$x_{ij} \in \{0,1\}, \quad i = 1, \ldots, n, \quad j = 1, \ldots, m \quad (14)$$

Where:
c is the distance traveled.
i, j are cities that take the value of 1 to n.
x_{ij} acquires the value of 1 if a vehicle goes from City i to city j and 0 in another.
u_i, u_j define a sequence of visits to the problem cities, also representing the cities of origin and destination, respectively.

The objective function (10) seeks to minimize the distance traveled. Moreover, the constraint (11) forces the vehicle to leave only once from each City. The constraint (12) requires that the vehicle arrives only once to each City. The constraint (13) avoids sub-routes of length greater than 1. The constraint (14) ensures that the variable x_{ij} is binary.

The distances between the customers were obtained using Google Maps, to and from the Company, these distances are shown in Appendix B, where the depot is node one.

With the distances matrix, the TSP model is applied in Lingo, and the result of the best route is the next 1-18-12-17-9-10-15-11-7-14-4-8-16-13-6-5-2-3-1, where the depot is node one, as shown in Figure 11. In this figure, the variable X shows the route obtained. The route begins in node one and connects with node 18. Later, it is necessary to find node 18, and in the figure, it is observed that it is connected with node 12, following the route, can we appreciate that node 12 is connected with node 17. To complete the route is necessary to follow the connections to finally find that the node three return to node 1, with this the route ends. In Figure 4, the nodes that were not connected (with cero) were omitted to avoid use more space for the figure.

Until now, it has been obtained the quantity and type of product to carry each route and the route to follow for the deliveries.

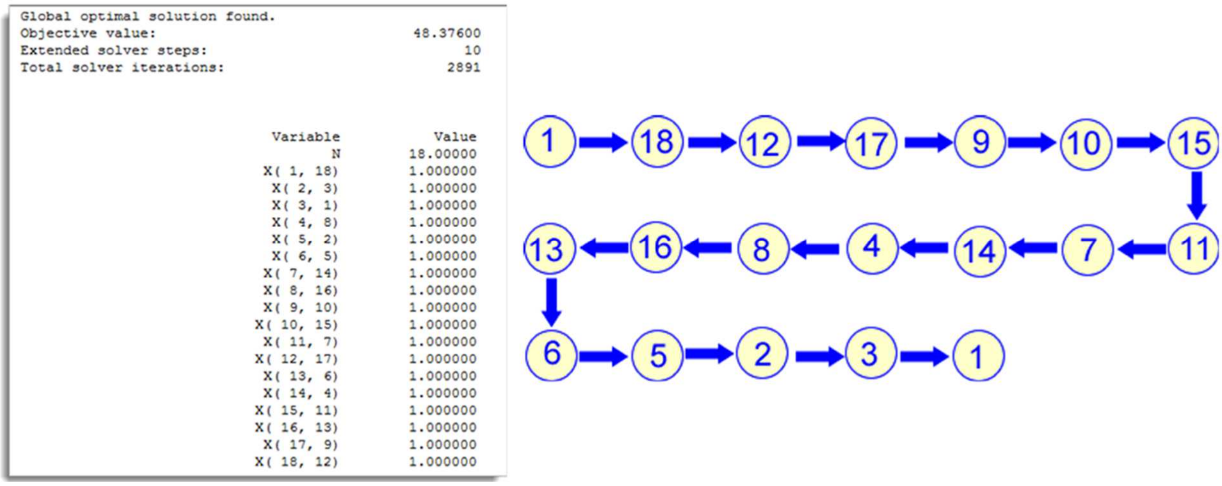
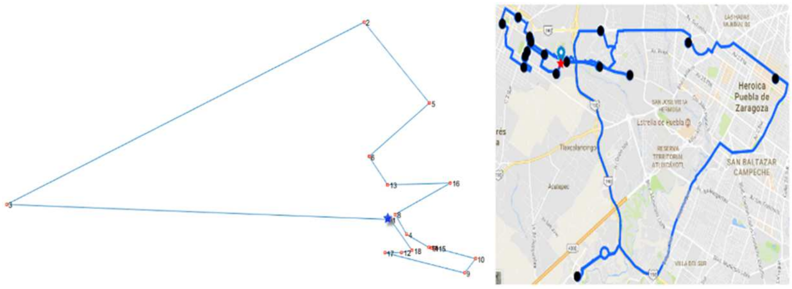


Figure 4 LINGO runs to get the TSP model results and the route obtained

The route obtained with the TSP algorithm was modeled in MATLAB using strength lines to connect the customer points. Also, the customer points were connected in a map, using the streets and their direction. The route obtained with TSP to attend the customers is shown in Figure 5.



(a) (b)

Figure 5 The route obtained with the TSP algorithm. (a) drawn with MATLAB, (b) in a map

5.3 Greedy Algorithm

Finally, Greedy Algorithm is used to identify the data and sort it according to the route obtained with the TSP model, and select the customers according to their demand, verifying that the demand is as close as possible to the result obtained in the KP, this process is shown in Figure 6.

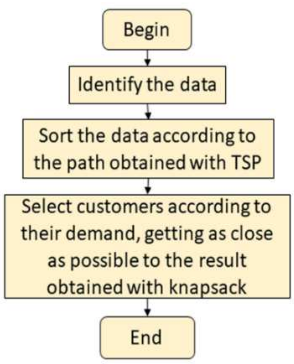


Figure 6 Flow Diagram of the Greedy Algorithm

The Greedy Algorithm was used to assign the products for each of the three routes. When making the assignment the customer's request, the goods of customer four are divided into two routes, because the customer demand exceeds the capacity of the truck. Taking into account the result of the TSP model, and the allocation of boxes and barrels obtained with the KP, a Greedy Algorithm is performed for the specific allocation of products in each route.

In Table 9, (customer column), the route designated by the TSP model for delivery is observed. In the following columns, the quantities of the product to be delivered by the KP are written.

Table 9 Assignment of the Greedy Algorithm

Customer	Route 1				Route 2				Route 3			
	y1 [a]	y2 [a]	y3 [b]	y4 [b]	y1 [a]	y2 [a]	y3 [b]	y4 [b]	y1 [a]	y2 [a]	y3 [b]	y4 [b]
1												
18	0	0	0	1								
12	2.25	2.25	0	0								
17	11.25	0	0	0								
9	6.525	5.85	0	0								
10	3.375	3.375	0	0								
15	4.5	4.5	0	0								
11	4.5	2.25	0	0								
7	3.375	2.25	0	0								
14	2.25	2.7	0	0								
4	11.75	0	0	0	13	86.985	0	0				
8	6.75	5.625	1	0								
16	3.375	5.625	0	0								
1												
13									22.5	22.5	0	0
6									4.5	4.5	0	0
5									6.75	6.75	0	0
2									2.25	4.5	0	0
3									4.5	9	0	0
1												
Total	59.95	34.43	1	1	13	86.985	0	0	40.55	47.35	0	0
Volume	58643.55				57391.39				50368.5			
Weight	420.165				419.937				368.55			

[a] boxes, [b] barrels

The route one carries a load of products for twelve customers. The load is composed of 95 boxes of product *y1* and *y2*, delivery 1 barrel of *y3*, and 1barrel of *y4*. Route two delivery to customer 4 with 87 boxes *y1* and *y2*. Finally, route three delivery to 5 customers with 88 boxes. In Figure 7 are shown the routes obtained, using strength lines for the union of customer points.

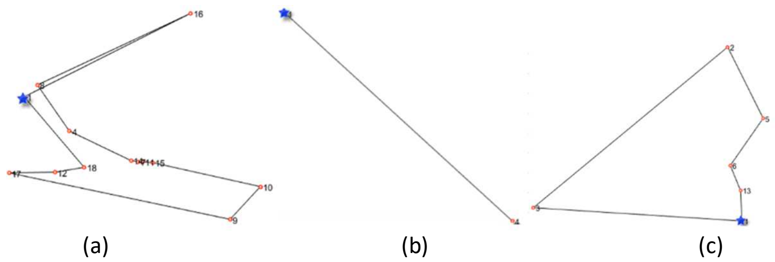
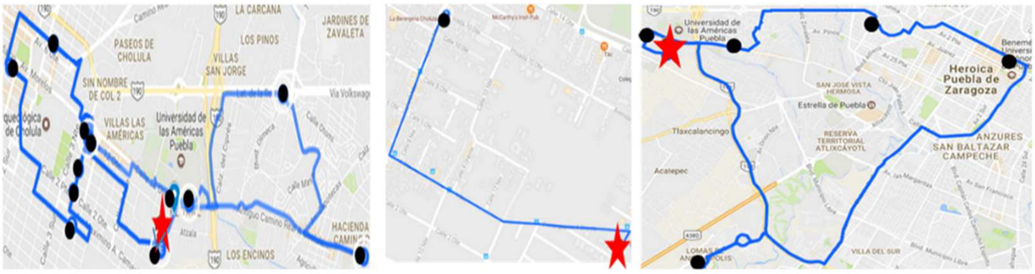


Figure 7 Routes obtained with Greedy Algorithm - route 1 (a), route 2 (b), route 3 (c)

5.4 Results discussion

The combination of these three models helps us to solve the problems of deliveries by first delivering the products that generate the highest profit to the Company and optimizing the route to make those deliveries. In route one, it supplies 12 customers and delivers 95 boxes of which 60 boxes are of type 1, and 35 boxes are of type 2, one barrel of 19 liters of beer type 1, and one barrel of 29 liters is of beer type 2. The route two was done for a customer, 100 boxes are delivered, which 13 boxes of beer type 1 and 87 boxes of beer type 2. The route 3, supplies five customers, and 89 boxes are delivered, which 41 boxes are of type 1 beer and 48 boxes are of type 2. The route of each of the three routes is added, where the depot is the red star, and the black spots are the customers, as can be seen in Figure 8.



(a) (b) (c)

Figure 8 Route 1 (a), route 2 (b), route 3 (c)

The vehicle used for the Company is a truck with a capacity of 1143 kg of weight. The dimension of the back of the pickup truck is 225 cm x 135 cm. The boxes can carry one on top on another, stocking a maximum of two boxes. With the maximum boxes stocked, the volume that the vehicle can carry is 57400 cm^3. The median fuel consumption is 7.3 Km/liter. The current cost of diesel is USD 0.84.

In Table 10, the kilometers per route and the total kilometers of the three routes are presented.

Table 10 Kilometers to cover the three routes.

Route	Km
1	14.734
2	2.37
3	37.151
Total	54.255

According to the total kilometers cover by the three routes and the median of fuel consumption of the vehicle, the vehicle needs 7.432 liters of diesel to cover the routes. With the current cost of diesel, the Company will spend USD 6.2.

The routes that the Company follows typically are random, but the median of the costs incurs per week were USD 8.7; with this improvement, the saving per year is USD 130.

6 Conclusions and future research directions

To help the small companies to survive, it is necessary for the interaction between the schools and the companies. In Table 1, the decrease of small companies from 2008 to 2013 is 8.3. The idea of helping small companies is to avoid them continue decreasing. The small companies contribute to jobs, and if they decrease, the number of employees will decrease, as can be seen in Table 2.

The proposed model is based on the combination of the knapsack problem, the Traveling Salesman Problem, and the Greedy Algorithm. The proposed model satisfies the demand of customers, focusing on the profits according to the needs of the Company.

The scheduling of delivery days to the customer supports production to keep track of a demand history and to carry out the production schedule, so that in the future, they may have optimal delivery routes established. It is improving the attention to customers, avoiding the shortage, and being able to give information on delivery dates according to the scheduling of previously established routes. Moreover, it also supports production planning to maintain a suitable make to stock (MTS). As a future work can be used, the Capacity Vehicle Routing Problem (CVRP) instead of the TSP model.

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