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Scheduling production and transportation in multi-site supply chain simultaneously regarding to exclusive suppliers

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Abstract

Delivering on time is an essential factor for the survival of factories in a competitive environment, which requires planning in the supply chain. Therefore, with the correct planning in the supply chain scheduling, it can leads to reduce the cost, lower prices, customer satisfaction and ultimately leads to competitive advantage for organizations. This study considers the scheduling of production and transportation in two-stage Multi-Site supply chain (MS-SC) regarding geographical zoning and using exclusive suppliers (MSZ-SC). The first stage contains suppliers with different production speeds and ability to produce a particular production. The second stage is composed of vehicles, each of which may have a different speed, capacity and setup time. In fact, 5 major factors that are able to be seen as a value for owners are considered. We have presented a mathematical model for scheduling of this supply chain, and then the model coded by Dynamic Genetic Algorithm (DGA), which is an improved version of genetic algorithm, with MATLAB software. Covering the wide range of problems, 648 random problems are solved reaching reasonable achievement. Experimental results from both model with and without zoning, clearly show that proposed model offers better performance in critical variables. In fact, managers are able to use this planning regarding geographical zoning and exclusiveness to gain competitive advantage by time and consequently cost reduction. Better operation abilities in tow-stage proposed model that is clearly shown, certainly, lead to have merits on managerial decision making.

Keywords: Scheduling, geographical zoning, exclusive supplier**,** cumulative transportation, integrated supply chain, dynamic genetic algorithm

1- Introduction

It has taken a lot of attempt to define SCM, as described by different authors in the past. SCM involves many partners (manufacturers, processors, importers, exporters and retailers) as in figure 1, working together to achieve a common purpose (Cham & Wang, 2011). It is also the combination of activities, which includes mainly manufacturing, materials, information and financial flow (Chavez et al., 2012). The supply chain is comprised of different organizations or partners who, directly or

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indirectly, partake in the fulfillment of a customer's request. However this is not made up of manufacturers and suppliers alone, but involves retailers, warehouses, transporters, and the customers.

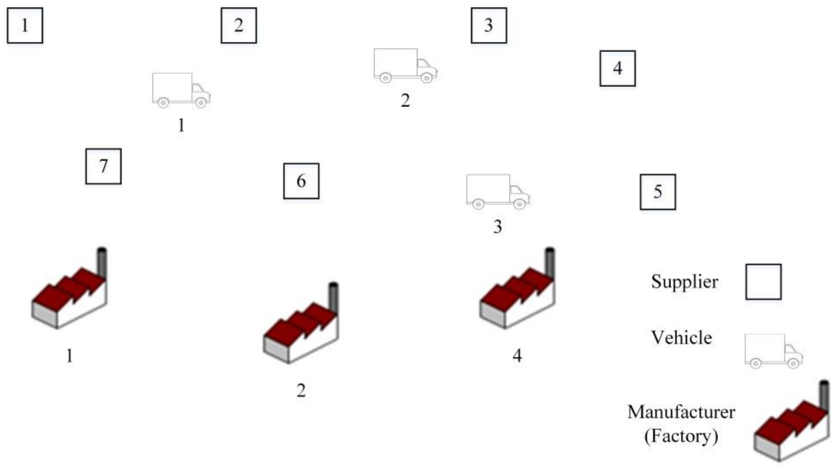


Fig 1. A schema of supply chain basic components

Part of the supply chain processes in a manufacturing organization could also include receiving and completing of customer requests, in addition to new product development, marketing, operations, distribution, finance, as well as customer service (Chopra & Meindl, 2010). Management in the FMCG industry Integration is the coming together of two or more organizations to carry out activities jointly in the supply chain (Forsland & Johnson, 2009). Effective supply chain integration will assist organizations to achieve enhanced operational performance (Wong et al., 2011). The need for organizations to come together through integration, is propelled by global competition and demand for effective customer service, as organizations do not run separately or in isolation, but rather in a coordinated and collaborated manner, to enhance performance or as a network, referred to as a supply chain (Lambert, 2008). SCM is a very important concept for the success of business in all parts of the world, with integration said to assist in reducing cost (Flynn et al., 2010) and improving efficiency (Danese & Romano, 2011).

Among the integrated systems, the relationship between ordering timing in the production and their allocation and timing to suppliers is one of the most important issues that many research has been done (Beheshtinia & Khatibi, 2017), (Beheshtinia & Moghimi, 2015), (Beheshtinia & Moghimi, 2017). There are two types of relationships between the manufacturer and the supplier (One-site and Multi-site supply chain). In the first structure, the supply chain has one manufacturer to produce and in the second one, there has some manufactures can produce final product. In this research, the multi-site is considered that problems such as:

1. Disruption of the relationship between suppliers and the manufacturers.
2. Non-participating manufacturers with some suppliers.
3. There are various geographic locations between suppliers with manufacturers.

Most suppliers, in addition to this company, have other customers and do not produce a single piece of equipment for this company, but the use of this structure is in the process. So an integrated planning in the production sector and in the transportation sector is important. In this regard, this paper presents a model (Comprehensive management of production and transportation with a shared transport approach) investigates the integration of production scheduling and transportation in Multi-site Supply Chain. The goal is to determine how orders are assigned to suppliers, to determine the sequence of production, to assign orders to vehicles and to determine the sequence of their transportation in order to minimize the total time of delivery of orders to the manufacturers.

The innovations of this research are:

- Investigate a new issue in supply chain scheduling focusing on delivery times.
- Provide a new model in supply chain management with the integration of production and transportation scheduling in Multi-Zone plus Multi-Site and Single-Site

manufacturing in supply chain and comparing results with Single-Zone plus Multi-site and Single-Site manufacturing in supply chain.

- Exclusive supplier that can be assume as independent unit in different geographical zones.
- Considering suppliers with different ability to produce.
- Considering transportation system with different speeds, capacity and setup time simultaneously.
- Multi-site Supply Chain considering in wide ranges of problems
- Genetic Algorithm and using one of its improvements (DGA).

2- Material and methods

In the supply chain there are two types of integration (internal and external). Internal integration involves the process of interaction between the functional units through collaboration, coordination and cooperation, to achieve strong relationships within an organization (Flynn et al., 2010), (Zhao et al., 2011). The coming together of specialists, or 'subject matter experts', who share useful information and concurrently make products, processes and manufacturing decisions as a team, is also part of the process. Since Organizations work with their customers and suppliers to obtain the information and necessary resources that may be used to achieve competitive advantage, External Integration going to means. Gimenez & Gimenez (2005) and Stein (1998) iterate that, in their opinion, external integration is a continuation of internal integration. With external integration classified into two areas of emphasis namely, Customer and Supply integration, by Frohlich & Westbrook (2001), Zhao, Baofeng, Willem & Jeff-Hoi (2011) further explain that external integration is the interaction between an organization and its suppliers, to bring about an adequate flow of supplies. Due to globalization, FMCG manufacturing industries have realized that competitiveness involves continuous collaboration between different partners, with companies that do not practice integration set to fail and therefore unable to compete with rival organizations (Lee, 2000), (Kannan & Tan, 2010). The level of company integration with their suppliers will determine their competitiveness (Christopher, 2011). A collaborative advantage is important, given the fact that organizations form part of a larger network or relationship that, to a large extent, determines the scope of activities and competitive advantage. The source of competitive advantage of an organization could be hinged on the effort of the network of organizations, instead of focusing on inherent resources or a single organization (Ritala & Ellonen, 2010). For having a comprehensive attitude on this research, the research steps are mentioned below in figure2.

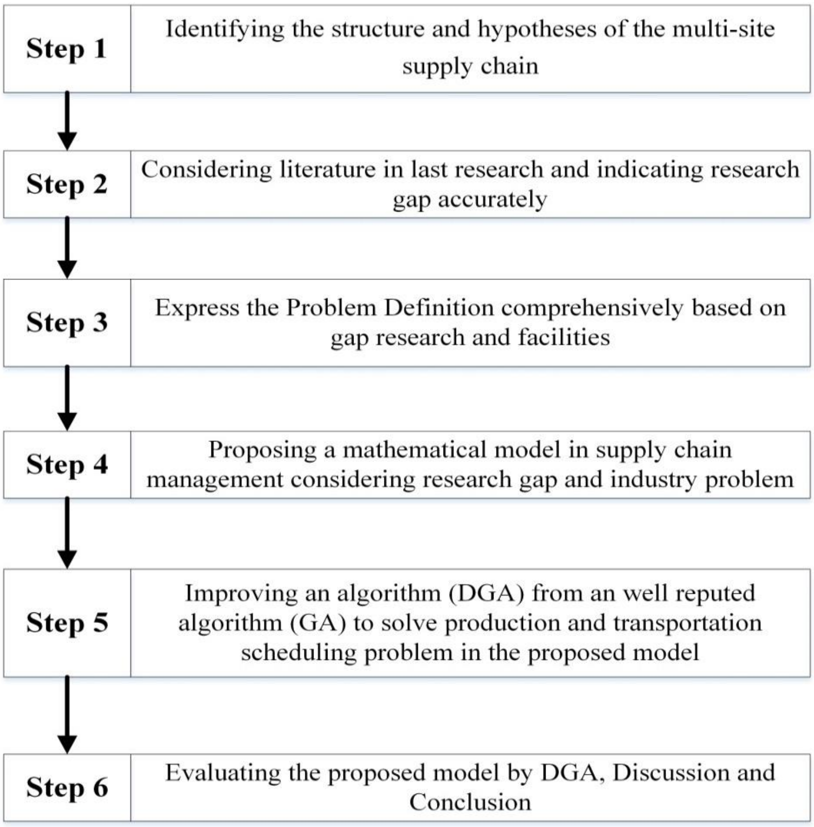


Fig 2. Research steps in summary

2-1- Literature

There are a number of researches in SCM. In this case authors try to present the most related of them to the material. Chang and Lee (2004) study a two-stage supply chain scheduling problem. The first stage involves production, while the second stage involves the transportation of products and the distribution of orders to customers. The jobs require different amounts of storage space during delivery. Karabuk (2007) studies the assignment of jobs to suppliers and aims to determine optimal production scheduling that can minimize the makespan. Each supplier may require a different length of time to process each job. To solve this problem, an adaptive genetic algorithm with a new mechanism named dominated gene crossover is proposed. Amaro & Barbosa-Póvoa (2008) investigated the planning and timing of the drug supply chain by taking into account reverse flows. Li & Womer (2008) examine the supply chain composition with regard to resource constraints. Zandieh & Molla-Alizadeh-Zavardehi (2009) examined the integrity of production scheduling and aviation issues. To this end, various models have been proposed to minimize the cost of the whole chain of materials, including transportation costs, intervals, early costs and late fees .Zegordi et al (2010) have introduced a new genetic algorithm for a single-phase two-stage supply chain. They have been using different speed suppliers and with different fleets of transportation. Averbakh (2010) examines the timing of the supply chain of a factory and several customers with the goal of minimizing the total weight of the workflow of orders. Rostamian Delavar et al (2010) presented a genetic algorithm for the integration of scheduling production and air transport. Mehravaran & Logendran (2012) have examined the scheduling in a workflow environment with sequencing preparation times with two objective functions to minimize the orders of the semi-built and maximize the level of service. Sawik (2014) has investigated the timing relationship with the selection of suppliers in the event of a downtime risk and provided a complex integral and probabilistic programming model for the problem. Han et al (2015) reviewed the minimization of the completion time of the final work and the cost of delivery on parallel and single-machine machines with a customer. Beheshtinia & Moghimi (2015) considered a novel model on reducing supply chain vulnerability by multi-site that. They considered 108 problems and conclude that sometimes with increasing sites we can reach better delay time. Guo et al (2016) examined two evolutionary optimization methods for integrated production and transportation planning. Lei et al (2016) have investigated the meta-heuristic methods for scheduling jobs according to waiting time and time delay. Beheshtinia & Khatibi (2017) review analyzing of three different scenarios to optimize energy consumption and scheduling in supply chain.

2-2- Methodology

In this part of the article, the supply chain is described first, and then the problem is described with the assumptions. The supply chain examined includes several final product companies that have assigned their orders to a number of suppliers. Suppliers will deliver them with a number of vehicles for their intended purposes by producing these orders. Figure 3 shows an overview of the proposed model. One of the main points that have been addressed in this article is comprehensive management about the scheduling of production and transportation. Considering the components of the supply chain in this research, the assumptions of the problem are expressed.

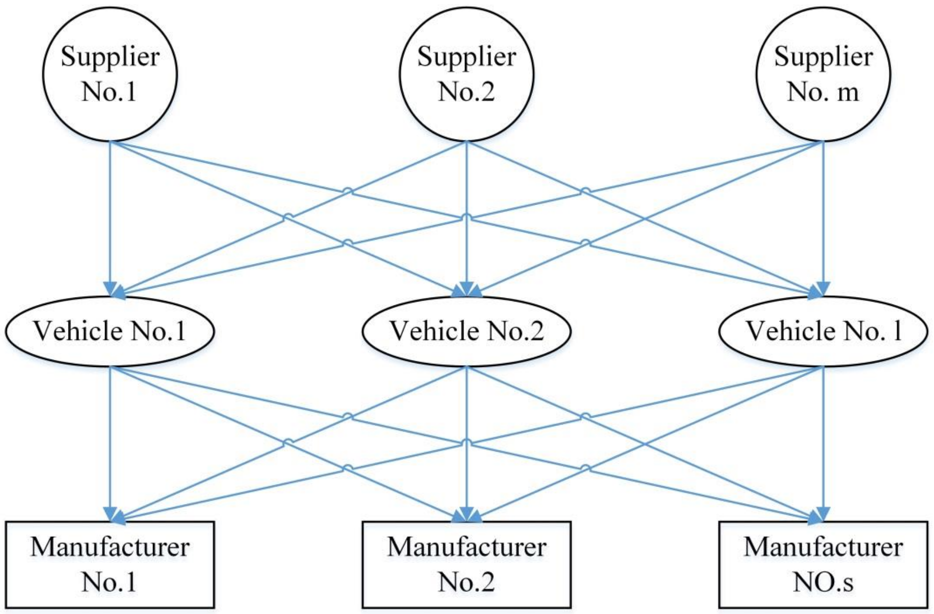


Fig 3. Multi-site Supply chain model examined

- There are **J** suppliers that generate orders for customers. Suppliers have different production capabilities due to the availability of various equipment and machinery. Also their production speeds are completely different.
- The processing time of each order by different suppliers can be different due to the different speed of the suppliers and supplier's machinery orders in due.
- There is **I** order that should be given to the suppliers for processing.
- Each supplier is able to process only some orders depend on its capability and machinery technology or equipment.

In order to show this limit, a matrix called the ALLOW matrix is used with elements of zero and one with dimensions of **J** * **I**. If the supplier s can process the order i, the element (s, i) in the matrix is equal to 1 and otherwise 0.

For example, in a problem with 3 suppliers and 3 orders, (s, i): $\begin{matrix} 1 & 1 & 0 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{matrix}$

In this example, supplier 1 can process order 1 and 3, supplier 2 as the same and supplier 3 is able to process order 3 only.

- Each order has a destination. The destination of orders from supplier is transportation system and from there they must to transport to the manufacturer. So, the final destination is manufacturer, that depend on the order specification is clear before production process. There is k vehicle which sends orders processed by suppliers to their destination.

- Vehicles have different capacity to carry goods. Also, the time taken to carry a route by any vehicle due to different vehicle speeds may vary.
- Depend on cargo category, vehicle can show different setup time. Setup time, actually, is the time that squander for making cargo.
- Each vehicle is not removed from the problem after being transported to its destination, but can be reused. As a result, return time should also be taken into account in scheduling.
- There are **F** manufacturers of finished products. This manufacturer has to be able to receive cargos from the transportation system and we are not face with delay time for delivering to manufacturer.
- At the beginning of the timetable, Vehicles are at a same terminal that is located in an particular position in **X-Y plate**. So the distance between the terminal and the supplier and distance between each supplier is clear.
- Vehicles can carry multiple cargos from different suppliers to their destinations. The point that is worth mentioning is that whole of them must to be same in terms of destination.
- Total weight of the all orders or cargos that is assigned to a vehicle must be less than the capacity of the vehicle.
- Completion Time of each order is equal to the time the order is delivered to its destination. It contains process time, waiting time, setup time, transport time, setup time.
- Setup time can be different from order to order. It depends on the supplier condition and also vehicles capabilities. So it is not a fix amount and in each cargo define base on the parameters above.

The goal is to determine how to assign orders to suppliers (considering their capabilities and speeds), determine production sequences, allocate orders to vehicles and determine the sequence of their transportation in order to minimize the delivery time of orders to their final destinations. Considering the main objective, the pivotal point is that order assignment may be different in suppliers or transportation facilities and factors that influence on that may be process time, setup time and total transportation time.

Chang and Lee (2004) showed that a simpler problem with just one supplier and one vehicle of constant capacity has NP-hard complexity. A current survey of Multi-site SCM problems shows that most problems are solved by heuristic algorithms and exact algorithms can only be used to solve small size problems where the number of depots used for stopping is usually less than 5. Thus our developed model also belongs to the NP-hard class, which suggests that it would be challenging to find an optimal solution in a reasonable timeframe.

2-2-1- Proposed model

In this section, the mathematical model of the complex integer of the problem is described. We use the following notation and definitions as in Table 1. In this model it is assumed that geographical zone are intervened and all assumption is based in that.

Table 1. Indices, parameters and variables used in mathematical modeling

Symbol	Description	Symbol	description
i	Job Indicator, i=1,2,…,N	u_l	Vehicle capacity l
m	Supplier Indicator , m=1,2,…,M	c_{ij}	The completion time of work i in stage j
l	Vehicle Indicator , l=1,2,…,L	st_{lb}	When the b batch of l vehicle is ready to move
s	Manufacturer Indicator , s=1,2,…,S	C_{max}	The maximum completion time in end of stage
N	Num of Jobs	d_{lb}	Demonstrating delivery time of b batch by means of l vehicle
M	Num of Suppliers	w_{lib}	Weigh of b batch from I order into l vehicle
L	Num of Vehicles	$T_{ss'}$	Time interval between manufacturer s,s′
S	Num of Manufacturer	$T_{m'm}$	Time interval between supplier m,m′
V_l	Speed of vehicle k	X_{mi}	If i^{th} order assigned to m^{th} supplier equal with one otherwise equal zero
V'_m	Operational speed of supplier m	Z_{ilb}	If i^{th} order assigned to b batch of l^{th} vehicle equal with one otherwise 0.
V''_s	Operational speed of Manufacturer s	$F_{ilbmm'}$	If the vehicle l is required to complete the shipment b from the order i between the supplier m′, m otherwise 0.
P_{ij}	The processing time job i In stage j (j=1,2,3)	$F'_{lbss'}$	If the vehicle l is required to complete the shipment b from the order i between the manufacturers s, s′ otherwise 0.

The set of constraints (1) ensures that each work is only assigned to one supplier. The set of constraints (2) ensures that Parts for the production of an i^{th} order are assigned to one vehicle and to one batch of that vehicle. The set of constraints (3) considers the capacity of each vehicle in carrying the parts. The set of constraints (4) considers the relationship between the completion time of each job and its completion time in the previous stage for the stage of the supplier & manufacturer and also if there are inter-site shipments to complete the i^{th} order, take their time. Q is a very large positive number. The set of constraints (5) determines the time of delivery of the b batch of the l^{th} vehicle to the manufacturer and also to complete the i-order, there would have existed shipments between suppliers, take their time. The set of constraints (6) consider the ready time of the batch b to the vehicle l to move towards the companies. This time is when the job assigned to that shipment is produced by the supplier and the lm vehicle is ready. It is meant for this time that the job assigned to that shipment is produced by the supplier and the l vehicle is ready. The set of constraints (7) takes into account the completion time of each task in zero step. The set of constraints (8) determines the C_{max} according to the completion time of the works in the final stage. The set of constraints (9) states that the completion time of a job belonging to a shipment is not smaller than the time of delivery of that shipment to the companies.

$$MinZ = C_{\max}$$

$$s.t:$$

$$\sum_{s=1}^{m} x_{si} = 1 \qquad i = 1,2,...,n \qquad (1)$$

$$\sum_{l=1}^{L} \sum_{b=1}^{\left[\frac{N}{ul}\right]+1} Z_{ilb} = 1 \qquad i = 1,2,...,n \qquad (2)$$

$$\sum_{i=1}^{N} W_{lib} \leq u_l \qquad L=1,2,\ldots,L \quad b=1,2,\ldots,\left[\frac{N}{ul}\right]+1 \qquad (3)$$

$$C_{3i} \geq C_{2i} + \frac{P_{3i}}{v''_s} + \sum_l \sum_b \sum_s \sum_{[s \neq s']s'} T_{ss'} \times F'_{ilbss'} \qquad \begin{array}{l} s, s' = 1,2,\ldots,S \\ l = 1,2,\ldots,L \\ b = 1,2,\ldots,\left[\frac{N}{ul}\right]+1 \\ i = 1,2,\ldots,N \end{array} \qquad (4)$$

$$C_{1i} \geq \frac{P_{1i}}{v'_m} - Q \times (1 - x_{mi}) \qquad \begin{array}{l} i = 1,2,\ldots,N \\ m = 1,2,\ldots,M \end{array}$$

$$d_{lb} \geq st_{lb} + \frac{P_2}{v_l} - Q \times (1 - Z_{lib}) + \sum_l \sum_b \sum_m \sum_{[m \neq m']m'} T_{mm'} \times F'_{ilbmm'} \qquad \begin{array}{l} m, m' = 1,2,\ldots,M \\ l = 1,2,\ldots,L \\ b = 1,2,\ldots,\left[\frac{N}{ul}\right]+1 \\ i = 1,2,\ldots,N \end{array} \qquad (5)$$

$$st_{lb} \geq C_{1i} + Q \times (1 - Z_{lib}) \qquad \begin{array}{l} l = 1,2,\ldots,L \\ b = 1,2,\ldots,\left[\frac{N}{ul}\right]+1 \\ i = 1,2,\ldots,N \end{array} \qquad (6)$$

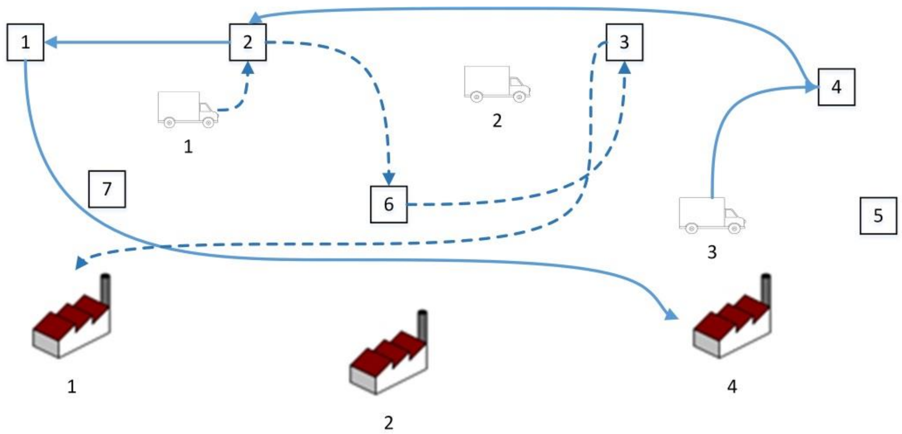
$$st_{lb} \geq d_{l(b-1)} + \frac{P_2}{v_l} \qquad \begin{array}{l} l = 1,2,\ldots,L \\ b = 1,2,\ldots,\left[\frac{N}{ul}\right]+1 \end{array}$$

$$C_{0i} = 0 \qquad i = 1,2,\ldots,N \qquad (7)$$

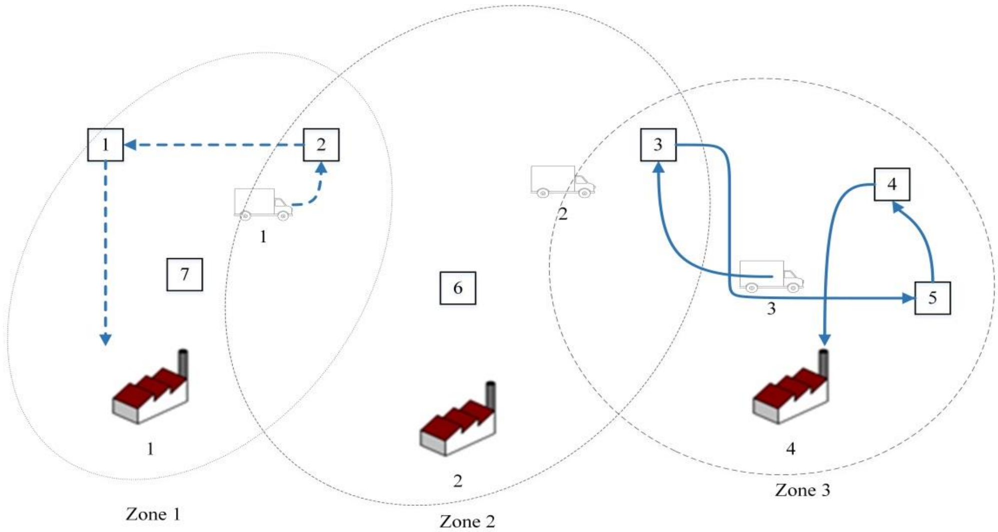
$$C_{\max} \geq C_{3i} \qquad i = 1,2,\ldots,n \qquad (8)$$

$$C_{2i} \geq d_{lb} - Q \times (1 - Z_{lib}) \qquad \begin{array}{l} l = 1,2,\ldots,L \\ b = 1,2,\ldots,\left[\frac{N}{ul}\right]+1 \\ i = 1,2,\ldots,N \end{array} \qquad (9)$$

$$\begin{array}{l} X_{mi} \in \{0,1\} \\ Z_{ilb} \in \{0,1\} \\ F_{ilbmm} \in \{0,1\} \\ F'_{ilbss'} \in \{0,1\} \end{array} \qquad \begin{array}{l} m, m' = 1,2,\ldots,M \\ s, s' = 1,2,\ldots,S \\ l = 1,2,\ldots,L \\ b = 1,2,\ldots,\left[\frac{N}{ul}\right]+1 \\ i = 1,2,\ldots,N \end{array}$$



(a)



(b)

Fig 4. a) Multi-Site and Single-Zone supply chain
b) Multi-Site and Multi-Zone supply chain (MSZ-SC) with exclusive supplier

As in figure 4, the supplier may be located in an area and the manufacturer in another geographical area. Even in some cases, suppliers operate exclusively. In this situation, this article can provide a well-integrated scheduling of transportation and production in a supply chain. Figure 4 (a) shows model 1 of the assumptions and it is assumed that each manufacturer is able to order to each supplier freely and transportation system is obliged to transport the orders to the indicated destination. On the contrary, figure 3 (b) it is assumed that each manufacturer is able to order to related geographical zone and transportation system based on suppliers ability to produce have to transport orders to the final destination. It is worth mentioning that if a specific supplier was not able to produce specific order (based on Allow matrix) it is possible to travel to different geographical zone in particular cases.

2-2-2- Genetic algorithm

Many different approaches have been proposed for solving scheduling problems. Genetic algorithms (GAs) have been widely adopted in recent years (Zegordi & Beheshtinia, 2009). In GA, any potential solution is represented as a chromosome in an initial population. A relevant fitness function is assigned to it. The initial population gets enhanced over the course of several generations. In each generation, new chromosomes are produced by various genetic operators, such as crossover and mutation. Chromosomes for the next population are selected from the previous population by a criterion considering their fitness function. This procedure is repeated until a termination condition is satisfied. Development of the genetic algorithm (GA) is one of the efforts to solve scheduling problems during 1960–1970 (Holland, 1992). GA has been a successful meta-heuristic solution (Goldberg, 1989). Some research in the literature used genetic algorithm for solving the scheduling problem in the supply chain environment (Karabuk, 2007), (Ko & Evans, 2007).

In the standard GA, the length of the string(s) of genes is constant, and changing the solution changes only the genes. In the proposed GA (**DGA**[3]), solution changes may change either the genes or the string length in the related chromosome. Since the structure of chromosomes can be altered, we named it dynamic genetic algorithm. In other words, in the DGA, the structure of the chromosomes and operators are significantly modified to match the structure of the problem. Characteristics of DGA are defined as follows:

a- Chromosomes structure

Each chromosome is composed of a string of genes for each supplier and each vehicle in which each gene indicates a job. For more explanation, suppose that there are five jobs, two suppliers, and two vehicles. A feasible chromosome structure is presented in table 2 complex.

This chromosome indicates that job 2, 5, 7 is assigned to supplier 1. Supplier 1 must process in sequence. Jobs 1, 5 7 and supplier 2 must just process job 1. Vehicle 1 must transport jobs 4, 1, 3 and 7 from the suppliers to the manufacturing company with the proposed priority. Dispatch order is related to the capacity of vehicle 1 and to the size of each assigned job to it. Finally, jobs 2, 5, 6 must be performed by vehicle 2.

Table 2. Sample Chromosome structure

Production							**Transportation**						
Supplier No.	**Process Priority**	**Achieved Chromosome**					**Vehicle No.**	**Shipping Priority**	**Achieved Chromosome**				
Supplier1	2→5→7	2	5	7	*	*	Vehicle 1	4→1→3→7	4	1	3	7	*
Supplier2	1	1	*	*	*	*	Vehicle 2	2→5→6	2	5	6	*	*
Supplier3	4→6	4	6	*	*	*							
Supplier4	3	3	*	*	*	*							

*Free Time

Having better overview on chromosome structure, production part and transportation part are shown separately in table 3 as below.

Table 3. Sample Chromosome structure (separated in production and transportation)

Integrated Production and Transportation						
	Priorities	**Integrated Achieved Chromosome**				
Produce	2→5→7	2	5	7	*	*
	1	1	*	*	*	*
	4→6	4	6	*	*	*
	3	3	*	*	*	*
shipping	4→1→3→7	4	1	3	7	*
	2→5→6	2	5	6	*	*

*Free Time

[3] Dynamic Genetic Algorithm

b-The initial population

The initial population is generated randomly and the size of the initial population is one of the genetic algorithm parameters, given by Pop-size. This chromosomes have to produce randomly because of taking part all kinds of probable answers in solution.

c- Fitness function

The fitness function of each chromosome i defined as $\frac{\mathrm{Max}(C_{\mathrm{Max}})-C_{\mathrm{Max}}}{\mathrm{Max}(C_{\mathrm{Max}})}$, where C_{Max} is the maximum completion time in end of stage that obtained from scheduling of each chromosome and $\mathrm{Max}(C_{\mathrm{Max}})$ is the maximum C_{Max} among all chromosomes in the population.

d-Crossover

A Parameterized Uniform Operator is used in the dynamic genetic algorithm, the number of crossover operations in each repetition is constant and is determined by the coefficient of Pop_size called percross, which is the parameters of the genetic algorithm and obtain from cross_rate*Pop_size. cross_rate parameter is an input parameter.

e-Mutation

In the proposed genetic algorithm, a chromosome is first selected randomly and reverses and swap operators are executed on it. After each mutation operation, the resulting chromosome timing is calculated and the value of its fitness function is calculated. The number of repetitions of the mutation operator in each repetition is constant and is determined by a coefficient of Pop-Size called permut, which is the parameters of the genetic algorithm and obtain from mute_rate*popsize. mute_rate parameter is an input parameter too.

f-Selection Operator

The number of chromosomes existing after the crossover and mutation operators is equal to Pop-Size * (1+ cross_rate + mute_rate). For the selection operator in this research, 50% of the selected of chromosomes are selected by the Roulette Wheels operator, 25% elitism operator and 25% randomly.

g-Stop criteria

The stop criterion for the algorithm is that if the best value of the fitness function is not improved for several consecutive generations, the algorithm ends. The number of these repetitions is determined by a parameter called termination. This parameter can be achieved by repeat several algorithm base on programmer’s experience.

In this algorithm we have Pop_size, Termination, cross_rate, mute_rate and indicate selection operators as input parameter. Also it is necessary to have Num of Job, Num of Supplier, Num of Factory, Vehicle Capacity, Shipping Time and Production time for being able to solve problems. These parameters are expressed accurately in next section. For having better comprehension about the algorithm construction, it is shown in figure 5.

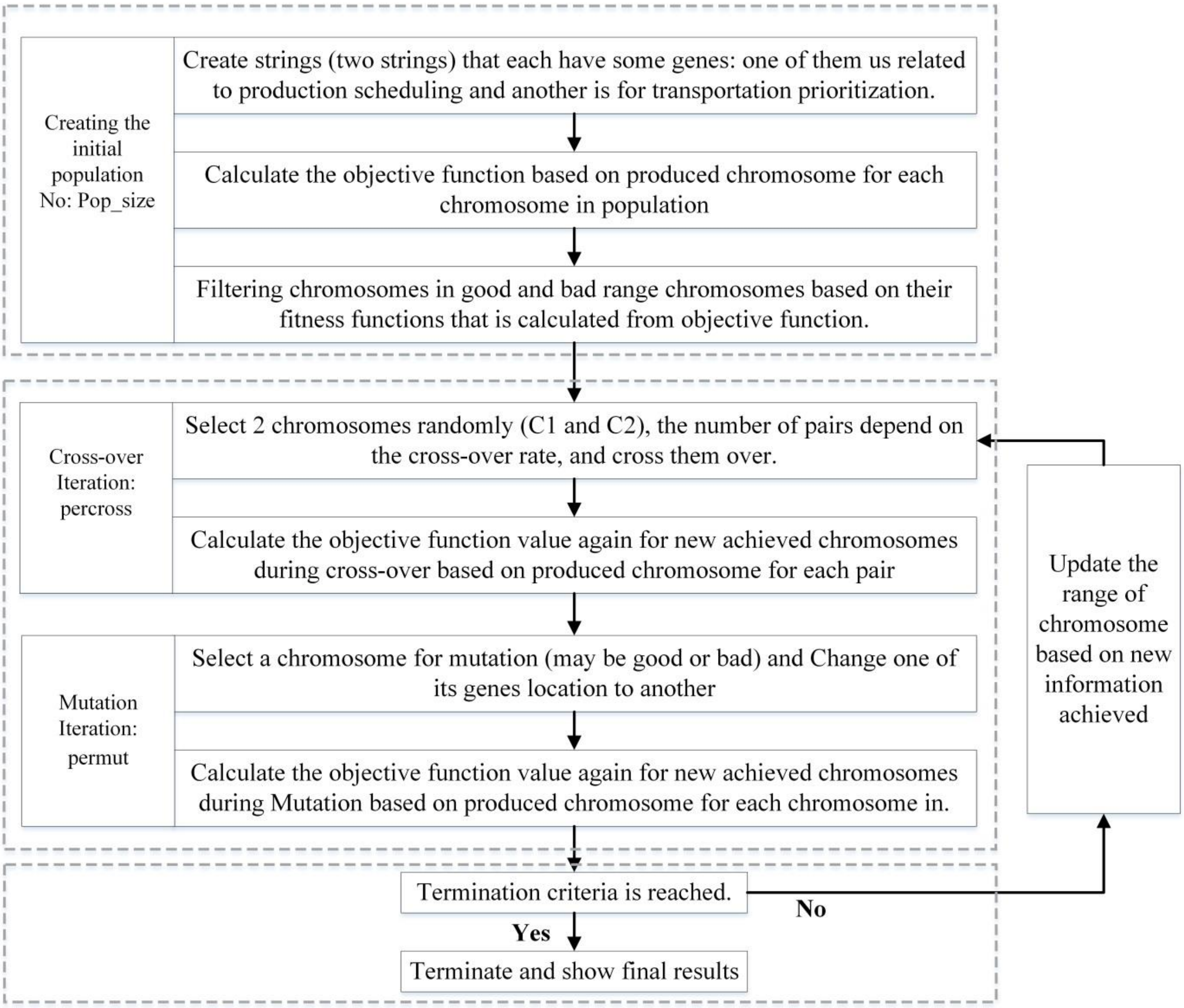


Fig 5. An overview on algorithm working and process path

4- Results

In this section, at first different issues with different dimensions have been investigated and then the model proposed is solved. Also, the model regardless geographical zoning and exclusive supplier is solved. Then results are compared and discussed.

In two models is considered the integration of production and transportation but with minor difference. In proposed model we have some zone that manufactures have been scattered across different areas and also can have exclusive suppliers.

The problem in this study has different parameters, for some of them the levels are high, low and medium and are classified into six categories that shown in table.4.These six categories are:

(1) Number of job, (2) number of suppliers, (3) number of final product manufacturers, (4) number of vehicles, (5) vehicle capacity, (6) production time.

This 648 problem has been solved using a genetic algorithm. All Coding in this study were written by Matlab2015a programming language and run by a 16GB computer with RAM, as well as 8-core CPUs. The genetic algorithm has four parameters: Pop_size, termination, cross_rate, and mute_rate were assigned respectively 120, 90, 0.5 and 0.1. Each of the 648 randomized examples for the proposed model in Single-Zone supply chain (figure 3a) and Multi-Zone supply chain (figure 3b) and the industry-standard model were solved with dynamic genetic algorithms, and the results are presented in table 5 and table 6 respectively. Additionally, Total Improvement percentage (TI%) that shows Table.6 information improvement percentage in comparison with Table.5 information, Vertical Improvement percentage (VI%) that shows improvements percentage when manufacturer sites increase in comparison with last mood (last vertical mood), Horizontal Improvement percentage

(HI%) that shows improvement percentage in comparison with last horizontal mood are shown in tables. It is clear that table 5 doesn't have TI.

Table 4. Number of scenarios and problems supply chain examined (input parameters modes)

No	Categories	Number of modes	Scenarios (Ranges)
1	Num of Job	3	20(Low) & 60(Medium) & 180 (High)
2	Num of Supplier	3	[1,5] (Low) & [6,10] (Medium) & [11,15] (High) (Uniform distribution)
3	Num of Factory	3	1(Low) & [2,5] (Medium) & [6,9] (High) (Uniform distribution)
4	Num of vehicle	3	[1,5](Low) & [6,10](Medium) & [11,20](High) (Uniform distribution)
	Vehicle Capacity (Volume unit)	2	5(Low) & 10 (High)
5	Shipping Time (Time unit)	2	[10,20] (Low) & [21,30] (High) (Uniform distribution)
6	Production time (Time unit)	2	[1,10] (Low) & [11,20] (High) (Uniform distribution)
7	Setup time	1	1
	Num of the problems		**3×3×3×3×2×2×2×1 = 648**
	Solver System	Computer with 16GB RAM, 8-core CPUs, Matlab2015a	
	DGA inputs	Pop_size: 120 Termination: 90 cross_rate: 0.5 mute_rate: 0.1 Selection Operator: Roulette Wheels, Elitism operator and Randomly	

Table 5. Results of Single-Site and Multi-Site manufacturing using Model regardless geographical zones and exclusive suppliers (Average result) in Low (L), Medium(M) and High (H) levels of variables

Variables		**Moods (VI%) (HI%)**		
Num of orders		20	60	180
	Number of manufacturing site(s)			
	[1,1]	1043 (-) (-)	2888 (-) (-176)	8913 (-) (-208)
	[2,5] UD	1198 (-15) (-)	3089 (-7) (-157)	12045 (-35) (-289)
	[6,9] UD	1344 (-12) (-)	3743 (-21) (-178)	15913 (-32) (-325)
Num of suppliers		[1,5] UD	[6,10] UD	[11,15] UD
	Number of manufacturing site(s)			
	[1,1]	5239 (-) (-)	4114 (-) (21)	3491 (-) (15)
	[2,5] UD	6981 (-33) (-)	4910 (-16) (29)	4440 (-27) (10)
	[6,9] UD	7935 (-14) (-)	7153 (-45) (10)	5911 (-33) (17)
Num of Vehicles		[1,5] UD	[6,10] UD	[11,20] UD
	Number of manufacturing site(s)			
	[1,1]	5218 (-) (-)	4632 (-) (11)	2994 (-) (35)
	[2,5] UD	6441 (-22) (-)	5651 (-22) (12)	4235 (-41) (25)
	[6,9] UD	8232 (-28) (-)	6341 (-12) (23)	6428 (-52) (-1)
Vehicle Capacity (Volume or Mass Unit)		5	10	
	Number of manufacturing site(s)			
	[1,1]	3641 (-) (-)	4921 (-) (-35)	
	[2,5] UD	4154 (-14) (-)	6791 (-38) (-63)	
	[6,9] UD	6999 (-68) (-)	6401 (5) (9)	
Shipping Time		[10,20] UD	[21,30] UD	
	Number of manufacturing site(s)			
	[1,1]	3443 (-) (-)	4508 (-) (-30)	
	[2,5] UD	4650 (-14) (-)	6195 (-37) (-33)	
	[6,9] UD	6013 (-29) (-)	7987 (-29) (-33)	
Production time		[1,10] UD	[11,20] UD	
	Number of manufacturing site(s)			
	[1,1]	3059 (-) (-)	5502 (-) (-79)	
	[2,5] UD	4087 (-34) (-)	6757 (-23) (-65)	
	[6,9] UD	6016 (-47) (-)	7985 (-18) (-33)	
Results for all random issues		**All Problems**		
	Number of manufacturing site(s)			
	[1,1]	4281 (-) (-)		
	[2,5] UD	5422 (-26) (-)		
	[6,9] UD	7002 (-29) (-)		

Table 6. Results of Single-Site and Multi-Site manufacturing using proposed Model regarding on geographical zones and exclusive suppliers (Average result) in Low(L), Medium(M) and High(H) levels of variables

Variables		**Moods (TI%) (VI%) (HI%)**		
Num of orders		**20**	**60**	**180**
	Number of manufacturing site(s)			
	[1,1]	995 (5) (-) (-)	2243 (22) (-) (-125)	5977 (33) (-) (-166)
	[2,5] (UD)	943 (21) (5) (-)	2510 (23) (-11) (-166)	6832 (43) (-13) (-172)
	[6,9] (UD)	1018 (24) (-7) (-)	2602 (30) (4) (-156)	7198 (54) (-5) (-176)
Num of suppliers		**[1,5]** UD	**[6,10]** UD	**[11,15]** UD
	Number of manufacturing site(s)			
	[1,1]	3439 (34) (-) (-)	2923 (28) (-) (15)	2852 (18) (-) (3)
	[2,5] (UD)	3806 (45) (-10) (-)	3340 (32) (-14) (12)	3140 (29) (-10) (6)
	[6,9] (UD)	4011 (49) (-5) (-)	3419 (52) (-3) (15)	3388 (43) (-8) (1)
Num of Vehicles		**[1,5]** UD	**[6,10]** UD	**[11,20]** UD
	Number of manufacturing site(s)			
	[1,1]	1777 (65) (-) (-)	3034 (34) (-) (-41)	4403 (32) (-) (-45)
	[2,5] (UD)	1974 (69) (-11) (-)	3334 (41) (-10) (-68)	4978 (-17) (-13) (-49)
	[6,9] (UD)	2099 (84) (-6) (-)	3402 (46) (-2) (-62)	5317 (17) (-7) (-56)
Vehicle Capacity (Volume/Mass Unit)		**5**	**10**	
	Number of manufacturing site(s)			
	[1,1]	3233 (11) (-) (-)	2911 (41) (-) (-10)	
	[2,5] (UD)	3532 (15) (-9) (-)	3254 (52) (-12) (8)	
	[6,9] (UD)	3657 (47) (-4) (-)	3555 (44) (-9) (3)	
Shipping Time		**[10,20]** UD	**[21,30]** UD	
	Number of manufacturing site(s)			
	[1,1]	2522 (27) (-) (-)	3621 (20) (-) (-43)	
	[2,5] (UD)	2649 (43) (-5) (-)	4208 (30) (-16) (-58)	
	[6,9] (UD)	2697 (55) (-2) (-)	4515 (43) (-7) (-67)	
Production time		**[1,10]** UD	**[11,20]** UD	
	Number of manufacturing site(s)			
	[1,1]	2696 (12) (-) (-)	3447 (37) (-) (-28)	
	[2,5] (UD)	3118 (24) (-15) (-)	3739 (45) (-8) (-20)	
	[6,9] (UD)	3390 (44) (-9) (-)	3822 (52) (-2) (-12)	
Results for all random issues		**All Problems**		
	Number of manufacturing site(s)			
	[1,1]	3072 (28) (-) (-)		
	[2,5] (UD)	3429 (37) (-12) (-)		
	[6,9] (UD)	3606 (48) (-5) (-)		

5- Discussion

In this research it is considered for covering the wide range of problem to solve 648 sample problems in different possible variable in both models. The results from Single-Site and Multi-Site manufacturing regardless on geographical zones and exclusive suppliers model are shown in Table.5. Also results regarding geographical zoning process and using exclusive suppliers are shown in table 6. The average of the solutions from each model, with different parameters and also the average of the total objective function of the delivery time are shown.

Considering table 5, at all three levels of the number of manufacturers, the total delivery time increases with the increases of number of orders. This increase is more pronounced when we are in the high end of the production sites, i.e., the interval U[6,9]. During single-site manufacturing, as order increases from 20 to 60, delivery time increases 176% and from 60 to 180 it is 208%. Within interval U[2,5], in the first range of orders to second (from 20 to 60) total delivery time increased by 157% and in the second range of orders to third (from 60 to 180) increased by 289%. For interval U[6, 9], these numbers are 178% and 325% respectively. This indicates the high sensitivity of the number of manufacturing plants to the number of orders in the absence of geographical zonation without the use of exclusive suppliers. Also, by increasing the number of manufacturers from one to U[2,5] and from U[2,5] to U[6,9] when we have 20 orders, 15 and 12 percent respectively, 60 orders, 7 and 21 Percentage respectively and for 180 orders, 35 and 32 percent respectively we have increases. Therefore, with the increase in the number of orders, the overall delivery time of the chain rises, and multi-site manufacturing may be reasonable for high volume of orders provided not to be too high. By increasing the number of suppliers in all single-site and multi-site manufacturers, improvement was seen which is due to lack of zoning in the supply of goods, and in this case, the ever-increasing number of suppliers will be beneficial for sure. However, multi-site manufacturers compared to single-site ones have not achieved favorable results, and we experience a recession. This recession certainly has had the lowest level in the highest level of suppliers, i.e. U[11,15], which confirms the positive impact of increasing supplier numbers. When we reach the average number of suppliers, we observe a higher improvement over its long range, so overreliance of suppliers is not always profitable. With the increase in the number of vehicles in all cases, the final result has been improved, with the exception of one that is at the highest level both in the number of vehicles and production. The rate is of course, only one percent, which can be completely neglected in the face of other developments. In high interval of the number of vehicles, we observe the highest level of improvement, other than one case, which indicates that the increase in the number of vehicles leads in a better results. Of course, this is economically a matter of debate. Improvements are also more impressive in single-site mode. However, passing through a single-site mode to a multi-site in the same scenarios, we see performance drop. Therefore, multi-site manufacturers still show weaknesses in the system. Looking at the results in various vehicle capacities, we notice a tangible downturn in results, with the exception of the high range in the number of manufacturers, i.e. U[6,9], which is associated with a slight improvement (9%). Therefore, increasing capacity in this approach might be unbeneficial. It seems that the main cause of this problem is the vehicle's pointless travel in the overall zone. It is also seen that with the increase in the number of manufacturers, we are faced with a drop in the results, except for a 5% improvement in the high capacity and high level of the manufacturer, which is not an appropriate improvement to justify the model. By increasing shipment time, the delivery time has dropped in all situations, which is normal. Also, with the transition from single-site to multi-site manufacturer, we experience a recession. As the production time increases, the delivery time increases, partly due to increased production time and partly due to the weakness of the shipping system. This downturn is quite tangible in a single-sit manufacturer with 79%. But the increase in the number of manufacturers ameliorates the situation and we observe 65% and 33% recession respectively. It seems that this can be solved partially by controlling the number of manufacturers. Also, we are faced with a drop in the chain performance in a multi-site versus single-site manufacturer, but this drop seems to be lower at times of high manufacturing, due to the fact that in this model the transportation system consumes a lot of time. The general results of Table.5 show that multi-site compared to single-site manufacturers do not have a good performance and we observe 26% and 29% recession respectively. Considering the results obtained from the first model and the conditions described in this study, we will discuss the results of the proposed model below.

According to the results presented in the proposed model, taking into account geographic zoning and exclusive suppliers in table 6, we observe progress at all levels of orders and all levels of the number of manufacturers, compared to the absence of zoning and exclusive suppliers. With an increase in the number of orders, this progress increases, indicating that the model is responding to an increase in order and has the best performance in large orders. This improvement is also seen with increasing orders and increasing the number of manufacturing sites simultaneously, indicating that the model is responsive to high orders and more manufacturing sites compared to the previous model. But as orders increase in this model, order delivery time increases, which is normal. For example, in a single-site manufacturer, by increasing the orders from 20 to 60 and then from 60 to 180, we experience 15% and 166% drop respectively. However, the severity of this decline is still lower than the previous model. With the increase in the number of manufacturing sites, the dominant problem is the drop in delivery time, but given the low drop rates as well as the percentages of low growth, it cannot be concluded that how the increase in the number of manufacturing sites exactly relates to the number of orders. The present model, with any number of suppliers, showed considerable improvement from 18% to 49% compared to the results of the previous model. The highest improvement, however, is in the multi-site manufacturer at the highest level and the number of suppliers at the lowest level with 49%, indicating the best performance in this range. Also, in this model, as in the previous model, with increasing the number of suppliers in all modes, improvement has been achieved, but improvements are lower, which indicates lower sensitivity of this model to the number of supplier due to correct zoning. Significant progress has been made in partitioning of vehicles in all modes from 17% to 84%, with only 17% recession seen in one case. This reflects the overall improvement of the model. It can be seen that in all cases, with the increase in the number of vehicles, the results have been declined, but these retreats are less than those seen in the previous model, and it seems that the main reason for that is the queue of vehicles in their geographical areas. In different vehicle capacities, in all modes, we see improvements from 11% to 52%, and the best improvement is related to the high capacity levels. Also, with the increase in capacity in the single-site manufacturer model, we experience 11% recession, and in multi-site manufacturer models, we see 8 and 3 percent decline respectively. This shows that by increasing the capacity of the vehicles, we may use the potential of this model appropriately and simultaneously with geographical zoning and achieve the appropriate response of the model. The results obtained based on delivery time in all modes, show 20% to 55% improvement compared to the previous model, indicating that the highest progress is related to the upper limit of manufacturers and the average delivery time which is 55% and the upper limit of delivery time which is 43%. With increasing delivery time, we see a decline in all modes, with more intensity than the previous model, which indicates the high sensitivity of this model to intervals, and it may also be due to the vehicle's waiting time in queue. In partitioning of production time, we see 12% to 52% improvement in all modes compared to the previous model, most of which is related to the upper limit of manufacturers and the upper limit of production time with 52%. Also, with the increase in production time, we face a decline in results of this model. In the overall outcomes of this model, we see progress in all modes, which is 28% in single-site manufacturer, 37% within the medium range of manufacturers, and 48% within the high range of manufacturers, indicating that the overall model is responsive compared to the previous model. An increase in the number of manufacturing sites will still result in a decline, but not as much as in the previous model. As the number of production sites increased, as we saw in the overall results of this model and the previous model, we experience a recession.

As can be seen in results and their analyses, with sharing transportation, the geographical zoning and the exclusive supplier, we see progress in all states compared to the previous model, which did not use of geographical zoning or exclusive supplier. Also, in reviewing the number of manufacturing sites in each segmentation, we see a reversal with increasing number of production sites in both models. The recession in the proposed model is between 2% and 17%, and in the previous model, it is between 14% and 41%, which reflects the improvement of the proposed model in increasing the number of manufacturing sites. Also, in the results presented in partitioning, in some cases, progress is observed, and in some cases, we witness a decline as we pass through the variables' levels. As discussed above and are visible in the result table, it can be concluded that the proposed model's disadvantages are negligible, against the recessions seen in the previous model, which indicates that this model is expandable for all single-site and multi-site manufacturer with different range and scenarios. Ultimately, if a manufacturer's need is supplied by suppliers – sometimes exclusive – in the same zone as the manufacturer, everything will be beneficial to the manufacturer and supplier, which is debatable economically and strategically.

6- Conclusions

This paper reviews Single-Site and Multi-Site manufacturing regardless and regarding on geographical zoning process and using exclusive suppliers. For this purpose, it has been trying to optimize the delivery time by offering a model that includes comprehensive management based on a supply chain integration program with sharing transportation. Scheduling problem in a three-stage supply chain is investigated with the objective function of minimizing the delivery time. The first and the second and the third stages of the supply chain are composed of suppliers and vehicles and manufactures. Since this is the first study of this problem that investigate the Multi-site supply chain with considering exclusive supplier. To solve this problem due classified as NP-hard, the problem was encoded using the genetic algorithm with MATLAB. Then three type of problem is compared together in 648 problem randomly. The results indicated that the proposed model's solutions were superior to all parameters. In a comprehensive look the result lead to reduce costs, customer satisfaction, and competitive advantage. The result of this model is useful for special industries that have exclusive product, High-tech industry, working on special areas, want to create value chain and wider range of businesses than transportation business. They are able using exclusive supply chain to have better customer service that can lead to more customer satisfaction and increasing market share consequently. Another plus point that is worth mentioning is power of increasing product variety using exclusive supply chain model through devoting particular orders to particular producers in order to prepare for particular part of customer. Such level of customization has the ability to make a significant competitive advantage for organization that can prevent feeling the gap by competitors.

In the result better performance of proposed integrated production and transportation model with sharing transportation regarding geographical zoning and exclusive supplier in MSZ-SC and MS-SC in comparison with lack of geographical zoning and exclusive supplier's model to reach better supply chain performance is clearly shown. However, in some cases acceptance of partial delays or disruption may be undeniable, in the wide range of real cases, certainly it can be seen as a beneficial plus point to businesses which is involve with cost and delivery time reduction issue. In this research we were faced with some limitations as Genetic Algorithm limitations. In this case we tried to solve the problem with improving algorithm to Dynamic Genetic Algorithm that in a number of cases are capable to show better performance than GA. Also lack of real cases was another limitation. We considered a wide range of problems and solved them to reach the best achievement covering this limitation and with several coding, running and debugging could finally reach to the best solution with the best performance. For future research, researchers are able to work on developing new heuristic or meta-heuristic algorithm for solving this problem or problems such. Providing practical case with more precise input data can be an interesting development for this research, it is achievable certainly. Adding a logic comparison between algorithms can be seen as a useful development that can be combined with uncertainty condition in wide range of supply chains.

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