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Centro Interdisciplinario de Posgrados

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Escuela de Ingeniería

Maestría en Logística y Dirección de la Cadena de Suministro

Reducción de costos de transporte de producto terminado en la
industria automotriz

Presenta

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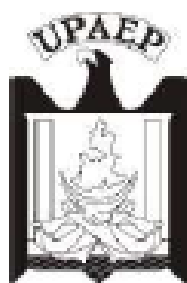
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Se aprueba la Tesina a José Arturo Díaz Méndez:

REDUCCIÓN DE COSTOS DE TRANSPORTE DE PRODUCTO TERMINADO EN LA INDUSTRIA AUTOMOTRIZ

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I. Generalidades

El uso de proveedores 3-PL (logística terciaria) asume un factor muy importante para las empresas: reducción de costos. Anteriormente las manufactureras se encargaban de todo el proceso logístico involucrado en el producto terminado, desde la proveeduría de las materias primas hasta la entrega final con el cliente. Con el paso de los años, las compañías evolucionaron a enfocarse en sus *core-business* y contratar los envíos.

La reducción de costos al contratar proveedores logísticos se da por lo siguiente: las empresas ya no necesitan tener en su nómina a los conductores de los vehículos ni a personal que les dé mantenimiento a estos, por otro lado, se reducen los activos de la empresa y los envíos se pagan directamente de una cuenta de gasto.

Esta investigación se enfoca en una empresa manufacturera que realiza los envíos de productos terminados por medio de 3-PL sin embargo, al comparar su presupuesto vs el pago real a los proveedores no ha habido ninguna reducción de costos, por el contrario estos se han incrementado. El mayor problema recita en que la empresa tiene contratos con diferentes proveedores pero cada uno ofrece diferentes tarifas y capacidades.

El objetivo de esta tesina es desarrollar un modelo de programación lineal basado en métodos de asignación y transporte que indique cómo debe de hacer la manufacturera sus envíos mensuales: cuantos con cada proveedor para poder obtener una reducción de costos.

II. Artículo enviado a revista

REDUCTION OF SHIPPING COSTS OF FINISHED PRODUCTS IN THE AUTOMOTIVE INDUSTRY

Abstract

Nowadays companies use Third-party logistics in order to reduce its costs. The challenge lies on selecting the cheapest supplier combination to continue lowering the costs while still fulfilling the company's needs. The purpose of this research is to design a model for the transportation of finished vehicles of a Mexican manufacturer. The shipments from the factory to the port and vice versa have different suppliers' costs and capacities. This means that the automaker depends on the rates of a third-party. Applying the transport model we developed a continuous solution for the company. The results suggest that by applying the model, the company will optimize the usage of each third-party, thus reducing logistic expenses.

The article draws its conclusions from a custom transport model developed for the company.

Keywords: automotive industry, optimization, transportation model.

1. Introduction

The automobile industry is important to many economies worldwide, and it has been a source of several innovations in product design and manufacturing technologies (e.g., the assembly line, just-in-time inventory, and kan-ban management). It is expected that by 2020, the automotive industry in Mexico will produce about 5 million light vehicles from 13 different brands in more than 30 manufacturing plants. In recent years, the country has evolved from its initial maquila focus to become a powerhouse in the global automotive industry, creating new opportunities for both domestic and international suppliers of components and services, thus contributing to the rapid development of this sector. [1].

The automotive industry is very important for Mexico; it generates 3.5% of its GDP and 19.8% from the manufacturer GDP. It also influences and impacts 23 other industrial sectors of the country. More than 1.5 million jobs are generated by these car manufacturers [2]. In the year 2016 Mexico ranked 8th place in the countries with the highest car production volume, followed by developed economies such as France and UK with 9th and 10th place respectively. The majority of automobiles manufactured in Mexico, are destined for the Americas market. In 2015 approximately 72% of this production was shipped to the US, 10.5% to Canada and 8.2% to Latin America [1].

Many studies focus on production, procurement, or new product development processes rather than finished goods in downstream supply chains [3]. However, after the manufacturing process of the vehicles, the next steps should be as least complex as possible: Deliver to the distributor, take them to the border, the main ports of the country for shipment and export or take them to the dealers, if they are imported. In order to achieve each of these deliveries, a specialized service in the transportation of non-rolling vehicles, through car carrier trailers, plays a key role in the automotive logistics model, becoming a critical factor for competitiveness [4]. In this context, the distribution of vehicles must guarantee delivery timings at a low cost; the current trend is the outsourcing of comprehensive, generally specialized logistics services. The priority of this paper is to optimize the distribution of finished product (vehicles) between factory and port and vice versa.

This research focuses on developing a transportation and assignment model for the finished vehicles of a Mexican manufacturer. The company uses a Third-Party for the import and export logistic activities. The heightened competitive pressure of today's global business environment has forced companies to focus on their core competencies and increasingly outsource business tasks perceived as non-core [5]. Even when using 3PL, this OEM is not focusing on cost and waste reduction. The use of Best Practices in distribution processes could be interpreted as a higher cost for the company, however after a longer period lead times will drop and customer satisfaction will significantly improve [6].

In order to reduce costs, a transport and assignment model was developed. Transport problems generally occur while distributing products from several sources or organizations to many localities or destinations. The target was to find the optimal shipment scheduling system that reduces costs to the minimum [7].

1.1 Problem description

Since the company hired different 3-PL suppliers for the vehicles, the shipping cost per car has not been reduced because each provider has different rates and car carrier capacities. The main problem focuses on the company's decisions; the managers are not considering the supplier's rates and capacities in order to have a potential cost reduction. On the other hand the company's employees seek to have a good lead time and customer satisfaction without taking into account the financial cost of their criteria.

Based on internal performance tracking data, on average, the current shipping process wastes 20% of costs versus the assigned budget when the company took the decision of hiring 3-PLs. Considering the annual volume production a solution was proposed: designing a transportation and assignment model that could determine the cheapest weekly shipments.

For this specific model, two different destinations and nine logistic suppliers were considered. Suppliers A to I can ship vehicles from the port to the factory, but only suppliers A, B and C have the availability to ship units to the port. As shown in the next image.

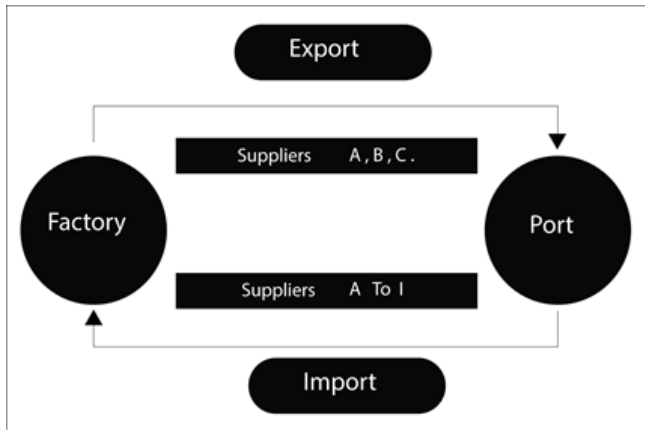


Fig. 1 Suppliers and destinations

Also, one of the main restrictions in the model is that only 80% of the round shipments from suppliers A and B have a discount price, but C supplier has the same offer for only 20% of its trips. The central point of the model is to find the ideal combination of each supplier.

The highest percentage of shipments of the company is between the factory and the port, but also vehicles are sent to the country's borders. The biggest benefit to the manufacturer is that the model will also work for different destinations.

2. Tools and Methods

2.1 Model design

A linear programming model was considered to calculate the supplier's freights required in each week. In the case of minimizing costs (maximizing rewards), approximate linear programming offers a lower (upper) bound on the optimal long-run costs (rewards). Upper (lower) bounds can be generated fairly easily by simulation of any policy. Therefore, there is a possibility of identifying from the approximate linear programming solution whether the chosen linear architecture is satisfactory or further refinements may lead to substantial improvement in performance. [8].

A linear programming model for goods transportation has the following benefits:

- a) Environmental benefits.

- b) Economic benefits.
- c) Transportation system enhancement.
- d) Management benefits.
- e) Operations improvement.
- f) Better lead time

The mathematical transportation model using a linear programming is described as follows [9]:

- a) A set of m origins.
- b) A set of n destinations.
- c) A cost variable C_{ij} of transportation from an origin i to a destination j .

		Destinations					Supply
		1	2	3	...	j	
Origins	1	C_{11}	C_{12}	C_{13}	...	C_{1j}	b_1
	2	C_{21}	C_{22}	C_{23}	...	C_{2j}	b_2
	3	C_{31}	C_{32}	C_{33}	...	C_{3j}	b_2
	.				.		
	.				.		
	i	C_{i1}	C_{i2}	C_{i3}	...	C_{ij}	b_i
Demand		a_1	a_2	a_3	...	a_j	

Fig. 2 Cost matrix

The general formulation of this assignment problem is then [10].

$\{1, 2, \dots, I\} \mid I \in \mathbb{Z}^+$ set of origins

$\{1, 2, \dots, J\} \mid J \in \mathbb{Z}^+$ set of destinations

a_j = quantity of units required by the destination j .

b_i = quantity of units available in the destination i .

x_{ij} = quantity unites transported from an origin i to a destination j .

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

$$\sum_{i=1}^I x_{ij} = a_j \quad \forall j \quad (2)$$

$$\sum_{j=1}^J x_{ij} \leq b_i \quad \forall i \quad (3)$$

$$x_{ij} \in Z^+ \quad (4)$$

Equation 1 minimizes transport costs from origin i to destination j , equation 2 indicates that everything that is sent from origin i to destination j must be equal to the demand of destination j , and equation 3 that all that shipment from a origin must be less than or equal to the capacity of the origin i .

2.2 Case implementation

According to the approach of the problem in previous paragraphs, the development of the model for the solution of the problem is as follows:

a) Problem statement.

Supplier / Destination	Factory-Port \$	Port-Factory \$	Supplier vehicle transportation capacity
A	19,327	19,327	4,704
A'		5,437	80% A capacity utilization from Factory to Port
B	18,693	18,693	1,568
B'		5,258	80% B capacity utilization from Factory to Port
C	19,805	19,805	1,960
C'		5,864	20% C capacity utilization from Factory to Port
D		19,827	441
E		19,915	294
F		21,427	220
G		19,186	147
H		20,412	220
I		21,679	367
Weekly vehicle demand	2,418	2,636	

Table I. Problem statement according to the transportation model

b) Mathematical formulation

$\{1,2,\dots,I\} \ I \in \mathbb{Z}^+$ set of suppliers

$\{1,2,\dots,J\} \ J \in \mathbb{Z}^+$ set of destinations

a_j = quantity of required trailers to satisfy the demand in the J destination.

b_i = quantity of available trailers from the supplier i .

x_{ij} = quantity of trailers from the supplier i to the destination j .

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

$$\sum_{i=1}^I x_{ij} = a_j \quad \forall j \quad (2)$$

$$\sum_{j=1}^J x_{ij} \leq b_i \quad \forall i \quad (3)$$

$$x_{ij} \in \mathbb{Z}^+ \quad (4)$$

3. Results

Once we had a model that could fit the company's requirements, the results were compared to the shipments made in the first semester of the year 2016. Although some variables were not considered in the model because they could affect the final results, the logistics expenses can be reduced up to 20%. This percentage was calculating the payments per month versus the model results. The comparison not only showed that the company could reduce its logistics expenses, but it also demonstrated some potential within in the company (e.g. negotiation capacity).

Comparing the first three months of 2016 versus the payments made by the company, the model results would reduce 20% the costs.

Supplier / Destination	Actual shipments		Model results	
	Factory- Port (Units)	Port-Factory (Units)	Factory- Port (Units)	Port-Factory (Units)
A	600	770	850	
A'		415		637
B	618	356	1,568	822
B'		344		1,176
C	1,200			
C'				
D		441		
E		200		
F				
G		100		
H				
I		10		
January week demand	2,418	2,636	2,418	2,636
Total cost	4,188,792	3,853,686	4,083,801	2,382,584

Table II. Problem statement according to the transportation model

Month	Cost reduction %
January	24
February	25
March	21
Average	23

Table III. Cost reduction using the model's results

By using the model each month, we conclude that it could reduce the costs up to 20%. On the other hand the model showed the following improvement potentials in the shipping process:

- a) Negotiating cheaper shipping costs
- b) Increase of suppliers capacities
- c) Better decision taking

Having the model to thank for, the operative and logistics areas of the company realized how much money their decisions were costing. The model is intended to be applied as of January 1st 2017 in order to immediately report savings by comparing each month to the previously forecasted month. The results obtained demonstrate that it is not only a question of hiring a 3-PL, the cost reduction is achieved when the supplier's costs are taken into account and the manufacturer prioritizes based on that information.

As mentioned before, the factory to port shipments are the highest percentage for the company, but also vehicles are sent to different borders. The positive result found that this model can also be implemented for the other destinations. For this reason the manufacturer realized the importance of applying linear programming principles for its main activities.

4. Discussion

As customers become increasingly integrated in the supply chain, the need to respond more rapidly to varied and often-changing customer demand requires the flow of the supply chain to be increasingly time sensitive. Companies have concentrated not only on their production capacity but also on their inventory capacity. In achieving cost reductions by fleet management and by reorganizing transport networks, supply chain directors have rationalized supply chains by reducing the number of warehouses and by outsourcing specific transport activities. Co-operation between various transporters and shippers is optimizing the use of, and thereby reducing the number of warehouses in most metropolitan areas in OECD countries [11].

5. References

- [1] “LA INDUSTRIA AUTOMOTRIZ MEXICANA: SITUACIÓN ACTUAL, RETOS Y OPORTUNIDADES” [online], ProMéxico, México 2016 [ref. may 2017], Available at: < <http://www.promexico.mx/documentos/biblioteca/la-industria-automotriz-mexicana.pdf>>
- [2] “Diálogo con la Industria Automotriz 2012 - 2018. Propuestas para la Agenda Automotriz 2012 – 2018” [online], Asociación Mexicana de Distribuidores de Automotores [ref. may 2017], Available at: http://www.amda.mx/images/stories/Analisis/asociaciones_2012-2018_121210.pdf
- [3] Hu, Z.-H., Zhao, Y., & Tao, S. “Finished-vehicle transporter routing problem solved by loading pattern discovery”, Springer, January 2015, DOI 10.1007/s10479-014-1777-1.
- [4] Segura, R. “Las “madrinas”, claves en el proceso logístico de la industria automotriz”, Revista TRANSPORTES Y TURISMO, December 2014, Available at: < <http://tyt.com.mx/reportajes/las-madrinas-claves-en-el-proceso-logistico-de-la-industria-automotriz/>>
- [5] Zacharia, Z. G., Sanders, N. R., & Nix, N. W. “The Emerging Role of the Third-Party Logistics Provider (3PL) as an Orchestrator”, Journal of Business Logistics, 2011, 32(1): 40–54.

- [6] Díaz Gómez, H. B., García Cáceres, R. G., & Porcell N. "Las PyMES: costos en la cadena de abastecimiento", Revista Escuela de Administración de Negocios No. 63, May- August 2008 p.5-22.
- [7] Munguía Ulloa, L., & Protti Quesada, M. A. "Investigación de operaciones", EDITORIAL UNIVERSIDAD ESTATAL A DISTANCIA, 2005.
- [8] Farias, D. P. "THE LINEAR PROGRAMMING APPROACH TO APPROXIMATE DYNAMIC PROGRAMMING: THEORY AND APPLICATION", ProQuest, June 2012, UMI Number. 3048515.
- [9] ELsiddigIdriss , M. I., & ElfarazdagMahjoub , H. M. "Application of Linear Programming (Assignment Model)", International Journal of Science and Research (IJSR), 2013, ISSN (Online): 2319-7064.
- [10] Hillier, F. S., & Lieberman, G. J. "Introducción a la investigación de operaciones" , Mc Graw Hill, 2010.
- [11] "Delivering the Goods: 21st CENTURY CHALLENGES TO URBAN GOODS TRANSPORT", [online], 2013, ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, OECD available at: < http://www.oecd-ilibrary.org/transport/delivering-the-goods_9789264102828-en>

III. Trabajo futuro

En el modelo actual no consideramos ciertas variables que pudieran hacer ruido en este como: la duración del viaje, tiempo de carga de la nodriza y tiempo de espera en los garajes de autos.

Estas restricciones se evitaron para obtener los resultados más precisos en cuantos a la reducción de costos; el objetivo de dicha investigación.

Para posteriores futuros e investigaciones se recomienda tomar en cuenta dichas variables para poder hacer otra comparación entre los envíos de los meses anteriores vs los resultados del modelo.

IV. Anexos

Acuse de envío a revista