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Research Article **EAI.EU**

A proposal for the supply chain design: A digitization approach

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Abstract

The logistics network of an automotive company in Mexico, was analyzed to propose a better logistics network in the country to improve delivery times to customers. The network design considers elements of digitization of Greenfield Analysis and Network Optimization processes. Taking into account the information given by the company, it was possible to obtain optimal scenarios for better operation, which involved the construction of distribution centers throughout Mexico.

Received on 11 April 2020; accepted on 16 April 2020; published on 27 April 2020

Keywords: Supply chain digitization, ERPs, big data, digital twins, supply chain management.

doi:10.4108/eai.13-7-2018.164112

1. Introduction

The globalization level reached in today's World must go in hand with an infrastructure that is capable of satisfying all markets. In this case, we are talking about Supply Chain [1]. This topic has evolved by using tools to face the most challenging organizational problems [2]. Supply Chain global companies face many more challenges tan small supply chain companies since there are more and more complex planning and control variables [3–5]. For example, they need to consider sustainability, balance economics, environmental care, and social issues, such as creating strong job positions for the population [6]. Some companies can invest resources for including in their supply chain, environment-friendly steps such as renewable energies, or recycling processes [3]. Today, organizations seek for all these concepts because they know they add value to their brands.

However, they must also control the production process, to achieve this, organizations must also control the required amount of raw material, minimize their waiting periods - both during production and final delivery – control their manufacturing material planning processes. Besides, the manufacturing plant location must have the best suitable conditions for optimal communication and transportation to final destinations. This way, the supply chain planning is supported by several platforms that offer models that analyze assorted variables and transform the supply chain into a more cost-effective and efficient process.

By developing these platforms and using assorted variables, it is not only possible to geographically know in which exact point it is most optimal to build a manufacturing plant taking into account communication routs or trained workforce or to know if there are distribution centers nearby. These are some very important variables to think of upon planning a supply chain. Make blind decisions would be very expensive for organizations. It's critical to have a Software that provides data for making decisions on this basis. Obviously, it is not an easy task to integrate so many variables, but it's worth it if you want the supply chain to succeed.

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2. Literature review

Top executives must understand this planning process for transmitting it to the whole organization, and this means that the proper management of each supply chain link will allow the smooth operation of the methods. Even selecting suppliers should be as per the objectives of the organization so to meet the established timing and quality standards as well, and for them to adjust appropriately. Let's say, for example; they should meet the minimum delivery amounts or a given period of time; this way, the organization assures smooth logistics.

The sustainability concept has been increasing during the last years. Besides the concern of having proper logistics planning, the whole supply chain should include sustainability in its processes to increasingly reduce the manufacturing CO2 emissions. It is clear that polluting emissions do not come only from manufacturing processes but also from means of transportation, and that is why the transportation network within the supply chain must include a strategy aimed at controlling polluting emissions [7]. There must be multi-disciplinary teams forming new supply chains since the economic, financial, environmental, and social aspects must be taken into consideration.

There must be an optimal product moving process from the outset point up to the sales point: this is, the planned logistics must meet in good time and proper form the production of goods, as well as the delivery thereof.

To achieve proper production planning, it is critical to developing demand forecasts, so this way, you can control production with the right amount of waw material, equipment, workforce, etc. These variables must be calculated appropriately since they highly impact on the organizations´expenses, and not having a clear view of the demand forecast might lead the company to a shady path.

There are models developed before 1990 for supporting supply chain management that analyzed and provided the organizations with the best expense, tax, and fare-minimization options. Later on, models were exchange-rate variability-focused [8]. Therefore, since it is an international business, the economy has a significant role to play because it impacts the supply chain prices, costs, and expenses in the production Country, as well as in those Countries where organizations want to export their products to. There are some models providing customers with this analysis, such a Hodder and Dincer, which includes the financial impact derived from the Government subsidy and tax reduction, thus allowing a correlation between the changes in prices within the global markets [8].

There are even other models such as the Breitman and Lucas´ which allows studying the manufacturing plant location, the production amount, the required quantity of raw material, and the introduction of new products into the market.

Supply chain models need to involve more than the geographic location of manufacturing plants, but also their internal and external flow, as well as optimum suppliers who meet the sustainability organization's objectives, and the internal handling of material in each process [9].

Supply chains must expand their variables to respond to the needs of today's globalization in which we are immersed; this is the reason why they need to address alternative, trustable objectives flexibly by calculating operation costs and assets [9, 10]. Also, the ideal thing is there were multi-level production and distribution analysis due to the large amount of data required for analyzing supply chains. Many current models just address the supply chain first stage, neglecting other steps, such as performance and supplier selection [11–13]. Most companies seek for proper supply chain planning, finding accuracy and ethical management in each stage for preventing unnecessary expenses, avoidable delays, etc.; this is because, more often than not, companies don't own the facilities where they produce. Therefore, the supply chain mus control the variables involved must; for example, determine the minimum order quantities per supplier, plus budgetary restrictions, number of suppliers, geographical preferences, and capacities. Besides, these models should have objectives and constraints for assessing the impact quality, lead times, and service level. This last concept, service level, is one of the organizations' most wanted. Customer satisfaction is guaranteed by having a proper supply chain.

3. Supply Chain Design

For this study the data used were scaled by a factor to not disclose confidential company information. Therefore, the information presented does not correspond to reserved information.

For this project, 50,843.00 data on vehicle demand; were collected; which were divided into 3 different origins: Non-North America (Product 1, Product 2, Product 3, Product 4, Product 5), North America (Product 6, Product 7, Product 8, Product 9, Product 10, Product 11, Product 12, Product 13, Product 14, Product 15 and Product 16) and Mexico) Product 17, Product 18, Product 19 and Product 20). This project will only focus on vehicles from Non-North American origin; which reduces the database to 25,696.00 vehicles, with 5 lines of vehicles divided in the following way (see Table 1):

Table 1. Sales 2018.

Vehicle line	Units 2018 non North America (NNA)	Assignment Percentage
PRODUCT 1	2,757	10.73
PRODUCT 2	3,085	12.01
PRODUCT 3	14,230	55.38
PRODUCT 4	3,469	13.50
PRODUCT 5	2,155	8.39
TOTAL	**25,696**	**100**

Table 2. The database headers.

Vehicle key: VIN8
Retail Distributor
Catalogue
Wholesale Distributor
Vehicle line
Wholesale city
Retail city
State
Payment date
Release date
Date of production
Wholesale invoice date
Retail invoice date

For the analysis, the following information (Table 2) provided by the company per vehicle unit was considered:

The information provided goes from january 2018 to October 2018, from which the monthly historical demand by distributor was obtained.

Table 3. Percentage of allocation by city.

Ranking	City	%	Accumulated
1	Mexico city	24%	24%
2	Guadalajara	14%	38%
3	Chihuahua	5%	43%
4	Monterrey	4%	47%
5	Mérida	3%	51%
6	Puebla	3%	54%
7	Cancún	3%	57%
8	Hermosillo	2%	59%
9	León	2%	61%
10	Queretaro	2%	63%
11	Saltillo	2%	65%
12	Villahermosa	2%	67%
13	Irapuato	2%	68%
14	Culiacán	2%	70%
15	Cuernavaca	1%	71%
16	Mexicali	1%	73%
17	Cd Obregón	1%	74%
18	Veracruz	1%	75%
19	La Paz	1%	76%
20	Cd. Juárez	1%	78%
21	San Luis Potosí	1%	79%
22	Resto de las ciudades	21%	100%

4. Data analysis

4.1. Percentage of allocation of sales by city

When performing an analysis of the database it was obtained that 79% of sales of vehicles was held in 21 cities and the 21% remaining is divided into the other 42 cities (See Table 3 and Figure 1).

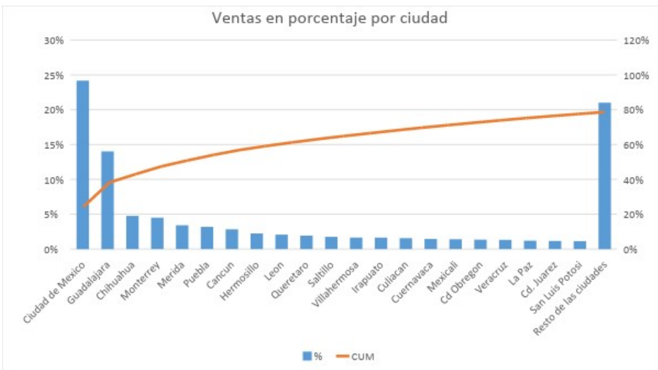

Figure 1. Dealers automotive company

4.2. Assignment of cases

Based on the concern of the automotive company, the cases were classified as follows:

Success: It is considered success when units were ordered and sold at the same distributor in less than 45 days

- Error #1: Units that were ordered and sold at the same distributor, but the 45 days credit were overcome.
- Error #2: Units that were ordered and sold at different distributors in the same city, but did the 45 days credit were not exceed.

- Error #3: Units that were ordered and sold at different distributors in the same city, but the 45 days credit were overcome.
- Error #4: Units that were ordered and sold at different distributors in different cities, but not exceeding from the 45 days of credit.
- Error #5: Units that were ordered and sold at different distributors in different cities, but the 45 days of credit were overcome.

Errors 3, 4 and 5 are considered as the most serious, since they involve overcoming the 45 days of credit and some kind of exchange (see Table 4):

Table 4, it can be further enhanced that 32.37% of the units are ordered and sold at the same distributor, without exceeding the 45 days credit. In the same way, it stands out that the most disturbing errors (3, 4 and 5) add up to 28.68%, which could be dramatically reduced if there was a centralized distribution facility, with an optimal location and distribution network. By using the cost information provided by automotive company and the information obtained in the previous table, the approximate cost that might be caused to the company in 2019 with the same distribution network is calculated. (68,636*26.25%)*$141=$2,516,195.76 Being:

- The number of forecasted sales units in 2019 = 68,636
- The cumulative percentage of error 4 and 5 = 26.25%
- The average transport cost ($) = $141
  By eliminating such errors, the automotive company and its distributors might save approximately $2,516,195.76 usd. It is believed that by having a centralized distribution facility the other types of errors will decrease since distributors will have a higher turnover of inventory.

4.3. Sales forecast

The database was used to obtain the percentage of allocation of vehicles from each of the distributors and with the prognosis of vehicle sales, the number of units by vehicle line estimated for each of the distributors to sell through 2019 was obtained (Table 5 and Table 6). The table in percentage of allocation is presented in table 3 and table 7 Information provided by the automotive company.

4.4. Additional information

Time in Product 5: Since the billing and delivery to the distributor dates are available, the average time in days that the automotive company takes to deliver a vehicle in their different points of sale throughout the country was calculated. The average number of days in Product 5 from wholesale billing to delivery to the distributor was calculated in 8.6 days. This retrieved data will be used as a before and after comparison with the results of the Greenfield Analysis and Network Optimization.

Average sale days: With the analysis performed it was verified that the average number of days that it takes to sell vehicle is 101 days, this data meets the information given by the automotive company.

5. Mathematical Model

The following analysis aims to define the ideal location for the new production plant, taking into account the place where each of the customers is located and their demands. It is based on the following mathematical method.

$$C_x = \frac{\sum_i d_{ix} w_i}{\sum_i w_i} \quad (1)$$

$$C_y = \frac{\sum_i d_{iy} w_i}{\sum_i w_i} \quad (2)$$

Where:
$d_i x = x$ coordinate of the locality i
$d_i y = y$ coordinate of the locality i
w_i= volumen for the locality i

One of the main features of AnyLogistix (ALX) is that it takes into account actual strokes of distances from one point to another. In the same way, it considers suitable transport roads. By using the mathematical method, only coordinates are considered, but not actual distances or roads [14].

6. Software Used

AnyLogistix (ALX) is a specialized software that serves to address a wide range of supply chain management (SCM) issues, see figure 2. Decision making in supply chain management involves the use of quantitative methods, which normally are typically based on optimization or simulation. ALX allows finding appropriate locations and characteristics of the site through the optimization of the network, taking into account demands, capabilities, seasonality, types of products, customer locations, roads, fixed costs and variable and inventories. The above helps to make an informed decision based on costs, revenue, service levels, utilization rates and other parameters used in supply chain.

On the other hand, an analysis on how efficient the current distribution network is may be performed and verify if it is reasonable to reset, by opening additional stores or closing any existing. A simulation model of ALX allows capturing the randomness in the behavior

Table 4. Success and error table.

	$P = V$	$P \neq V$	<45 days	>45 days	Same City	Different City		Percentage
Success	X		X				G	32.37%
Error #1	X			X			Y	37.01%
Error #2		X	X		X		Y	1.94%
Error #3		X		X	X		R	2.43%
Error #4		X	X			X	R	9.82%
Error #5		X		X		X	R	16.43%

Table 5. Sales forecast 2019.

Vehicle line	**Sales**
Product 3	19,597
Product 1	4,181
Product 2	3,998
Product 4	11,135
Product 5	4,586
Total	**43,497**

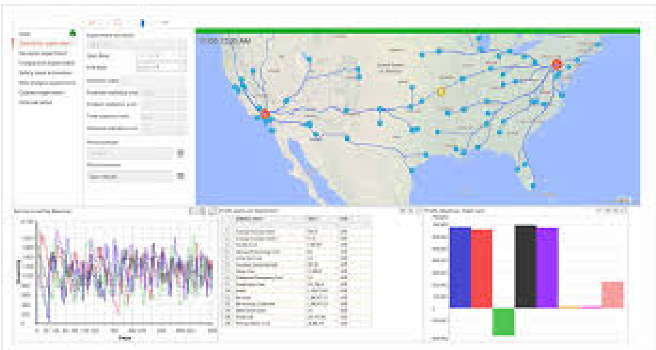

Figure 2. AnyLogistix Software

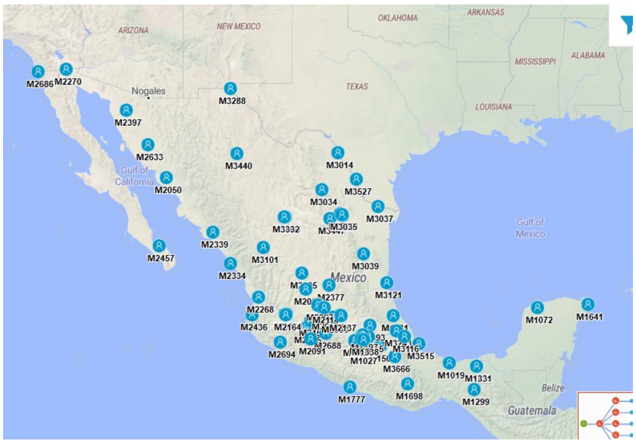

Figure 3. Dealers automotive company

of the elements of the chain and enables the evaluation of risks. Also, how the parameters change over time may be assessed; thus identifying cause and effect in network dependencies. ALX combines analytical methods of optimization with simulation in order to have a much deeper analysis. An optimization model describes a network based on the flow of product between locations. In a simulation model, the effect that each variable has within the system may be seen; which gives the possibility to dynamically change parameters during the experiment and to analyze their impact. A simulation does not produce an optimal solution from different combinations, but allows to study in a comprehensive manner particular dynamic scenarios and interdependencies of the supply chain. If more details are considered, then more opportunities to find improvements are created.

7. Location analysis

Several Greenfield Analysis scenarios were performed to obtain the optimal location for the distribution centers, which required the following information. Eighty three distributors and one supplier were taken into account, which in this case is the Port of Veracruz, since those are Non- North America vehicles. Figures 5, 6 and 7.

7.1. Historical data

As enough data were available, it was decided to use the historical demand from January to September, since the information from October did not cover the entire month and also, some of the sales information of the distributors was missing.

7.2. Population index

One of the advantages of the software is that it has an option to perform experiments with population density. Therefore, by conducting a comparison between the population data from INEGI and the figure 1 and 4 of vehicle sales by state, it is possible to observe that for greater population densities, there will be higher vehicle sales.

Table 6. Sales forecast per vehicle by distributor

Distributor Name	Product 1	Product 2	Product 3	Product 4	Product 5	Total
Productos Automotrices	4	7	116	14	7	148
Country Americas	9	16	97	24	11	157
Automovilistica Andrade	2	3	174	7	1	188
CDA Peninsula	4	5	88	7	1	105
Jimenez Automotriz	3	3	54	1	1	62
CDA Peninsula (Suc. Cancun)	7	4	77	24	1	113
Jalisco Motors	7	10	214	23	5	260
Plasencia Guadalajara	3	3	118	10	7	141
Autos de Hermosillo	7	6	142	11	4	169
Centro Automotriz Vallarta	4	5	195	13	2	219
Sanchez Automotriz	2	3	34	18	2	59
Automotores Coahuilenses	3	5	106	15	1	130
Tabasco Automovilistica	7	8	92	20	2	128
Autos SS de Irapuato	3	5	51	14	1	73
Alden Condesa	5	3	168	12	3	191
Surman Mexico	2	2	64	12	2	82
Autos y Tractores de Culiacan	3	3	42	11	0	59
Car One Valle	0	1	14	3	1	20
Autos y Accesorios	8	5	81	5	114	213
Motores de Morelos	5	5	63	7	0	79
Automotriz del Valle de Baja California	3	2	76	12	3	97
Rivera	5	12	193	46	10	266
Gema Automotores	7	7	165	34	7	220
Zapata	5	4	106	26	3	145
Automotriz Monterrey	4	4	110	26	3	148
Dinastia Automotriz Mexico	4	5	156	43	1	208
Automotriz Baja Cal	4	6	210	14	2	235
Dinastia Automotriz Oaxaca	3	2	127	16	1	150
ACASA PERINORTE	5	8	79	8	3	102
Jacobo Rodriguez Motors Piedras Negras	2	7	112	23	22	165
Alden Juárez	4	3	58	29	1	95
Zapata (Suc. Pachuca)	18	7	418	30	4	476
Autos SS de Leon	14	12	347	37	9	418
Automotriz Jalbra	1	2	70	26	4	102
Autos SS de San Luis Potosi	9	5	255	21	6	297
SURMAN BC	4	3	80	3	2	93
Superservicio	5	3	66	17	3	94
Country Aguascalientes	5	4	103	20	3	136
Gimsa Automotriz	17	17	502	49	6	591
Distribuidores de Autocamiones de Chiapas	4	6	82	9	1	101
Rivera (Suc. Angelópolis)	4	5	127	14	9	159
Vehiculos y Servicios Satelite	7	7	110	24	2	151
Leon Automotriz	3	4	64	14	1	87
Automotores Cumbres	7	7	82	26	1	124
Mylsa Queretaro	4	6	98	3	1	112
Cambher Torreon	6	9	138	30	1	184
Montes Queretaro	7	6	118	12	0	144
Autocamiones de Tapachula	5	4	97	2	1	110
Lomas Automotriz	3	5	151	13	1	173
Automotriz Elfer	10	7	367	27	4	414

7.3. Products

As mentioned above, the following lines of vehicles will be used:

8. Results

The following results were obtained:

Since the software has geolocation, it is possible to locate the exact coordinates from the distributors.

By using the database above mentioned, the program gave a result of a distribution center at latitude 19.96 and longitude -98.29 coordinates, which correspond to the state of Hidalgo

Figure 8 shows the distributors, the located distribution center and the provider that is the Port of Veracruz.

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Distributor Name	Product 1	Product 2	Product 3	Product 4	Product 5	Total
CAMSA	3	5	40	15	1	64
Picacho Automotriz	5	7	449	42	4	507
Ecatepec	5	3	112	17	3	140
Gimsa Automotriz (Suc. Los Reyes)	7	7	87	1	5	107
Plasencia Mazatlan	5	5	86	19	2	117
Cavsa Colima Automotriz	4	4	84	8	0	100
Alden Tlalpan	10	8	129	17	6	170
CEVER DURANGO	3	5	53	10	3	74
Dimotors Coatzacoalcos	5	6	96	15	1	123
Centro Automotriz de la Laguna	2	2	48	8	1	60
Vista Hermosa Laredo Motors	4	8	79	9	3	104
Autos de Calidad de Zacatecas	2	2	51	8	1	64
Motores de Guerrero	9	8	342	28	4	392
Cever Azcapotzalco	4	4	91	12	1	113
Distribuidora Regional	1	2	92	5	0	101
MYLSA (Suc. La Villa)	9	13	526	77	7	632
Automovilistica Andrade (Suc.Tepepan)	1	2	48	14	1	66
Automotriz Monclova	3	4	49	12	1	70
Plasencia Puerto Vallarta	14	5	113	16	7	155
Automotriz Reynosa	4	7	108	13	3	135
Jimenez	9	7	183	27	13	239
Ravisa Motors	3	3	49	8	0	63
Automotriz del Valle de Zamora	5	3	154	10	0	172
Zapata (Suc. Aeropuerto)	2	2	35	10	1	50
Rangel de Alba	4	5	101	24	4	139
Super Autos Jalapa	5	13	147	29	4	198
Automotriz Victoria	8	10	184	46	1	249
Auto Comercial Santa Fe	3	2	43	6	1	55
Plasencia de Nayarit	2	3	25	11	1	43
Mylsa Tehuacan	5	7	106	8	4	131
Vehiculos Automotrices de La Piedad	5	4	84	7	1	100
Vehiculos de Teziutlan	7	11	88	10	12	128
Superservicio Autos del Golfo	3	3	40	9	2	58
Automoviles de Caborca	8	7	78	19	3	114
Total	440	471	10655	1476	378	13420

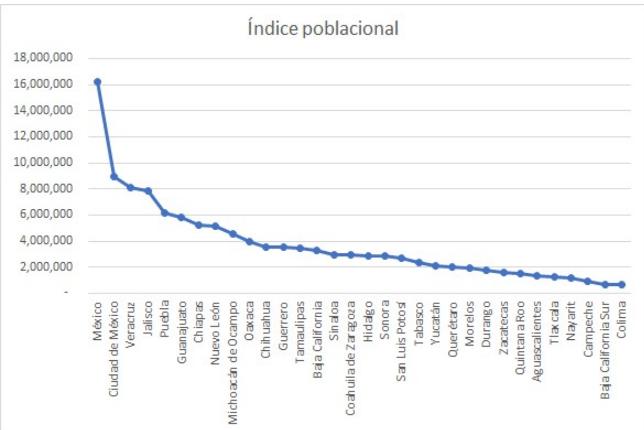

Figure 4. Dealers

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9. Conclusions

After analyzing the case study shown in this work, the digitization process of the supply chain is shown. The use of automated tools that allow the development of digital twins such as ALX, work as a support in the decision making of network design. Enablers of the digital supply chain such as agility, flexibility, real-time data exchange, are used to solve the problem of the company under study.

Acknowledgement. This research was partially supported by Universidad Anahuac Mexico-Universidad Panamericana Mexico.

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Table 7. Percentage of allocation per vehicle line by distributor.

Distributor	Product 1	Product 2	Product 3	Product 4 CREW	Product 5	Grand Total
ACASA PERINORTE	0.11%	0.18%	0.60%	0.13%	0.15%	1.16%
Alden Condesa	0.22%	0.40%	0.51%	0.22%	0.23%	1.58%
Alden Juárez	0.06%	0.07%	0.91%	0.07%	0.02%	1.13%
Alden Tlalpan	0.11%	0.12%	0.46%	0.07%	0.02%	0.77%
Auto Comercial Santa Fe	0.07%	0.07%	0.28%	0.01%	0.02%	0.45%
Autocamiones de Tapachula	0.16%	0.11%	0.40%	0.22%	0.01%	0.91%
Automotores Coahuilenses	0.18%	0.25%	1.11%	0.21%	0.12%	1.86%
Automotores Cumbres	0.07%	0.09%	0.61%	0.09%	0.16%	1.02%
Automotriz Baja Cal	0.17%	0.15%	0.74%	0.11%	0.08%	1.24%
Automotriz del Valle de Baja California	0.11%	0.14%	1.01%	0.12%	0.04%	1.41%
Automotriz del Valle de Zamora	0.05%	0.07%	0.18%	0.17%	0.04%	0.50%
Automotriz Elfer	0.08%	0.12%	0.55%	0.14%	0.01%	0.90%
Automotriz Jalbra	0.17%	0.19%	0.48%	0.18%	0.04%	1.06%
Automotriz Monclova	0.07%	0.12%	0.26%	0.13%	0.02%	0.60%
Automotriz Monterrey	0.12%	0.07%	0.87%	0.11%	0.07%	1.25%
Automotriz Reynosa	0.04%	0.06%	0.33%	0.11%	0.05%	0.59%
Automotriz Victoria	0.07%	0.08%	0.22%	0.10%	0.00%	0.47%
Automóviles de Caborca	0.00%	0.03%	0.07%	0.03%	0.02%	0.16%
Automovilistica Andrade	0.20%	0.14%	0.42%	0.04%	2.53%	3.33%
Automovilistica Andrade (Suc.Tepepan)	0.11%	0.12%	0.33%	0.06%	0.01%	0.63%
Autos de Calidad de Zacatecas	0.07%	0.05%	0.40%	0.11%	0.07%	0.70%
Autos de Hermosillo	0.11%	0.30%	1.00%	0.42%	0.22%	2.06%
Autos SS de Irapuato	0.18%	0.18%	0.86%	0.31%	0.15%	1.67%
Autos SS de León	0.12%	0.11%	0.55%	0.24%	0.07%	1.10%
Autos SS de San Luis Potosí	0.11%	0.11%	0.57%	0.24%	0.07%	1.09%
Autos y Accesorios	0.09%	0.13%	0.81%	0.39%	0.03%	1.44%
Autos y Tractores de Culiacán	0.10%	0.14%	1.09%	0.12%	0.04%	1.50%
Cambher Torreón	0.07%	0.05%	0.66%	0.15%	0.02%	0.96%
CAMSA	0.12%	0.21%	0.41%	0.07%	0.06%	0.88%
Car One Valle	0.06%	0.18%	0.58%	0.21%	0.48%	1.51%
Cavsa Colima Automotriz	0.11%	0.07%	0.30%	0.26%	0.02%	0.76%
CDA Peninsula	0.43%	0.18%	2.17%	0.28%	0.08%	3.13%
CDA Peninsula (Suc. Cancun)	0.34%	0.30%	1.80%	0.33%	0.19%	2.97%
Centro Automotriz de la Laguna	0.02%	0.04%	0.36%	0.24%	0.09%	0.75%
Centro Automotriz Vallarta	0.22%	0.13%	1.33%	0.19%	0.13%	2.01%
Cever Azcapotzalco	0.11%	0.09%	0.42%	0.03%	0.04%	0.68%
CEVER DURANGO	0.13%	0.08%	0.34%	0.15%	0.06%	0.76%
Country Aguascalientes	0.13%	0.11%	0.54%	0.18%	0.07%	1.03%
Country Americas	0.42%	0.42%	2.61%	0.45%	0.12%	4.03%
Dimotors Coatzacoalcos	0.10%	0.14%	0.42%	0.08%	0.02%	0.77%
Dinastia Automotriz Mexico	0.09%	0.14%	0.66%	0.13%	0.20%	1.22%
Dinastia Automotriz Oaxaca	0.17%	0.18%	0.57%	0.22%	0.05%	1.20%
Distribuidora Regional	0.08%	0.11%	0.33%	0.13%	0.02%	0.67%
Distribuidores de Autocamiones de Chiapas	0.18%	0.19%	0.43%	0.24%	0.02%	1.05%
Ecatepec	0.10%	0.16%	0.51%	0.03%	0.02%	0.81%
Gema Automotores	0.14%	0.23%	0.72%	0.28%	0.02%	1.39%
Gimsa Automotriz	0.17%	0.16%	0.61%	0.11%	0.00%	1.05%
Gimsa Automotriz (Suc. Los Reyes)	0.13%	0.11%	0.51%	0.02%	0.03%	0.79%
Jacobo Rodriguez Motors Piedras Negras	0.06%	0.14%	0.78%	0.12%	0.02%	1.13%
Jalisco Motors	0.23%	0.19%	1.91%	0.25%	0.09%	2.66%
Jimenez	0.07%	0.14%	0.21%	0.14%	0.02%	0.57%
Jimenez Automotriz	0.12%	0.19%	2.33%	0.38%	0.09%	3.11%
Leon Automotriz	0.12%	0.08%	0.58%	0.16%	0.07%	1.01%
Lomas Automotriz	0.18%	0.18%	0.45%	0.01%	0.11%	0.91%
Montes Queretaro	0.12%	0.13%	0.45%	0.17%	0.05%	0.93%
Motores de Guerrero	0.09%	0.10%	0.44%	0.07%	0.00%	0.70%
Motores de Morelos	0.25%	0.20%	0.67%	0.16%	0.12%	1.40%
MYLSA (Suc. La Villa)	0.08%	0.13%	0.28%	0.09%	0.06%	0.63%

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Distributor	Product 1	Product 2	Product 3	Product 4 CREW	Product 5	Grand Total
Mylsa Querétaro	0.13%	0.15%	0.50%	0.14%	0.02%	0.94%
Mylsa Tehuacan	0.05%	0.05%	0.25%	0.07%	0.02%	0.44%
Picacho Automotriz	0.11%	0.19%	0.41%	0.09%	0.07%	0.88%
Plasencia de Nayarit	0.05%	0.05%	0.26%	0.07%	0.01%	0.45%
Plasencia Guadalajara	0.23%	0.21%	1.78%	0.26%	0.09%	2.56%
Plasencia Mazatlan	0.09%	0.11%	0.47%	0.11%	0.03%	0.81%
Plasencia Puerto Vallarta	0.04%	0.04%	0.48%	0.05%	0.01%	0.61%
Productos Automotrices	0.22%	0.34%	2.73%	0.70%	0.15%	4.15%
Rangel de Alba	0.04%	0.06%	0.25%	0.13%	0.02%	0.49%
Ravisa Motors	0.08%	0.11%	0.26%	0.11%	0.03%	0.58%
Rivera	0.35%	0.12%	0.59%	0.14%	0.16%	1.36%
Rivera (Suc. Angelopolis)	0.11%	0.19%	0.56%	0.12%	0.06%	1.04%
Sanchez Automotriz	0.21%	0.18%	0.95%	0.25%	0.30%	1.89%
Super Autos Jalapa	0.07%	0.08%	0.25%	0.07%	0.00%	0.48%
Superservicio	0.11%	0.08%	0.80%	0.09%	0.00%	1.09%
Superservicio Autos del Golfo	0.04%	0.05%	0.18%	0.09%	0.01%	0.38%
SURMAN BC	0.11%	0.13%	0.53%	0.22%	0.09%	1.07%
Surman Mexico	0.13%	0.32%	0.76%	0.26%	0.10%	1.57%
Tabasco Automovilistica	0.19%	0.25%	0.96%	0.42%	0.02%	1.84%
Vehiculos Automotrices de La Piedad	0.06%	0.04%	0.23%	0.06%	0.02%	0.40%
Vehiculos de Teziutlan	0.05%	0.08%	0.13%	0.10%	0.02%	0.39%
Vehículos y Servicios Satélite	0.13%	0.18%	0.55%	0.07%	0.09%	1.04%
Vista Hermosa Laredo Motors	0.12%	0.09%	0.44%	0.06%	0.02%	0.73%
Zapata	0.16%	0.29%	0.46%	0.09%	0.27%	1.27%
Zapata (Suc. Aeropuerto)	0.08%	0.09%	0.21%	0.09%	0.04%	0.50%
Zapata (Suc. Pachuca)	0.19%	0.17%	0.40%	0.17%	0.06%	1.00%
Grand Total	**10.73%**	**12.01%**	**55.38%**	**13.50%**	**8.39%**	**100.00%**

Figure 5. Products analyzed (automobiles)

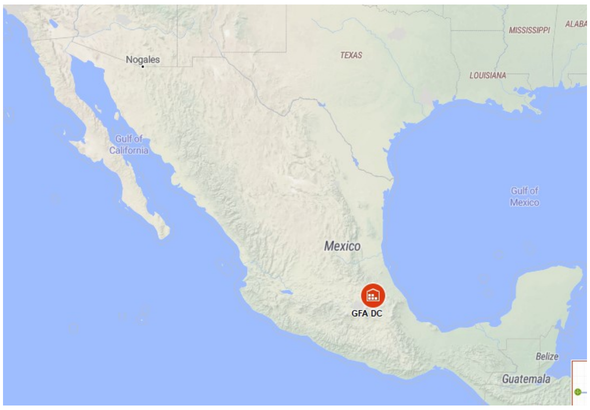

Figure 6. New distribution center location

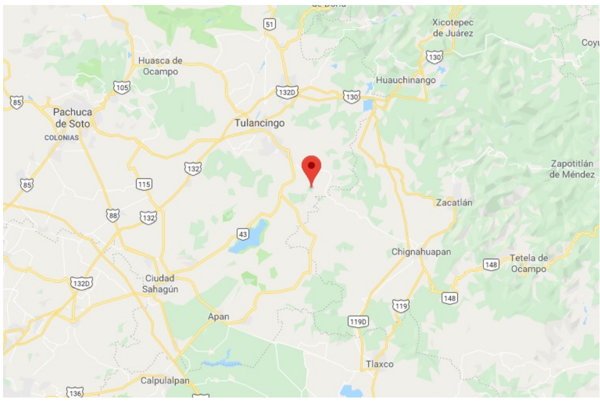

Figure 7. New facility location

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Figure 8. Supply chain network

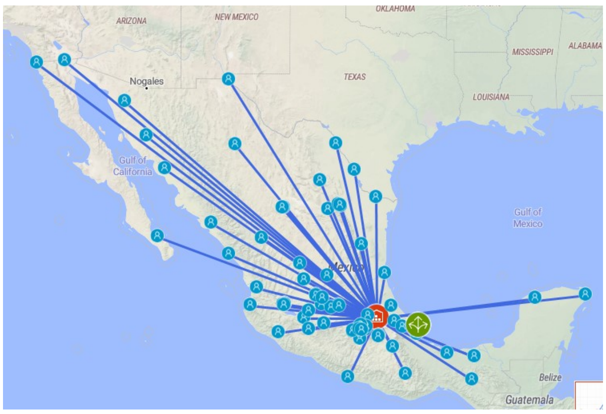

Figure 9. Assignment dealers automotive company

Table 8. Average days of delivery.

Distributor	Days
ACASA PERINORTE	2.8
Alden Condesa	3.5
Alden Juárez	10.8
Alden Tlalpan	4.1
Auto Comercial Santa Fe	4.0
Autocamiones de Tapachula	8.2
Automotores Coahuilenses	14.0
Automotores Cumbres	40.9
Automotriz Baja Cal	14.3
Automotriz del Valle de Baja California	8.3
Automotriz del Valle de Zamora	5.7
Automotriz Elfer	9.3
Automotriz Jalbra	4.9
Automotriz Monclova	12.5
Automotriz Monterrey	26.0
Automotriz Reynosa	17.8
Automotriz Victoria	13.3
Automóviles de Caborca	10.9
Automovilistica Andrade	3.5
Automovilistica Andrade (Suc.Tepepan)	3.9
Autos de Calidad de Zacatecas	13.9
Autos de Hermosillo	8.1
Autos SS de Irapuato	4.2
Autos SS de León	4.0
Autos SS de San Luis Potosí	8.0
Autos y Accesorios	9.9
Autos y Tractores de Culiacán	9.3
Cambher Torreón	12.7
CAMSA	3.0
Car One Valle	11.3
Cavsa Colima Automotriz	9.2
CDA Peninsula	7.1
CDA Peninsula (Suc. Cancun)	8.2
Centro Automotriz de la Laguna	12.8

Distributor	Days
Centro Automotriz Vallarta	7.3
Cever Azcapotzalco	4.3
CEVER DURANGO	11.7
Country Aguascalientes	10.0
Country Americas	8.6
Dimotors Coatzacoalcos	7.6
Dinastia Automotriz Mexico	3.2
Dinastia Automotriz Oaxaca	4.8
Distribuidora Regional	6.2
Distribuidores de Autocamiones de Chiapas	7.4
Ecatepec	4.0
Gema Automotores	6.4
Gimsa Automotriz	5.0
Gimsa Automotriz (Suc. Los Reyes)	4.4
Jacobo Rodriguez Motors Piedras Negras	12.5
Jalisco Motors	6.7
Jimenez	7.8
Jimenez Automotriz	20.3
Leon Automotriz	6.0
Lomas Automotriz	3.0
Montes Queretaro	5.5
Motores de Guerrero	5.2
Motores de Morelos	3.3
MYLSA (Suc. La Villa)	2.0
Mylsa Querétaro	3.4
Mylsa Tehuacan	5.4
Picacho Automotriz	3.4
Plasencia de Nayarit	9.9
Plasencia Guadalajara	8.4
Plasencia Mazatlan	10.1
Plasencia Puerto Vallarta	11.8
Productos Automotrices	19.0
Rangel de Alba	6.0
Ravisa Motors	7.4
Rivera	5.2
Rivera (Suc. Angelopolis)	5.0
Sanchez Automotriz	4.1
Super Autos Jalapa	6.9
Superservicio	9.8
Superservicio Autos del Golfo	7.0
SURMAN BC	10.3
Surman Mexico	4.3
Tabasco Automovilistica	7.6
Vehiculos Automotrices de La Piedad	8.6
Vehiculos de Teziutlan	7.4
Vehículos y Servicios Satélite	2.9
Vista Hermosa Laredo Motors	12.7
Zapata	2.9
Zapata (Suc. Aeropuerto)	4.1
Zapata (Suc. Pachuca)	3.4
Grand Total	**8.6**