Model Design of Integrated Multi-Target Green Supply Chain Timing under Uncertainty Circumstances

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Abstract: Increased concerns about environmental warnings has made the producers to try to find solutions regarding green management. Nowadays environmental management is one of the most important problems of customers, shareholders, governments and rivals and international pressures has obligated the organizations to produce products and services which are compatible with the environment. Making the supply chain green is an opportunity for those who are concerned about the stable consumption subjects and environmental business performances. Seeing the big picture, paying attention to green problems is a mechanism to increase the ability of designing green products and also as a tool to create new markets for environment compatible green products. Designing and using the supply chain network is a strategic decision which has consecutive effects for many years, and during that, the parameters of the business space (such as customers' demands) may change. Therefore, these parameters have an uncertain nature and the designed supply chain must be stable against these uncertainties. Therefore, the goal of current study is model designing of integrated multi-target green supply chain timing under uncertainty circumstances.

Keywords: Integrated model, multi-target, green supply chain, uncertainty.

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1- Preface:

In today's world, the fast-economical changes and the increasing pressure of the market make the companies to focus on the integrated logistics and supply chain. Because satisfying the needs and tastes of the customers is not only through the last connection to the customer (final product) but also comes from other upper hand providers (Rad [1] et al) In the late 1980, producers went beyond the needed rules and moved towards the green approach in their system operation. One of the most important activities of the reorganization in planning and managing the supply chain management is the effective

[1] Rad

design of the chain (Jaboor and Jaboor 2009[2] and lee 2009 [3]) and this subject is very important worldwide, therefore, the providers are under hard pressure to find any business opportunities, without green supply chain management practices and methods. (Nishitani, 2010) [4]. The environmental performance of an organization is affected by its providers environmental performance. Also, choosing a green provider is a strategic decision for more competition in today's world market. This importance is even more significant when companies look for new markets and therefore, new providers (Kadinski et al., 2017) [5]. In past customary point of views, managing the supply chain includes guiding all members of the supply chain to improve the performance and efficiency and earning more money, but nowadays, stable development of countries is tied to protecting and using the limited and irreplaceable resources wisely. The governmental regulation to obtain environmental standards and increasing demands of the customers for green products (not damaging the environment) in the supply chain which includes all the related activities from raw material to product delivery has led to the new concept of the green supply chain management (Davari Dolat Abad et al., 2017).[6]

In other levels such as tactic levels, decisions such as current management between the facilities are analyzed. Therefore, configurating the supply chain will have certain, effective and long-term effects on other levels' decisions, resources and assets. Designing and using the supply chain network is a strategic decision which has consecutive effects for many years, and during that, the parameters of the business space (such as customers' demands) may change. Therefore, these parameters have an uncertain nature and the designed supply chain must be stable against these uncertainties. Therefore, the goal of current study is model designing of integrated multi-target green supply chain timing under uncertainty circumstances.

2- Theory basics:

2-1- The green supply chains

Researches indicate that while individuals become more aware of environment problems and the effect of their products on it, they seek to use more green products. But first we must know that realizing these environment friendly goals won't be possible without paying attention to shopping activities such as choosing suppliers. Regarding the importance of preserving environment and accepting the social responsibilities by organizations, using the international standards of the environment management has become more common among organizations (Handfield et al., 2002).

2-2- Supply chain management

Supply chain is an integrated system of related processes which include accessing the needed material and pieces, transforming the material into products, pricing the products, delivering the products, simplifying the information transfer between the parts of distributer chain, mediums and retailers (Sadeqi and Mo'meni, 1388). The main components of the supply chain management are: (Talebi and Iron, 2015): Logistic management in the supply chain, information and information system management in the supply chain, managing the relations between the members of the supply chain.

[2]Jabbour, A.B. and Jabbour
[3]Lee
[4]Nishitani
[5] Kadziński
[6] Green Supply Chain Management

2-3- The concept of green supply chain management:

Managing the green supply chain from the perspective of life cycle includes all the steps such as material, design and production, selling and transportation, using and recycling it. using the supply chain management and green technology, the company is able to decrease the negative environmental effects and obtain efficient use of resources and energy. If a company uses the green supply chain management, it will achieve relative competitive victory while solving environmental problems. Furthermore, implementing the green supply chain management could avoid the green obstacles in international business.

2-4- The integrity effect of the supply chain

The integrated supply chain could be defined as an interactive process in companies in a supply chain to achieve goals which are acceptable for all the other organizations in the chain (Nobely, 1997_/ Some aspects of the supply chain integrity have direct and positive effects on some particular aspects of performance (Klein et al,. 2010).

Supply chain management operation: In the current study the factors are divided into 3 categories: preparations, production and distribution based on the general categorization of the supply chain (Chen and Paolirdge, 2004).

The integrity effect of supply chain on the supply chain management operation: A company could share its special operational resources and technology knowledge in the organization and with other organizations via the systematic integrity of the supply chain and therefore, improve supply chain management operation (Narasimhan, 1997).

The integrity effect of the supply chain on company's performance: The integrity of the supply chain could have advantages such as stock and cost reduction and increase in information sharing and therefore, having more income and better service provision, technological innovations and product design and finally, improving the operational and financial performance of the supply chain partners.

2-5- The uncertainties in the design of the supply chain network

The uncertainty in designing the supply chain which are strengthen by the long-time horizon of the decision making is categorizable in two categories: The first category is the uncertainty related to the parameters which is divisible into two categories: systematic and environmental. The second category is for unpredicted destructive event which could greatly damage the supply chains.

The environmental uncertainties related to the uncertainty in demand and presentation are a result of the performance of the customers and suppliers. The systematic uncertainties include the existing uncertainties in the production, distribution, gathering and recycling processes (Ozgan et al, 2008). The second kind of uncertainties are a result of unpredicted events such as earthquake, flood, economical crisis and terrorist attacks. These events will lead to customers' dissatisfaction. Since they disrupt the performance of the supply chain members and product delivery will definitely by delayed.

2-6- Past researches

Talebi and Iron (2015) studied the chain supply and choosing supplier risks using the network analysis process. In this study, in line with the risk management of the supply chain, the risks of the Iranian car producing supply chain are identified, then the identified risks are considered as the criteria for choosing the suppliers and the suppliers of Zamyad car company have been categorized using the network analysis method. Zandhesami and Savoji (2012) have studied the risk management in the supply chain management. In this paper, risk management in the chain supply has been stated as one of the main responsibilities of the managers, while the concept of uncertainty in the supply chain and also identifying the risks of the supply chain and their effects are described. Based on that, the effect of the most important risks of the supply chain are listed which are: Environmental, financial resources, strategy, information and communication technology and equipment.

Yin et al,. (2012) have used a new dynamic multi variable decision maker to choose the green suppliers in construction projects. In this paper, we suggest a new dynamic multi variable decision-making method in construction projects under time series to confront these problems. This method uses the valued geometrical phase revision method using the operator tool (IVIFGWHM) and the nonlinear multi variable model to calculate the results of the general assessment of the green suppliers. Finally, a green building case study is presented to analyze the practical efficiency of the suggested method. Sarpong et al,. (2016) have done a research titles assessing the actions of the green supply chain management in the mine industry in fuzzy environment. The green supply chain management action in this study are green information technology and systems, working with suppliers, logistic and operational integrity, internal environmental management, choosing new environment-based innovation methods. The research results indicated that green information technology and systems and managing internal environment have more importance.

3- Research method

The research is an applicative one. Also, simulation is the method used to achieve the main goal. GAMS and MATLAB software's are used to achieve the goals of this paper. Robust model of the GAMS software will be used to solve the model in the uncertain mode. Since the problem is Np-hard, this model will be solved using the hyper innovative algorithms in the MATLAB software. The used algorithm is Taboo search (TS).

Data was gathered in the field and from libraries. Common methods are descriptive statistics are used in this research to calculate parameters such as average, percentage, absolute frequency, cumulative frequency and other parameters. Also, GAMS and MATLAB software's will be used to model and analyze data.

4- Data analysis

4-1- modeling

In small sizes, the demand number is between 1 and 30, in medium sizes between 30 and 80 and in cast sizes between 250 to 1000. Regarding the model implementation in MATLAB, first we must present the analyzed data (data creation, in fact) to obtain the results based on them. Therefore, we present table 1 as the problem input data (data creation).

Table 1: Problem input information

parameter	Definition:	value
N	Number of things	30
D_j	Buyer demand	1000

A_{jS}	The constant order cost of retailer (million dollars)	420
A_{jB}	The constant order cost of buyer (million dollars)	85
K_j	Palette capacity	8
f_j	The taken space	2
L_j	The lower bound of order size	250
U_j	The upper bound of order size	600
M_j	The upper bound of palette numbers for each order	400
N_e	The number of buyers	10
N_n	The number of retailers	4
N_s	Lost sells	3
Cp_e	Discount	10 to 20 percent

4-2- The simulation results

Figure 1 is the result of executing the harmony search algorithm and figure 2 is the result of executing the taboo search algorithm.

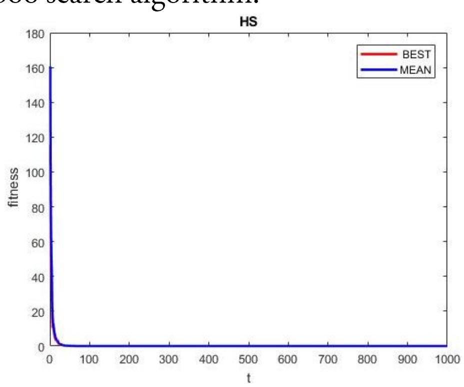


Figure 1: The convergence result of the harmony search algorithm

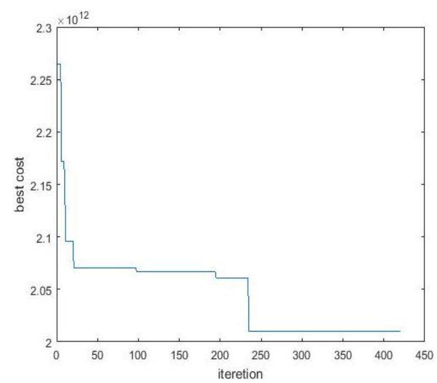


Figure 2: The result of taboo search algorithm

We have analyzed 1o models in small sizes using both search algorithms in tables 2 and 3:

Table 2: Time results in small sizes (taboo search algorithm)

sample	Product number	The number of orders	Time (second)	Gas spread (ppm)
1	2	1	2.35	350
2	2	5	4.65	384
3	2	7	6.998	399
4	3	10	7.885	450
5	3	12	9.551	459
6	4	17	13.74	632
7	4	20	16.475	885

8	4	23	19.770	935
9	5	27	23.542	1002
10	5	30	28.102	1027

Table 3: Time results in small sizes (harmony search algorithm)

sample	Product number	The number of orders	Time (second)	Gas spread (ppm)
1	2	1	3.40	362
2	2	5	5.32	397
3	2	7	7.105	421
4	3	10	8.998	469
5	3	12	10.421	479
6	4	17	15.636	704
7	4	20	18.462	910
8	4	23	21.332	936
9	5	27	25.948	1074
10	5	30	30.229	1102

The time comparison graph of both algorithms is shown in figure 3 in small sizes: In figure 4, we have compared the CO2 spread between the two algorithms.

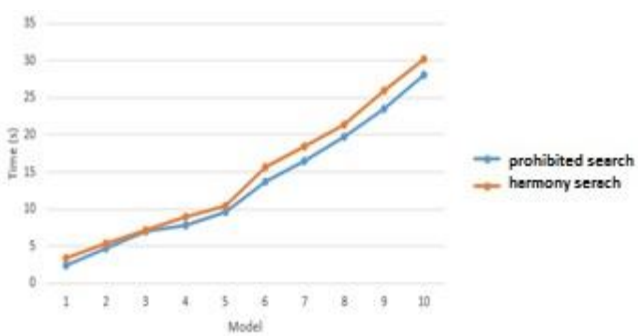


Figure 3: The execution time of the chain using two algorithms

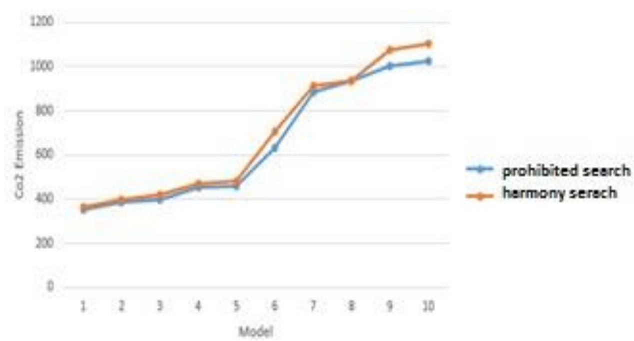


Figure 4: The CO2 spread comparison between using two algorithms

Based on figure 4, it's obvious that harmony search algorithm is 9 times faster than the taboo search algorithm. As shown in figure 4, the taboo search algorithm is 4 percent better than the harmony search algorithm.

We have analyzed 10 in medium sizes using both search algorithms in tables 4 and 5:

Table 4: Time results in medium sizes (taboo search algorithm)

sample	Product number	The number of orders	Time (second)	Gas spread (ppm)
1	6	31	8.6652	1178
2	6	35	11.472	1208
3	7	40	15.985	1321
4	7	45	18.663	1342
5	8	57	29.874	1574
6	8	61	32.412	1622
7	9	65	39.994	1700
8	12	70	42.412	1765
9	14	75	48.990	1932
10	16	80	51.062	2120

Table 5: Time results in medium sizes (harmony search algorithm)

sample	Product number	The number of orders	Time (second)	Gas spread (ppm)
1	6	31	10.221	1299
2	6	35	12.032	1368
3	7	40	17.087	1401
4	7	45	19.221	1433
5	8	57	20.145	1687
6	8	61	34.775	1710
7	9	65	42.745	1788
8	12	70	44.247	1822
9	14	75	50.664	1997
10	16	80	53.212	2241

The taboo search algorithm has better performance comparing to the harmony search algorithm in medium sizes based on the obtained results. Figures 5 and 6 show the comparison graph of the obtained results for both algorithm in medium sizes.

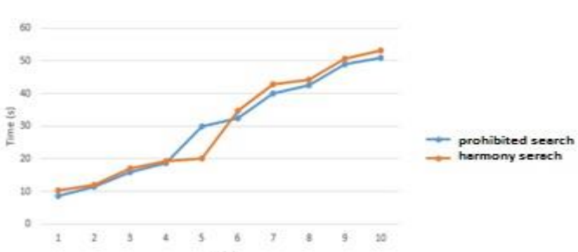
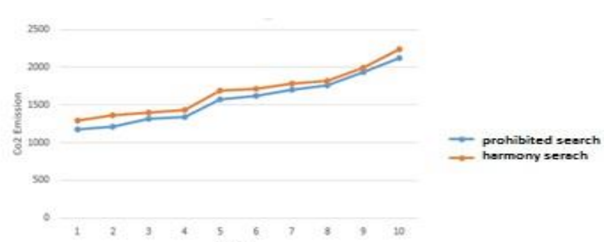


Figure 5: The execution time of the chain using two algorithms



Shape 6: The CO2 spread comparison between using two algorithms

Regarding the model solving in medium sizes, the taboo search algorithm is 1.5 percent faster than the harmony search algorithm. Also, using the taboo search algorithm, the co2 spread amount is 4.5 percent better than the harmony search algorithm.

Finally, we will solve the model for large sizes. Where the order size is between 250 and 1000. The results are presented separately in tables 7 and 8.

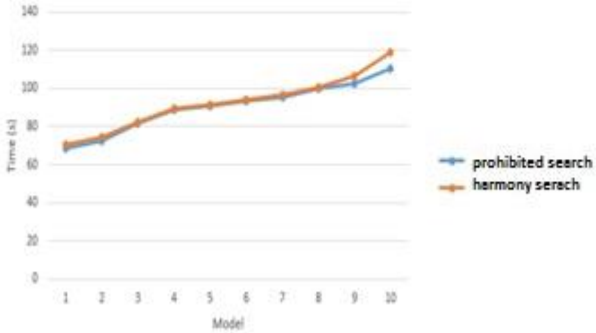
Table 7: Time results in big quantities (taboo search algorithm)

sample	Product number	The number of orders	Time (second)	Gas spread (ppm)
1	20	250	68.542	13526
2	20	300	72.332	13658
3	25	400	81.402	14002
4	30	510	88.484	14230
5	32	600	90.441	15200
6	38	650	93.221	16210
7	41	730	95.3325	16890
8	45	800	99.718	17532
9	50	900	102.332	18050
10	60	1000	110.475	19850

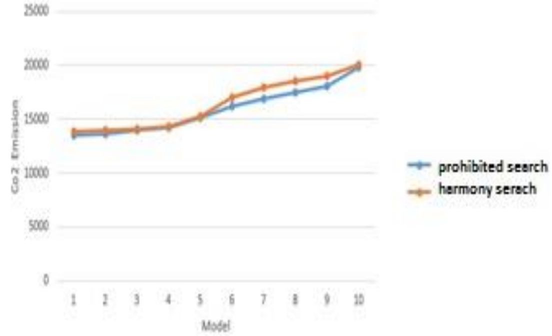
Table 8: Time results in big quantities (harmony search algorithm)

sample	Product number	The number of orders	Time (second)	Gas spread (ppm)
1	20	250	70.221	13875
2	20	300	74.547	14001
3	25	400	82.002	14124
4	30	510	89.6632	14366
5	32	600	91.554	15230
6	38	650	94.201	16995
7	41	730	96.387	17985
8	45	800	100.302	18551
9	50	900	106.554	18965
10	60	1000	118.869	20041

Figures 7 and 8 show the comparison graph of both algorithms in big sizes.



Shape 7: Comparing the execution time of the chain using two algorithms



Shape 8 : The CO2 spread comparison between using two algorithms

Based on the comparison, it is shown that the execution time, with an average of 90.227 seconds, has answered us 2 percent faster than the harmony search algorithm. Based on figure 8 which shows the co2 spread amount of both algorithms, it is shown that taboo search algorithm has 2.2 percent less co2 spread.

4-3- Sensitivity analysis

To analyze the sensitivity, we will analyze the model in small, medium and large sizes. We analyze the time and co2 spread results of Gams, harmony and taboo search algorithms.

Table 9: Time and spread results

size	item	GAMS		HS		TS	
small		time	spread	time	spread	time	spread
	3	5.24	16552	4.36	14300	3.854	14152
	6	7.854	19303	6.323	17878	5.102	16332
	8	9.232	25663	8.662	22307	7.968	17120
medium	12	-	-	12.328	25588	11.021	20352
	16	-	-	16.874	285970	15.001	24665
	18	-	-	19.885	302114	17.232	26681
large	20	-	-	23.332	321225	20.384	28968
	24	-	-	28.968	365247	26.363	32078
	28	-	-	31.204	381124	29.885	34585

Now, we use the genetics algorithm for statistical comparisons in problems with different sizes.

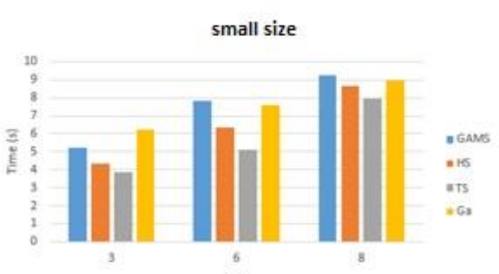


Figure 9: Time results comparison (small sizes)

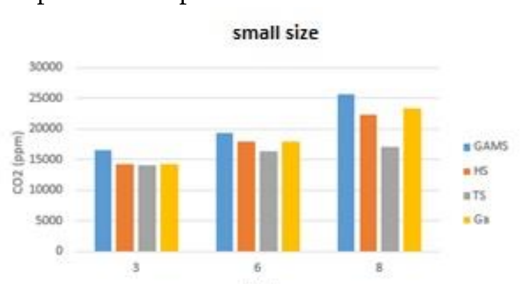


Figure 10: Co2 spread results comparison (small sizes)

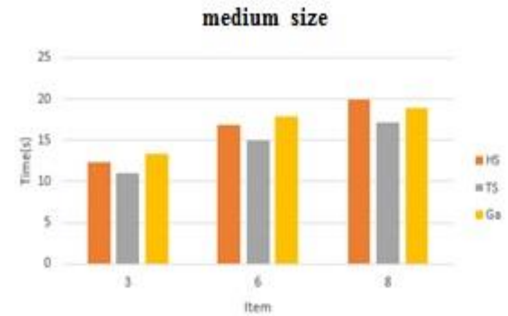


Figure 11: Time results comparison (medium sizes)

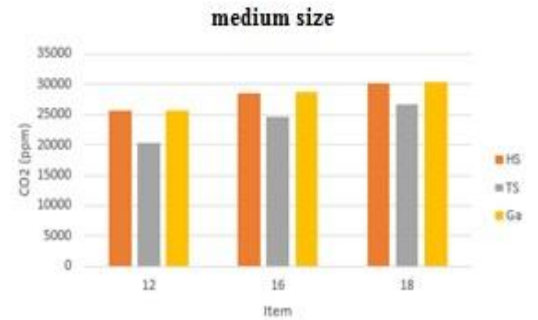


Figure 12: Co2 spread results comparison (medium sizes)

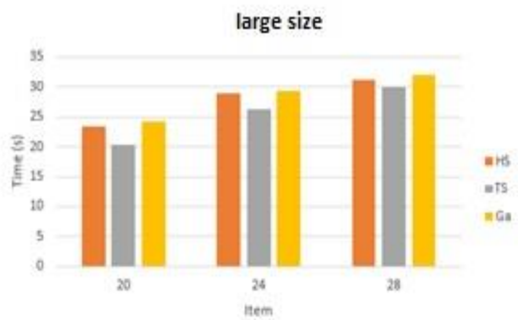


Figure 13: Time results comparison (large sizes)

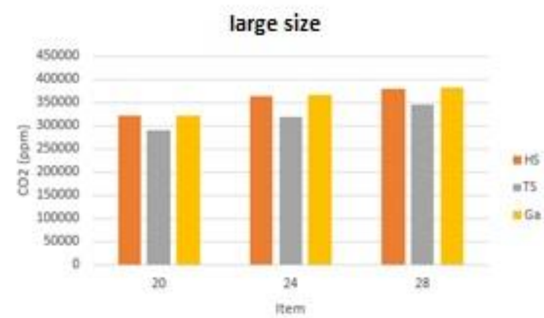


Figure 14: Co2 spread results comparison (large sizes)

The obtained results show the high efficiency of the taboo search algorithm in both fields of time and spread.

5- Conclusion:

Considering the simulation and obtained result in figure 1, we can conclude that the convergence of the harmony search algorithm has reached optimal state after several repetitions. Regarding figure 2 which is the result of taboo search algorithm, we can conclude that we have achieved the bet timing and cost between the service provider and the customer which will be obtained after 250 repetitions.

In this study, the hyper innovative algorithm such as harmony search and taboo search and also genetics have been implemented which have optimized the model answer. Also, we have implemented the problem parameters in GAMS software to present and solve a numerical example. Also, the sensitivity analysis of the input parameter will reveal the effect of parameters on the whole model.
Sensitivity analysis has been done using the GAMS and MATLAB software's using the said algorithm in three small, medium and large sizes, it's important to say that the problem is Np-hard and therefore, the medium and large sizes were not implementable in Gams software and only the small model was solved for this problem. The initiation time and co2 spread amount were assessed for each 3 methods and the results showed that the presented model has had better efficiency in the MATLAB software than the Gams software. The results indicated the better performance of the taboo search algorithm comparing to the harmony search algorithm. Analyzing all of the results, we see that the taboo search

algorithm is better than the harmony and genetics algorithm because it makes the time and cost to be optimized easier and faster.

5-1- Applicative suggestions

- Considering a more suitable criteria to calculate the navigation costs such as time, since situation such as car crashes and traffic make transport cost per distance an incorrect unit.
- Considering a backup cover for distribution centers such that if a product was unavailable, it could be received from other centers with a fine.
- Considering the transportation system between the factory and the customer, if the customer has a big demand rate.
- considering the disruption in machinery capacity due to reasons such as robbery or assault, also considering disruption on the way which could happen due to natural causes or planned operations such as flood, earthquake or unpredicted events.

Resources

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