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El uso de modelos de redes y modelos de transporte para la optimización y reducción de tiempos y costos de transporte en la Comercializadora Gonac S. A de C. V.

The use of network models and transport models for the optimization and reduction of transport times and costs in the Comercializadora Gonac S. A de C. V.

O uso de modelos de rede e modelos de transporte para a otimização e redução de tempos e custos de transporte na Comercializadora Gonac S. A de C. V.

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Resumen

El objetivo del presente artículo es enseñar los resultados en torno a cómo en la Comercializadora Gonac S. A de C. V. se pueden recortar los tiempos y costos de traslado de sus productos a través del uso de técnicas de optimización de redes y modelos de transporte denominados *ruta más corta*, *modelo de transporte* y *árbol de expansión mínima*. Cada una de estas técnicas fue resuelta de manera matemática y por medio del *software* Win QSB, lo que facilitó el proceso de programación y asignación de rutas en el área de logística de la mencionada empresa. Junto con la aplicación de estas técnicas se emplearon fórmulas para calcular el consumo de combustible de cada unidad de la dicha compañía. Estas técnicas de optimización de redes y modelos de transporte permitieron visualizar las ventajas y desventajas que se tienen al programar las diferentes rutas. En tal sentido, se debe prever que cada una de estas es diferente, por lo que las condiciones para programar y asignar las rutas de transporte varían, ya que se deben tomar en cuenta la cantidad y el volumen del producto solicitado por el cliente, así como el tiempo y la distancia recorrida, pues de esa manera se podrá escoger la unidad que debería trasladar determinado pedido a su destino, con lo cual se podrían disminuir los costos.

Palabras clave: árbol de expansión mínima, investigación de operaciones, logística y cadena de suministros, modelo de transporte, modelos de redes, ruta más corta, Win QSB.

Abstract

The objective of this article is to show the results about how the Gonac S. A de CV sales company can reduce the time and costs of moving its products through the use of network optimization techniques and transport models called route shorter, transport model and minimum expansion tree. Each of these techniques was solved mathematically and through the Win QSB software, which facilitated the process of programming and assigning routes in the logistics area of the aforementioned company. Along with the application of these techniques formulas were used to calculate the fuel consumption of each unit of the said company. These techniques of optimization of networks and transport models allowed to visualize the advantages and disadvantages that are had when programming the different routes. In this regard, it must be anticipated that each of these is different, so the conditions for programming and assigning transport routes vary, since the quantity and volume of the product requested by the customer must be taken into account, as well as the time and distance traveled, because that way you can choose the unit that should move a certain order to its destination, which could reduce costs.

Keywords: minimum expansion tree, operations research, logistics and supply chain, transport model, network models, shorter route, Win QSB.

Keywords: network models, shortest route, transport model and minimum expansion tree, logistics and supply chain, operations research, Win QSB.

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Resumo

O objetivo deste artigo é mostrar os resultados de como a empresa de vendas Gonac S. A de CV pode reduzir o tempo e os custos de movimentação de seus produtos através do uso de técnicas de otimização de rede e modelos de transporte chamados de rota. menor, modelo de transporte e árvore de expansão mínima. Cada uma destas técnicas foi resolvida matematicamente e através do software Win QSB, o que facilitou o processo de programação e atribuição de rotas na área de logística da empresa supracitada. Juntamente com a aplicação dessas técnicas, foram utilizadas fórmulas para calcular o consumo de combustível de cada unidade da referida empresa. Estas técnicas de otimização de redes e modelos de transporte permitiram visualizar as vantagens e desvantagens que se tem ao programar as diferentes rotas. A este respeito, deve-se antecipar que cada um deles é diferente, de modo que as condições de programação e atribuição de rotas de transporte variam, uma vez que a quantidade e o volume do produto solicitado pelo cliente devem ser levados em consideração, assim como como o tempo e a distância percorrida, porque dessa forma você pode escolher a unidade que deve mover uma determinada ordem para o seu destino, o que poderia reduzir os custos.

Palavras-chave: árvore de expansão mínima, pesquisa operacional, logística e cadeia de suprimentos, modelo de transporte, modelos de rede, rota mais curta, Win QSB.

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Introduction

In 2015, the Mexican authorities signed an agreement in Paris, whose central objective was that 35% of the energy consumed by 2025 must come from renewable sources, as this will reduce the emission of greenhouse gases, which is produced mainly by the transport sector. To achieve this goal, of course, Mexico should work on the investigation of other sources of energy, such as biofuels such as castor bean, corn, sugar cane, wheat, sorghum and citrus, which not only they have a lower environmental impact, but can also serve to reduce the costs invested in fossil fuels to distribute the products locally, nationally and internationally. Boluda Aguilar, M. and López Gómez, A. (2013).

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In the country, however, so far there is only one certified company (called Fuel Flex) in the commercialization and research of new biofuels, while at the institutional and government level the National Polytechnic Institute has the National Laboratory for Development and Assurance of the Quality of Biofuels (Landacbio), which offers analytical services and specialized consulting, scientific research, technological development and training of human resources to maximize the productivity and competitiveness of the national industry under the principles of sustainability. Likewise, and at the initiative of the Secretary of Energy (Sener) and the National Council of Science and Technology (Conacyt), the Mexican Center for Innovation in Bioenergy (Cemie-Bio) has emerged, made up of five clusters dedicated to research, development and innovation in different types of biofuel. Gay and García, C. (2014).

This means that there is still a lot of investment to develop alternative sources of energy. Meanwhile, the use of fossil fuels will continue to be one of the main axes to boost the economy of the country, which is why strategies must be presented to reduce the environmental and logistical impact of moving the products required by society.

The problem

The company Comercializadora Gonac S. A de CV is a modern Mexican company that seeks the continuous improvement of its services, which is evidenced in the use of technologies and engineering techniques to simplify the operation of its activities, which consist of manufacturing snacks and drinks that are marketed in Mexico, the United States and Central America. This has two plants: one in the city of Huamantla, Tlaxcala, CP 90500, specifically in the street Feria Nacional, number 7, Cd. Industrial Xicohtencatl II, and another plant in the city of Monterrey, located in the street Brazil, number 205 , in the Martel Santa Catarina Industrial Park, Nuevo León CP66358.

The company is currently working with six different brands of snack and beverage products (Kiubo, King Citrus, Chechitos, Chechi Fresco, Fruti King and Ecolive) and more than a hundred products on the market. To guarantee the quality standards, Gonac is based on the quality and continuous improvement scheme, as established in the NOM-251-SSA1-2009 standard, which determines hygiene practices for the process of food, beverages or food supplements. .

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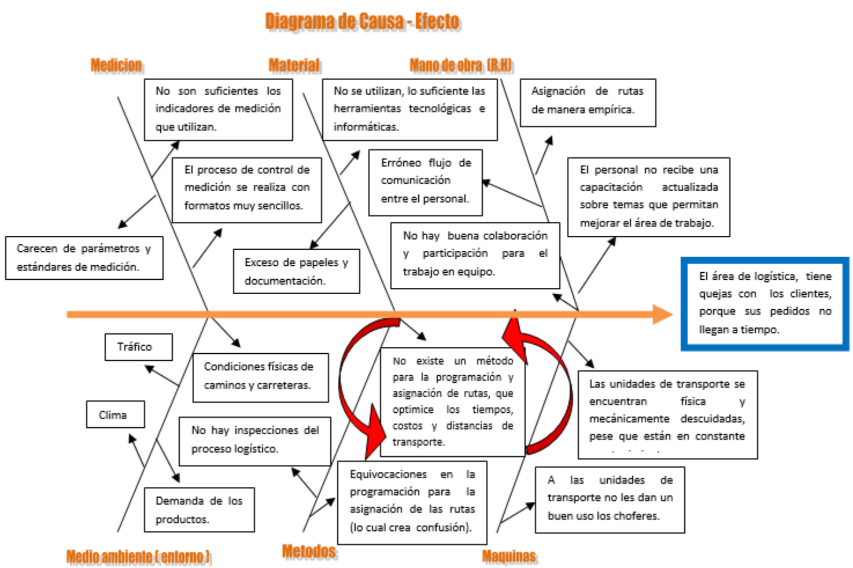
The logistics department of the company Gonac is responsible for developing, through a program of shipments, those activities that are linked to the allocation of routes and shipments of products to the required destinations. In this process, the units are monitored and tracked using a GPS satellite system called Qtracs Omnitraqs. In this way, the company ensures that its merchandise reaches customers in the correct manner and in the established period.

Despite this control, however, a problem has been detected related to the delay in the delivery of customer orders, as well as the costs involved in moving the merchandise to its final destinations (figure 1).

Figura 1. Diagrama de causa y efecto



Fuente: Elaboración propia

For this reason, the objective of this article is to show the results about how the times and costs of moving products can be reduced through the use of network optimization techniques and transport models called shorter route, transport model and minimum expansion tree.

Method

Each of the above techniques was solved mathematically and through the Win QSB software, which facilitated the process of programming and assigning routes in the logistics area in the company Comercializadora Gonac S. A de C. V.

Along with the application of these techniques formulas were used to calculate the fuel consumption of each unit of the aforementioned company. In addition, the toll rates or toll booths that the Ministry of Communications and Transportation establishes in Mexico, specifically those for the period 2013-2014, were considered.

However, in order to solve the problem in the company and optimize costs and transport times, the following techniques of industrial engineering focused on operations research, logistics and supply chain were used.

Logistics

These are necessary tasks to plan, implement and control the physical flow of materials, finished products and related information from the point of origin to the point of consumption to satisfy the customer's needs in a cost-effective manner. In the words of Ballou (2004), "it is the process of strategically managing the flow and efficient storage of raw materials, of stocks in the process and of finished goods from point of origin to consumption" (page 7).

Operations research

According to Prawda (2004), "the investigation of operations is an application of scientific methodology that through mathematical models seeks to represent a real problem and solve it" (page 936), which allows a detailed analysis for decision making in any organization or company.

Network models

A model is a representation or abstraction of a situation or real object that shows the relationships (direct or indirect), as well as the interrelations of action and reaction in terms of cause and effect. In this regard, Taha (2004) believes that "network modeling allows the resolution of multiple mathematical programming problems through the implementation of special algorithms created for this purpose, known as network optimization algorithms" (page 213). Some of the problems solved more commonly by modeling networks are linked to the transport model, the shortest route, the minimum cost model, among others. A network is the union of two or more points called nodes, which are linked by lines called arcs.

Network optimization

This concept seeks through deterministic mathematical models to decrease the time and distance between two or more points. This arises with the purpose of optimizing transport networks and electric power for the supply of fuel.

Route optimization

On this concept, Castellanos Ramírez (2009) explains the following:

> It could be understood by route optimization all those actions that contribute to the improvement of the distribution function, either in terms of service level, quality improvement, cost reduction. The optimization of routes is a concept that necessarily touches the three levels of decision, although, usually it acquires greater importance in decisions of a more tactical and operational nature, that is, at the moment of optimizing already existing models or adapting them to the need of Incorporate new products or customers into the distribution flows already implemented (p. 260).

The shortest route

The objective of this method is to simplify and shorten distances to reduce time and costs (Taha, 2004). Through this the problem is represented in a real way, as well as its solution in a graphic way, which allows to broaden the scope to make decisions regarding the distribution of the company's products. The shortest route, in other words, seeks to minimize the distance traveled, as well as the cost and time spent in a sequence of activities.

Minimum extension tree method

For Hillier (2006) "the minimum extension or expansion tree method consists of finding the most efficient or shortest connections between all the nodes in a network" (page 318). That is, connect all points of a network so that distance and time decrease, which cuts costs. In this network optimization model there are no cycles. The minimum expansion tree, therefore, is a model that consists of linking all the nodes of the network directly or indirectly so that the total length of the arcs or branches is minimal.

Transport model

The transport model seeks to determine a transportation plan for a merchandise from several sources to several destinations. The data of the model are the following:

1. Level of supply in each source and the amount of demand in each destination.
2. The cost of unit transport of the merchandise to each destination.

As there is only one commodity, a destination can receive its demand from one or more sources. The objective of the model is to determine the amount that will be sent from each source to each destination to reduce the cost of total transportation (Castellanos Ramírez, 2009).

This model is based on the premise that the cost of transportation on a route is directly proportional to the number of units transported. In this sense, the definition of transport unit varies depending on the goods moved, hence there are m sources and n destinations, which are represented by a node. The arches are the routes that link the sources and destinations. The arc (i, j) that joins the source i with the destination j contains two kinds of information: the cost of transport cij per unit and the amount transported xij. The supply quantity in source i is ai and the quantity of demand in destination j is bj. The objective of the model is to determine the unknowns xij to reduce the total cost of transport and satisfy, at the same time, supply and demand constraints.

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Win QSB program

WinQSB is an interactive system that helps decision-making. This contains very useful tools to solve different types of problems in the field of operational research. The system consists of multiple modules (one for each type of model or problem). It is a software that allows to define the problems of planning in three groups: simple model, transport model and linear programming models, so it is useful to specify the availability of overtime, delays in the delivery of orders, subcontracting, loss of sales, as well as contracts and dismissals of resources.

After explaining the above, the formulas used to calculate the fuel consumption of each of the routes assigned by the company are presented below, for which the performance of each type of transport unit, the kilometers of distance between each destination, was considered. and the unit cost of fuel:

Equation 1

$$consumo\ de\ combustible\ en\ litros\ = \frac{km}{rendimiento\ de\ la\ unidad}$$

Equation 2

$$costos\ de\ consumo\ de\ combustible\ = \frac{km}{rendimiento\ de\ la\ unidad}(\ costo\ unitario\ del\ combustible)$$

Table 1 shows the performances of transport units established and calculated by the company, for which it was taken into account if the vehicle needed adjustment or had a problem with excessive fuel consumption.

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Tabla 1. Rendimientos de las unidades

Tipo de unidad	Rendimiento
Camioneta	5.8
Torton	3.3
Rabón	4.2
Tráiler	2.7
Full	2.2
Palmex	10

Fuente: Comercializadora Gonac (2012)

To obtain the performance of the units, the following formula was used:

Equation 3

$$\frac{km\ recorridos\ B - \ km\ recorridos\ A}{litros\ B} = rendimiento$$

That is, the performance of the vehicle equals the kilometers traveled last time by the unit minus the kilometers traveled previously, and this result is then divided by the liters of fuel that the unit last loaded.

Now, the importance of applying the models of networks and transport models in the programming of routes to distribute products of the Gonac company is that it is intended not only to reduce the costs involved in the daily use of a fleet made up of more than 200 units, but also reduce the time invested in the delivery of your products or services. For this, this type of models is based on mathematical algorithms that help to make objective decisions regarding logistics and supply chain, all expressed in numbers that reflect cost, time and distance.

However, it is also worth noting that this model does not consider some factors, such as traffic, weather, road and road conditions, the operation of the units, the volume and load capacity of each truck, sales and forecasts sales, the generation of orders, the time in which the units are inactive, the rates of toll booths, transport measurement indicators, monitoring and tracking of the units, as well as the variability of the different destinations for the creation of routes, product delivery dates, road accidents, loading time and product unloading, or the geographical and economic area of the country.

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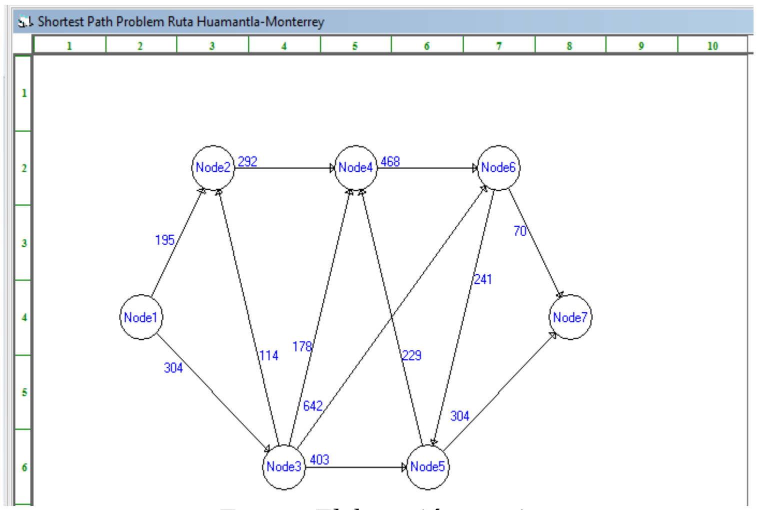
Results

Application of the shortest route model

For this model, the Huamantla-Monterrey route was considered, so that the following network shows the connections and kilometers that exist between one destination and another (figure 2):

Figura 2. Red de la ruta Huamantla-Monterrey



Fuente: Elaboración propia

The following network (figure 3) represents the route that should be carried out by the unit of transport assigned on the Huamantla-Monterrey route, which is established by the company and considered as the basis for establishing said method.

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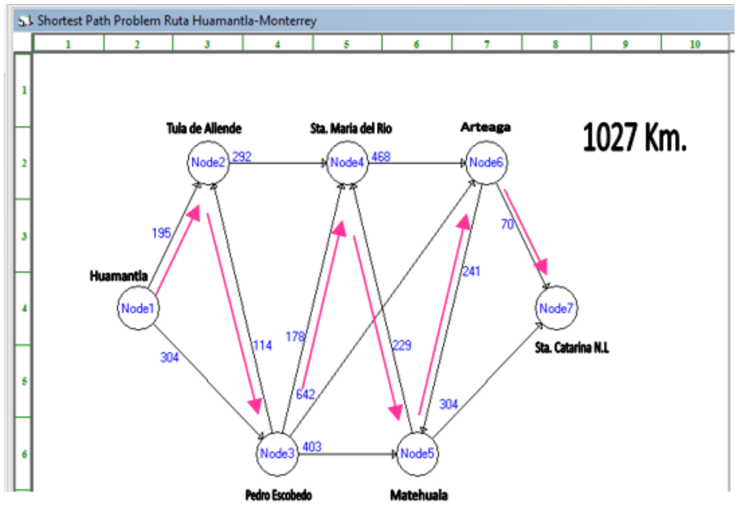
Figura 3. Red de la ruta Huamantla-Monterrey asignada por la empresa



Fuente: Elaboración propia

Table 2 shows the destinations or populations through which to pass to reach the final destination (Monterrey plant), as well as the distances between one destination and another in order to define the most viable route through the network.

Tabla 2. Muestra los destinos y kilometrajes de la ruta Huamantla-Monterrey

Desde	Hacia	km
Huamantla	Tula de Allende	195 km
Tula de Allende	Pedro Escobedo	114 km
Pedro Escobedo	Santa María del Rio	178 km
Santa María del Río	Matehuala	229 km
Matehuala	Arteaga	241 km
Arteaga	Santa Catarina NL.	70 km
	Total	**1027 km**

Fuente: Comercializadora Gonac (2012)

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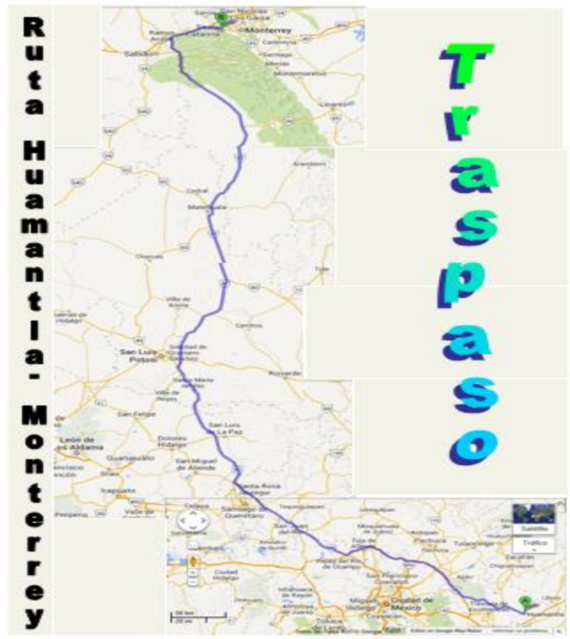
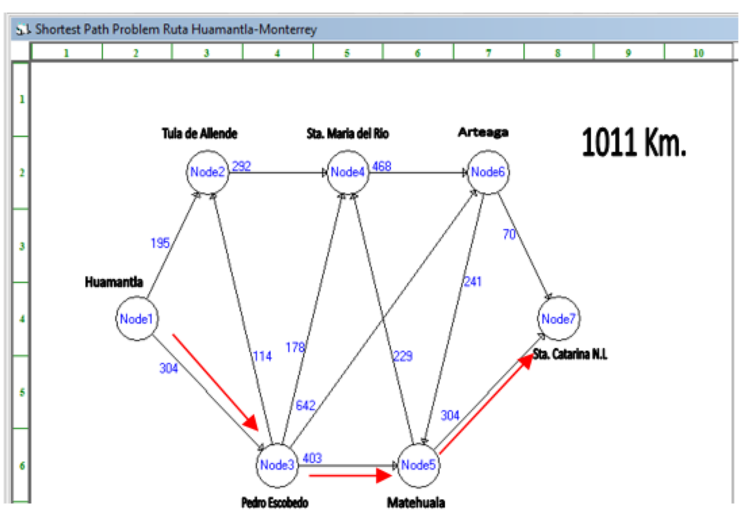
Figura 4. Mapa de la Ruta Huamantla-Monterrey



Fuente: Elaboración propia

The following network (figure 5) shows the route in kilometers, as well as the optimization of the distances between Huamantla and Monterrey through the shortest route method.

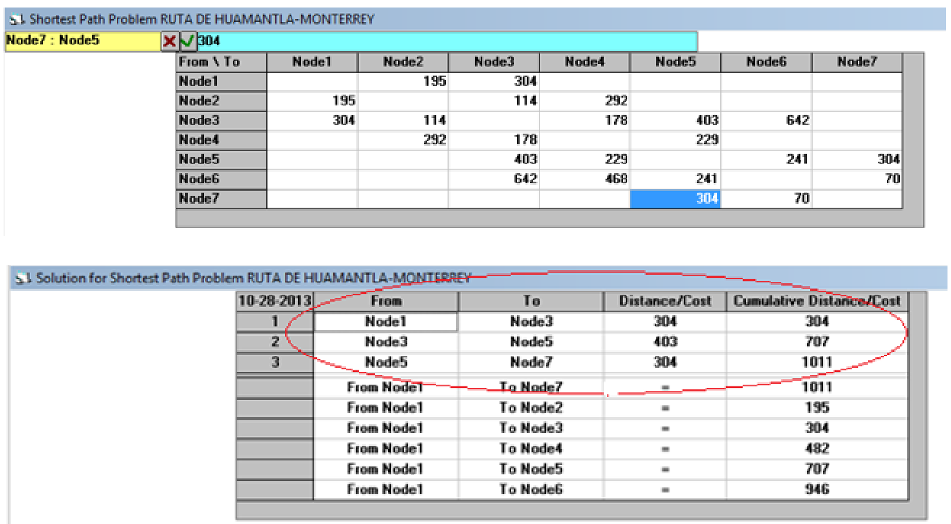
Figura 5. Red propuesta por el método la ruta más corta



Fuente: Elaboración propia

Next (figure 6), and with the help of the Win QSB program, the resolution of the algorithm of the Huamantla-Monterrey route is presented, through which a result equal to the previous one is achieved.

Figura 6. Solución del algoritmo de la ruta más corta entre Huamantla-Monterrey con el Win QSB


Shortest Path Problem RUTA DE HUAMANTLA-MONTERREY

Node7 : Node5 304

From \ To	Node1	Node2	Node3	Node4	Node5	Node6	Node7
Node1		195	304				
Node2	195		114	292			
Node3	304	114		178	403	642	
Node4		292	178		229		
Node5			403	229		241	304
Node6			642	468	241		70
Node7					304	70	

Solution for Shortest Path Problem RUTA DE HUAMANTLA-MONTERREY

10-28-2013	From	To	Distance/Cost	Cumulative Distance/Cost
1	Node1	Node3	304	304
2	Node3	Node5	403	707
3	Node5	Node7	304	1011
	From Node1	To Node7	=	1011
	From Node1	To Node2	=	195
	From Node1	To Node3	=	304
	From Node1	To Node4	=	482
	From Node1	To Node5	=	707
	From Node1	To Node6	=	946

Fuente: Elaboración propia

Resultado 7 → 5 → 3 → 1

Ruta: Huamantla, Pedro Escobedo, Matehuala, Santa Catarina NL.

Distancia 304 + 403 + 304 = 1011 km

Kilómetros reducidos: 1027 km - 1011 km = 16 km

Table 3 shows the algorithm of the shortest route, which yielded the following results:

Tabla 3. Algoritmo de la ruta más corta entre Huamantla-Monterrey

Nodo	u_{ij}	Etiqueta
1 Huamantla	$u_1 min = (0+0) = 0$	[0,0]
2 Tula de Allende	$u_{21} min = (0+195) = 195$	[195,1]
3 Pedro Escobedo	$u_{31} min = (0+304) = 304$	[304,1]
	$u_{32} min = (195+114) = 309$	
4 Santa María del Río	$u_{42} min = (195+292) = 487$	
	$u_{43} min = (304+178) = 482$	[482,3]
5 Matehuala	$u_{53} min = (304+403) = 707$	[707,3]
	$u_{54} min = (482+229) = 711$	
6 Arteaga	$u_{63} min = (304+642) = 946$	[946,3]
	$u_{64} min = (482+468) = 950$	
	$u_{65} min = (707+241) = 948$	
7 Santa Catarina NL.	$u_{75} min = (707+304) = 1011$	[1011,5]
	$u_{76} min = (946+70) = 1016$	

Fuente: Elaboración propia

Resultado: 16 km reducidos

Considering that a trailer was sent to travel this route with a yield of 2.7 and a unit cost of diesel of $ 12.70, the fuel consumption was calculated comparing the route assigned by the company and the applied method, as shown in the following equations:

Calculation of fuel consumption of the route assigned by the company:

$$consumo\ de\ combustible\ en\ litros\ = \frac{1027}{2.7} = 380.37\ litros$$

$$costos\ de\ consumo\ de\ combustible\ = \frac{1027}{2.7}(\ 12.70) = 4830.69$$

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Calculation of the fuel consumption of the route obtained by the shortest route method:

$$consumo\ de\ combustible\ en\ litros\ = \frac{1011}{2.7} = 374.44\ litros$$

$$costos\ de\ consumo\ de\ combustible\ = \frac{1011}{2.7}(\ 12.70) = 4755.38$$

Next, the quantity and cost of fuel consumption are presented, which were reduced using the shortest route method.

$$380.37 - 374.44 = 5.93\ litros\ 4830.69 - 4755.38 = 75.31$$

Taking into account the journey made by the unit to the plant on the way out and the return (Huamantla-Monterrey), the fuel consumption that was reduced was as follows:

$$Resultado\ 75.31(2) = \$\ 150.62$$

Minimum expansion tree

To optimize the distances of all the connected nodes and obtain a viable route to satisfy the demand in all points or destinations, the minimum expansion tree method was applied in the Huamantla-Tamanzunchale route (figure 7):

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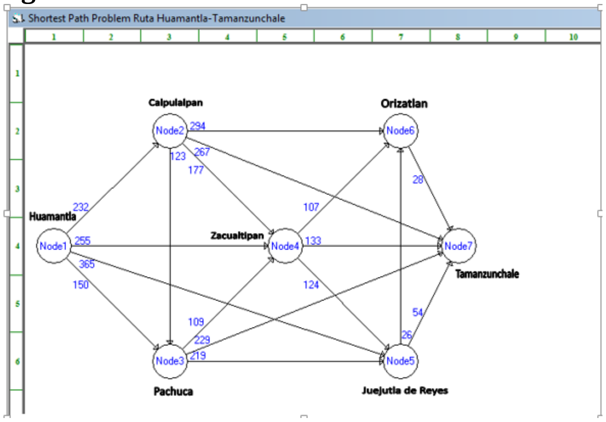
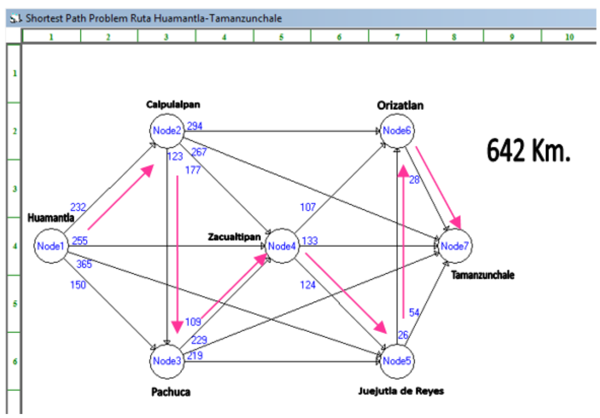
Figura 7. Red de la ruta Huamantla-Tamanzunchale



Fuente: Elaboración propia

Figura 8. Red de la ruta Huamantla-Tamanzunchale asignada por la empresa



Fuente: Elaboración propia

Figura 9. Mapa de la ruta Huamantla-Tamanzunchale

Fuente: Elaboración propia

Tabla 4. Destinos y kilometrajes de la ruta Huamantla-Tamanzunchale

Desde	Hacia	km
Huamantla	Calpulalpan	232 km
Calpulalpan	Pachuca	123 km
Pachuca	Zacualtipan	109 km
Zacualtipan	Juejutla de Reyes	124 km
Juejutla de Reyes	Orizatlan	26 km
Orizatlan	Tamanzunchale	28 km
	Total	642 km

Fuente: Comercializadora Gonac (2012)

The following network (Figure 10) presents the route and the most viable low-cost route that was obtained by applying the minimum expansion tree method:

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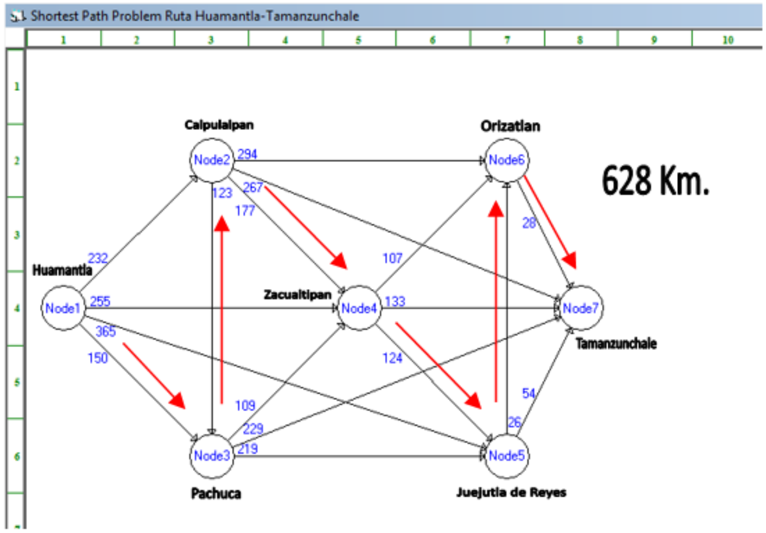
Figura 10. Red propuesta por el método de árbol de expansión mínima



Fuente: Elaboración propia

The minimum spanning tree method was solved based on table 5, which contains the nodes and the minimum distances that connect all the nodes in the network.

Tabla 5. Solución de la ruta Huamantla Tamanzunchale por el método de árbol de expansión mínima

C_K	$\overrightarrow{C_K}$	Distancia
7	6,5,4,3,2,1	–
7,6	5,4,3,2,1	28
7,6,5	4,3,2,1	26
7,6,5,4	3,2,1	124
7,6,5,4,2	3,1	177
7,6,5,4,2,3	1	123
7,6,5,4,2,3,1	–	150
Total: 628		

Fuente: Elaboración propia

Comparing the route assigned by the company and the route proposed by the minimum expansion method, the following result is obtained:

Resultado 642 km - 628 km = 14 km

As can be seen, with the minimum expansion tree method, it was possible to decrease 14 km on the Huamantla-Tamanzunchale route, in which they must deliver the orders requested by the customers.

Likewise, and to estimate the fuel consumption in this route, the performance of the trailer of 2.7 and the cost of diesel of $ 12.70 were taken into account. In this sense, according to the calculation of fuel consumption, and using the minimum expansion method, the following is the amount of fuel cost that was reduced on the way out and the return of the Huamantla-Tamanzunchale route:

$$3019.80 - 2954.02 = 65.78(2) = \$\ 131.56$$

Fuel consumption of the route assigned by the company:

$$consumo\ de\ combustible\ en\ litros\ = \frac{642}{2.7} = 237.78\ litros$$

$$costos\ de\ consumo\ de\ combustible\ = \frac{642}{2.7}(\ 12.70) = 3019.80$$

Fuel consumption of the route obtained by the minimum expansion tree method:

$$consumo\ de\ combustible\ en\ litros\ = \frac{628}{2.7} = 232.60\ litros$$

$$costos\ de\ consumo\ de\ combustible\ = \frac{628}{2.7}(\ 12.70) = 2954.02$$

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Application of the transport model by the Vogel method

The present model was based on the demand and supply for one week of the chechi kikis intermediate product (cheese-chile). Specifically, the offer was of 6480 packages and the demand of 5083 packages per week; The data may vary depending on the amount of product that the client required and the costs of moving to their destinations. Figure 11 shows the data collected and calculated on the supply and demand of the mentioned product for a week, as well as the cost that is generated when sending the orders to their respective destinations.

Figura 11. Datos recolectados de una semana para la aplicación del método Vogel

Destinos

Origen	FRESNILLO ZACATECAS (PH) 775 km (PM) 476 km	COMITAN CHIAPAS (PH) 876 km (PM) 1860 km	MORELIA MICHOACAN (PH) 424 km (PM) 853 km	OMETEPEC GUERRERO (PH) 554 km (PM) 1451 km	Oferta	Penalizacion
PLANTA HUAMANTLA	3645	4120	1994	2606	3200	612
PLANTA MONTERREY	2238	8749	4012	6825	1883	1774
Demanda	1282	801	1700	1300	5083 / 5083	
Penalizacion	1407	4629	2018	4219		

Fuente: Comercializadora Gonac (2012)

On the other hand, and because the production capacity of both plants is insufficient to satisfy the demand, supply and demand had to be balanced in figure 11 in order to apply the Vogel method.

Figure 12 shows the solution of the Vogel method through the use of the Win QSB program in order to assign the quantity of products demanded to their respective destinations at the lowest cost. The costs usually vary according to the destinations and types of units that are sent to deliver to customers, so in this model the performance of a trailer of 2.7 and an approximate cost of diesel of $ 12.70 was considered for all destinations.

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Figura 12. Solución del método Vogel aplicando el programa Win QSB

Transportation Tableau for Chechi Kikis Intermedio (queso-chile) - Iteration 1

From \ To	Destination	Destination	Destination	Destination 4	Supply	Dual P(i)
Source 1	3645 200*	4120 Cij=-6036 **	1994 1700	2606 1300	3200	0
Source 2	2238 1082	8749 801	4012	6825	1883	-1407
Demand	1282	801	1700	1300		
Dual P(j)	3645	10156	1994	2606		

Objective Value = 1.693606E+07 (Minimiz

** Entering: Source 1 to Destination 2 *Leaving: Source 1 to Desti

Fuente: Elaboración propia

$$200(3\,645) + 1\,700(1\,994) + 1\,300(2\,606) + 1\,082(2\,238) + 801(8\,749) = 16\,936\,065$$

$$729\,000 + 3\,389\,800 + 3\,387\,800 + 2\,421\,516 + 7\,007\,949 = 16\,936\,065$$

The previous figure shows how both plants must satisfy the demand of the mentioned product so that the costs are minimal, as well as the quantity of products that each of the plants must produce to meet the required demand, which can help to take better decisions.

The following advantages and disadvantages refer to the set of methods mentioned and applied in this article:

Disadvantages

- Only some variables are considered, such as supply, demand, time, distance, cost, destinations for optimization and route programming.
- It is not possible to consider in the model external factors or outside the scope of the company.
- There are not enough programs for the application of these models.
- The changes that companies face.
-

Advantages

- Flexible to program different routes.
- Easy to apply.
- It can be complemented with satellite maps.
- Used in conjunction with a GPS satellite tracking system for each unit.
- The results serve as indicators.
- The models serve as a transport control system.
- Help make better decisions strategically.
- Makes demand satisfied on time.
- Allows the organization and coordination of each unit with its routes or destinations.
- Reduces transport times, costs and distances.
- Models can be controlled and programmed from a cell phone or tablet.

Conclusions

The application of network optimization techniques and transport models allowed to visualize the advantages and disadvantages that are had when programming the different routes. In this sense, it must be foreseen that each of these is different, so the conditions for programming and assigning them vary, since the quantity and volume of the product requested by the client must be taken into account, as well as the time and the distance traveled, because that way you can choose the unit that should move a certain order to its destination, which could reduce costs.

On the other hand, it is worth mentioning that the changes to which companies are exposed make them look for opportunities to reduce operating costs, specifically with regard to transportation.

It must also be accepted that the models used in this work can be improved and adapted, for which other variables must be foreseen that interfere in the transport optimization process. In fact, technology must still be developed for heavy-duty trucks, since today smaller cars are being worked on.

Keep in mind that the transport of inputs is an essential link in the chain of operation of companies, which boosts the economy of any place. In addition, this factor has a significant influence on the pricing of any good or service.

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