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A Genetic Algorithm-Based Method for Optimizing the Distribution Path of Agricultural Products in Cold Chain

Lili Wang[1,✉]

[1] *Shandong Vocational College of Light Industry, Zibo, Shandong, 255300, China*

ABSTRACT

Aiming at the problems of large carbon emission and high vehicle transportation cost in the cold chain distribution process of agricultural products, an optimization method of cold chain distribution route of agricultural products based on genetic algorithm was proposed to reduce the transportation cost and improve the efficiency. Firstly, taking carbon emission cost and transportation cost as the objective function, carbon tax mechanism analysis was introduced, and demand, demand time and transportation time were considered to model the research problem. Then an improved genetic algorithm is proposed, which combines the traditional genetic algorithm with the multi-chromosome method, and uses the information updating strategy of ant colony algorithm to maintain the memorability of the population. The results show that this method can optimize the distribution route and reduce the distribution cost.

Keywords: Cold chain distribution path, Agricultural products, Genetic algorithm, Multi-chromosome method

1. Introduction

In order to ensure that consumers purchase products that meet the product quality standards[1-3]. According to statistics, China's cold chain logistics demand reached 104.88 million tons in 2014, representing a 19 percent increase over the previous year and amounting to up to 3.8 trillion yuan in total. However, China's cold chain logistics coverage rate is only 20%, a far cry from the developed countries' 90 percent coverage rate. Individuals have been forced into the Internet + age in recent years, as a result of the development and promotion of the use of information technology, as well as the widespread implementation of e-commerce. A self-regulatory declaration on the theme of China's attitude from the heart was released on 3 February 2016 in Shanghai by representatives from the poultry, meat, aquatic goods, seafood, and fruit industries, as well as representatives from the Internet fresh industry[4-5]. This means that the large corporations will enter the Internet fresh

✉ Corresponding author.
E-mail address: lili_1214@126.con (L. Wang).

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market in a comprehensive manner, laying the groundwork for the long-term, healthy development of the Internet fresh sector. Alibaba, Jingdong, and SF have all begun the process of establishing rural fresh food cold chain distribution networks in the hopes of securing a position in an industry with promising expansion potential[6-10].

As the Internet + era begins, information technology will become an important tool, and the development of e-commerce has also injected new vitality into the development of the agricultural industry, particularly fresh agricultural products in poor and remote areas, if the cold chain logistics and distribution system is perfected, it will change the situation in which good products are unable to reach the market. However, due to the fact that the majority of fresh agricultural goods are produced in wide rural areas, the usage of information technology in rural areas is still considered to be rather behind[11-12]. A number of difficulties exist, including outdated communication infrastructure construction, insufficient information coverage, and sluggish Internet speeds in rural areas[13]. The level of information technology used in fresh agricultural goods cold chain logistics and distribution must keep up with the development of the times, in order to be able to adapt to the creation of a complete cold chain logistics information network. For the purpose of optimizing and integrating cold chain logistics resources in the region, it is necessary to build a cold chain distribution (CCD) system in order to enhance connectivity between the chains[14-18]. To establish a website for fresh agricultural products cold chain distribution in order to disseminate the development status, information, and future prospects of the industry through the network in a timely manner, so that the vast majority of agricultural products producers can grasp relevant information in a timely manner and actively prepare for the production and sale of agricultural products[19-20].

High energy consumption and high carbon emission characteristics are characteristic of the CCD of agricultural products. As a result, it is critical to understand how to optimize the CCD path in order to reduce carbon emissions and transportation expenses[21-24]. Dantzig made the first formal proposal for the vehicle path problem in 1959[25-27]. This is why some scholars believe that vehicle distribution must take into account the impact of time spent; they consider soft time window to establish VRP model, or consider just-in-time logistics distribution to establish vehicle distribution model, while others consider working time and soft time window and integrate vehicle departure time, vehicle speed, and vehicle capacity to establish dual-objective vehicle path model on the basis of these considerations[28-29].

China's agricultural output and trade play a significant role in the country's economy, and the growth of agricultural product logistics can help to accelerate the development of Chinese agricultural production. Because of the ongoing improvement of China's national economy, the living standards of its citizens are also rising[30-33]. The notion of consumption has radically altered in recent years, and customers' expectations for the quality and timeliness of agricultural products are increasing. In turn, this has resulted in Chinese agricultural products lacking competitive advantages on the global market. China's national economy and living standards are improving, and people are placing more demands on the quality of their lives. Consumer demand is also increasing in the country. In tandem with the transformation of production and lifestyle, the production method for agricultural products has also undergone significant transformation, and the production and distribution of agricultural products that are free of pollution have attracted the attention of the entire society[34-35].

An introduction to a quantitative analysis of the carbon tax mechanism is provided in this paper, which takes into account demand quantity, demand time, and unloading time limitations, in addition to the mathematical model, in order to maintain population memorability, an improved genetic algorithm is proposed, which combines the standard genetic algorithm with the multi-chromosome approach and makes use of an ant colony algorithm information update strategy. After that, based on the selected mathematical model, the proposed method is validated by experimental simulation to effectively optimize the distribution path while simultaneously reducing the carbon tax cost.

2. Agricultural products CCD model and related theory

2.1. Distribution Model

The research problem in this paper can be modeled as

$$\begin{aligned}\min Z &= Z_1 + Z_2 + Z_3 \\ &= C_1 \sum_{j=1}^{N}\sum_{k=1}^{N} x_{jk} + C_2 \sum_{j=0}^{N}\sum_{k=0}^{N}\sum_{i=0}^{N} d_{ij}x_{ijk} + \alpha \sum_{j=0}^{N}\sum_{i=0}^{N} FC_{jk} \\ &+ \alpha\left(C_{11} + C_{12}\right) + \beta \sum_{j=1}^{N} \max\left\{E_j - t_j, 0\right\} + \varepsilon \sum_{j=1}^{N} \max\left\{E_j - L_j, 0\right\} \\ &+ \lambda \sum_{i=1}^{N} \max\left\{E_j - L_j, 0\right\}\end{aligned} \tag{1}$$

and the constraints are as follows:

$$\sum_{i=1}^{N} q_i y_{ik} \le Q, \forall K \tag{2}$$

$$\sum_{k=1}^{N} y_{ik} = 1, \forall K \tag{3}$$

$$\sum_{i=0}^{N} x_{ijk} = y_{ijk}, \forall j, k \tag{4}$$

$$\sum_{j=0}^{N} x_{ijk} = y_{ik}, \forall j, k \tag{5}$$

$$\sum_{i,j \in \ne x}^{N} x_{ijk} \le |s| - 1 \tag{6}$$

$$W_j = W_i + \max\left(e_i - W_i, 0\right) + x_i + t_{i,j} \tag{7}$$

$$W_0 = 0, i \ne j \tag{8}$$

$$t_j = t_i + t_{ij} \tag{9}$$

2.2. Cost Analysis

In equation (1), Z_1 represents the comprehensive transportation cost, as shown in equation (10):

$$Z_1 = C_1 \sum_{j=1}^{N}\sum_{k=1}^{N} x_{jk} + C_2 \sum_{j=0}^{N}\sum_{k=0}^{N}\sum_{i=0}^{N} d_{ij}x_{ijk} \tag{10}$$

α is carbon tax factor, and Z_1 represents the cost of carbon tax, which is as shown in equation (11):

$$Z_2 = \alpha \sum_{j=0}^{N}\sum_{i=0}^{N} FC_{jk} + \alpha\left(C_{11} + C_{12}\right) \tag{11}$$

C_{11} and C_{12} are transport refrigeration and unloading refrigeration costs, respectively, as shown in the following equation:

$$C_{11}=\sum_{k=1}^{N}\sum_{i=0}^{N}y_{ik}Pq_{i}\left(1-e^{-\sigma_{1}\left(t_{i}^{k}-t_{0}^{k}\right)}\right) \tag{12}$$

$$C_{12}=\sum_{k=1}^{N}\sum_{i=0}^{N}y_{ik}Pq_{m}\left(1-e^{-\sigma_{2}\left(t_{i}^{k}-t_{0}^{k}\right)}\right) \tag{13}$$

where σ_i is attenuation coefficient?

Z_3 represents the time penalty Cost, which is shown in equation (14):

$$\begin{aligned}Z_{3}=\beta\sum_{j=1}^{N}\max\left\{E_{j}-t_{j},0\right\}+\varepsilon\sum_{j=1}^{N}\max\left\{E_{j}-L_{j},0\right\}\\+\lambda\sum_{i=1}^{N}\max\left\{E_{j}-L_{j},0\right\}\end{aligned} \tag{14}$$

2.3. The current situation of CCD of agricultural products

1) Policies and regulations related to the CCD of fresh agricultural products need to be improved. There is a significant demand in China for fresh agricultural products CCD (FAPCCD), and a large number of enterprises have entered this industry to meet that need. Without appropriate laws and regulations, however, the market will develop on its own and eventually devolve into anarchy and fierce competition, as has happened in the past. The government should, as a result, actively participate in the reform of key rules and regulations to ensure that FAPCCD is properly protected during the construction and operation phases of the project. In part because, as we all know, the development of China's FAPCCD business is still in its early phases, the Chinese government has not established a relatively clear overall plan for the development of this industry, nor has the government implemented proper rules and regulations. Additional laws and regulations have been enacted, but their implementation has fallen short and they have become largely a formality in the eyes of the public. For example, FAPCCD has been legislated, but in the actual operation process, there is insufficient supervision, which leads to some enterprises speculating and affecting the quality of product distribution; FAPCCD performance evaluation indicators have been introduced, but there is no comprehensive and detailed classification of various types of agricultural products, even though the performance of all aspects of the distribution appears to provide evaluation criteria, but there is no comprehensive and detailed classification of agricultural products; FAPCCD performance evaluation indicators have been introduced, but there is no comprehensive and detailed classification As a result of a lack of systematic and coherent evaluation, the distribution hardware and equipment, the level of information technology, and the quality of after-sale service of products are not included in the evaluation index system, resulting in inaccurate results for the performance evaluation. The government should also take the lead in developing a linkage mechanism with businesses and industry organizations to establish an alliance system that will optimize and integrate CCD resources for fresh agricultural products throughout the region, as well improve the utilization efficiency of CCD resources. By collaborating with leading third-party logistics companies, we can actively promote the introduction of third-party logistics, improve the overall quality of third-party logistics services, emphasize the benefits of third-party logistics services, and promote the improvement of FAPCCD levels throughout the region.

A proper logistics information service system has not yet been established in some rural parts of China, and the necessary infrastructure is absent. At the moment, telephone communication is the primary means of contacting logistics vehicles and obtaining distribution information. Due to the relatively low literacy level of farmers in the rural areas where the XieLiu network platform has been established, it is difficult for them to effectively use information technology. This is compounded by a lack of technical training and guidance from the government and relevant departments, resulting in low utilization of the website. As a result, there is a lag in the collection and aggregation of information on agricultural products, affecting the judgment of farmers on the market. As a result, there are times when the supply exceeds the demand, and income declines even if production increases, resulting in fluctuations in the agricultural market and the stagnation of farmer-produced goods and services.

2) The industry standard for fresh agricultural goods CCD must be raised to a higher level of excellence. The 21st Century Business Herald published a news article on January 29, 2o16, stating that "industry data shows that only 1 percent of the country's 4,ooo fresh produce e-commerce companies made a profit in 2o14, and the important reason for the loss is that most fresh produce e-commerce companies have steeply increased costs due to self-built CCD. China Railway Corporation, for example, even though it possesses a large number of professional refrigerated special cars, does not have any. Additionally, since 2o1o, e-commerce platforms such as COFCO.com and Daily Orchard have made significant financial investments in their respective FAPCCDs. It is difficult for new e-commerce businesses to establish their CCD infrastructure. If you want to achieve cross-regional agricultural products FAPCCD perfection, according to Central Document No. 1, you must conduct FAPCCD standardization demonstrations and implement the special agricultural products production area pre-cooling project, which are both detailed in Central Document No. 1. All that is required is the standardization of industry standards to encourage smooth integration ofthe complete FAPCCD system.

At present, individual farmers in China are responsible for the majority of the agricultural product production and processing, which is characterized by its decentralized nature. The entire process, from the production of agricultural products to the sale of those items, is comprised of various nodes, each of which cooperates with the others to promote the development of the industry. There are many participants in each node upstream of the industry, which exhibits many-to-many distribution characteristics, whereas each node downstream of the industry gathers many parties for procurement, which is mostly in the form of many-to-many distribution. The complexity of the distribution chain is ultimately generated by the inadequacies in the scale and degree of organization of agricultural output, which are both factors to consider. As a result of the low degree of mechanization, there are high-cost expenses for agricultural product transportation, including excessive prices for loading and unloading labor as well as transportation, storage, and circulation losses, all ofwhich will have an impact on logistics costs.

At the moment, the relevant departments are unable to pay sufficient attention to the critical role played by agricultural product distribution, due to a lack of a more comprehensive market supervision and management system, as well as a lack of preferential policies to assist farmers. There have been difficulties in diversifying agricultural product distribution services, which has resulted in a drop in the excitement for agricultural product distribution. Some agricultural products distribution companies, influenced by the market, place too much emphasis on short-term interests and only use low prices as a means of obtaining customer orders through low prices and unregulated services, which destroy the rules of the agricultural products distribution business and reduce the trust of sub-consumers. Furthermore, the lack of training for business personnel in agricultural products distribution companies overlooks the critical role that talents play in the development of the agricultural products distribution industry, which is detrimental to the development ofthe agricultural products distribution industry.

3) It is necessary to improve the technology and infrastructure for the distribution of fresh agricultural products in the cold chain. It is essential that the development of the contemporary FAPCCD industry is supported by high-quality and high-standard infrastructure. First and foremost, we must aggressively research and develop modern cold storage technology to ensure that the cold storage standards of agricultural goods during the storage and transportation stages are up to

standard and that the technology is low in consumption, non-polluting, and efficient. Professional and modern transportation means should be used in the course of the FAPCCD, and the transportation department should open a green channel for it. The government should also invest in product preservation technology to ensure that fresh agricultural products remain as fresh as possible. To supply consumers with agricultural products of the highest possible quality. We should also establish a standardized operation method that is specific to the many types of agricultural products that will be transported, and we should target the employment of bulk technology and collecting technology for each type of agricultural product. The packaging of fresh agricultural products should also encourage the use oftechnically mature high-density polyethylene food fresh produce transportation crates to ensure that both the packaging environment and the quality of the fresh produce are not adversely influenced. In light of the dispersed origin of fresh agricultural products, we should also actively develop and apply logistics and distribution technology with many varieties, small batches, and high frequency, to promote the improvement of product distribution capacity and distribution capacity, as well as to promote the improvement of product distribution capacity. At the moment, China's FAPCCD infrastructure construction in the aforementioned areas is being bolstered even further. At the same time, we must increase investment in the construction of hardware facilities, accelerate the development of software environments, and conduct research and development in CCD technology to provide strong support for the development of the fresh agricultural logistics industry.

3. Our method

It is possible that the quality of the solution will be compromised when using a typical genetic algorithm to address several constraints, or that there will be no solution at all. A combination of the multi-chromosome approach and a genetic algorithm, which has higher performance in handling numerous constraints, is presented in this study. This combination helps to avoid the development of invalid and even unlawful solutions.

The following are the fundamental assumptions underpinning the model:

1) Even though there is just one distribution center with a well-known location, there is no lack of items available.

2) All distribution vehicles have the same model, have the same load capacity, and are equipped with refrigeration, which allows them to maintain the temperature necessary for their respective cargo.

3) All distribution vehicles begin and conclude their journeys at the distribution center; they do not make any stops along the way, and the travel path is uninterrupted.

4) The location of all customer points, the demand for their products, as well as a soft time frame for mandatory delivery, are all known.

5) The items are all of the same types of agricultural products that must be stored at the same temperature.

6) In addition, vehicle fuel consumption is proportional to the vehicle's actual load capacity, and the total demand from each customer location along each delivery route must not exceed the maximum load capacity of a single-vehicle.

7) The vehicle assigned to each customer point is the same and only one vehicle, and each vehicle can deliver to many customer locations.

There is only one delivery route for each CCD vehicle, and each destination location can only be served by a single CCD vehicle at a time. The following are the codes for the various destinations and vehicles:

$$sum = \sum_{m=0}^{h} K^{m} \tag{15}$$

Equation (15) represents the sum of the number of models, and the chromosomal order of vehicle sequences is coded as. The chromosome order of the distribution route sequence is coded as $Seq_2 = \{0,1,2,\cdots,n\}$ the number of customer points is, and 0 represents the distribution center.

After the encoding process has been completed. This is illustrated in Figure 1 by randomly initializing the distribution path sequence chromosome followed by a subsequent random initialization of the vehicle sequence chromosome corresponding to it. When a vehicle sequence chromosome is present, it represents the available vehicles and the order in which they will be used; when a distribution path sequence chromosome is present, it indicates the order in which customers will be served at the distribution locations.

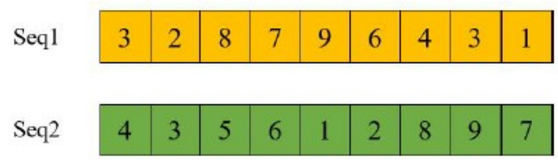

Fig. 1. Chromosome initialization

The merit of a person is determined by his or her appropriateness for the task at hand. It determines whether or not a certain individual will be allowed to continue in the iterative process. The distribution task is organized and the fitness is determined based on the individual's distribution path sequence chromosome and vehicle sequence chromosome, and the procedure is depicted as follows:

1) To maximize the number of customer points delivered to the ith individual in the population, first select an available vehicle based on its vehicle sequence chromosome. Then, choose as many customer points as possible along the vehicle's distribution path sequence chromosome, ensuring that the total number of points delivered does not exceed the vehicle's rated capacity.

2) Check to see if all of the customer points in the distribution path sequence chromosome have been delivered, if there are still customer points to be delivered, return to (1), and if there are no more customer points to be delivered, go to (3).

3) Following completion of the work assignment, produce the distribution plan for the ith individual in the population and calculate the total cost based on the formula (1).

4) Consider the cost that corresponds to the ith individual, and denote, where is the adaption degree of the ith individual.

This algorithm is used in this paper. A total of two chromosomes are present in each individual within the population: the distribution path sequence chromosome and the vehicle sequence chromosome. As illustrated in Figure 2, the crossover mechanism for chromosomes is called PMX.

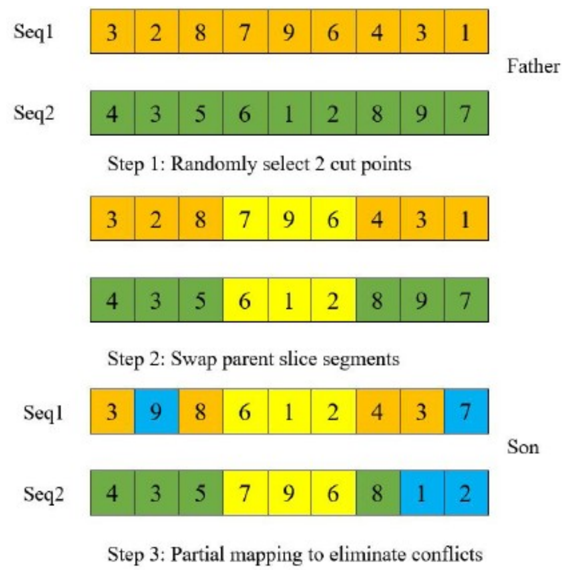

Fig. 2. Chromosome cross

The chromosomes encoding the distribution path sequence and the chromosomes encoding the vehicle sequence were modified individually in accordance with the mutation probability. The 2-opt algorithm for mutation operation in the chromosomes of individuals is used in this procedure, as illustrated in Figure 3.

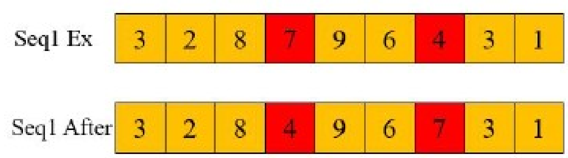

Fig. 3. Chromosome cross

4. Experiment results

Specifically, eight supermarkets of logistical distribution from the literature are chosen as service sites in this work, and the real distribution data from the literature is used as experimental parameters. The number of transportation centers is zero, and the number of supermarket client points is one, two, three, four, five, six, seven, eight. Table 1 shows the complete information on demand for supermarket customer points based on the supermarket customer points.

Table 1. The detailed demand information of supermarket customer points

Number	Customer point coordinates km	Customer Demand t	Unloading time min
0	(0,0)		
1	(50,50)	2.5	15
2	(60,120)	3	18
3	(35,45)	3.3	30
4	(33,42)	6	60
5	(55,52)	6.5	65
6	(58,130)	4.2	40
7	(95,150)	1.8	20
8	(13,35)	6.8	45

The optimal distribution path with different objectives is shown in Figure 4 and Figure 5.

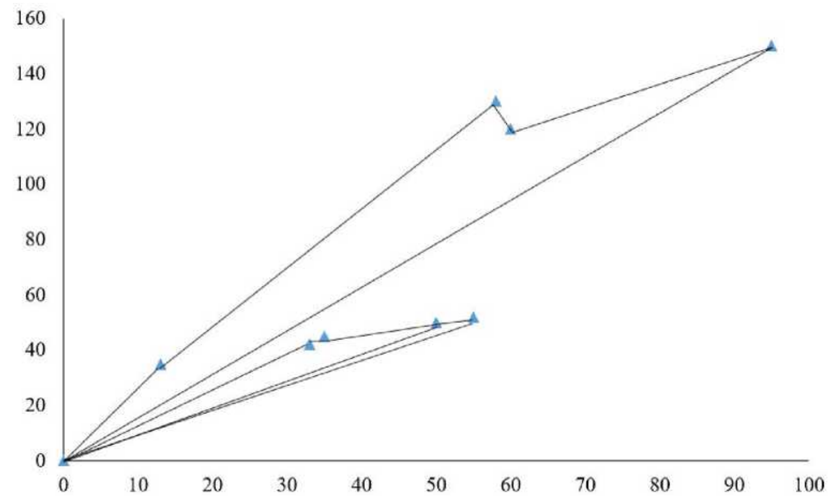

Figure 4 The path with the lowest carbon tax cost

Fig. 4. The path with the lowest carbon tax cost

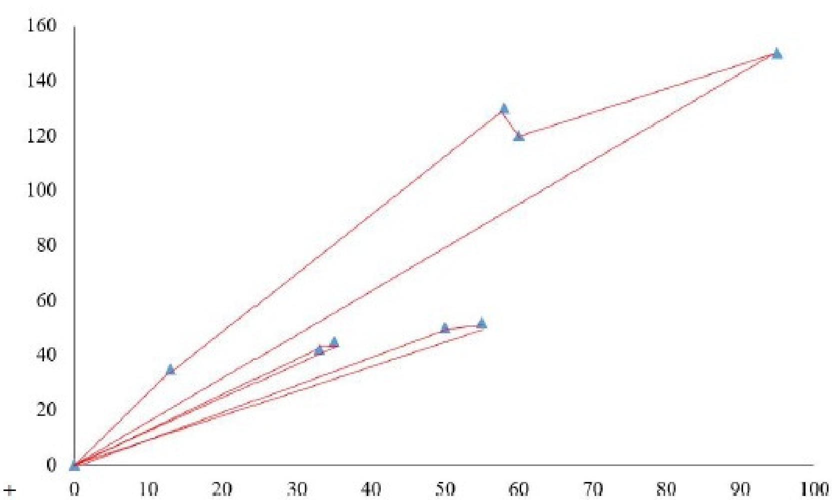

Fig. 5. The path with the shortest distribution time

From the study in Figure 6, it is obvious that the shortest distribution path does not necessarily lead to a reduction in carbon tax cost and overall cost. The experimental results demonstrate that although the distribution path grows by 12.3 percent under the carbon tax model, the overall cost falls by 4.5 percent, and the carbon tax cost decreases by 9.6 percent, which supports the validity ofthe model.

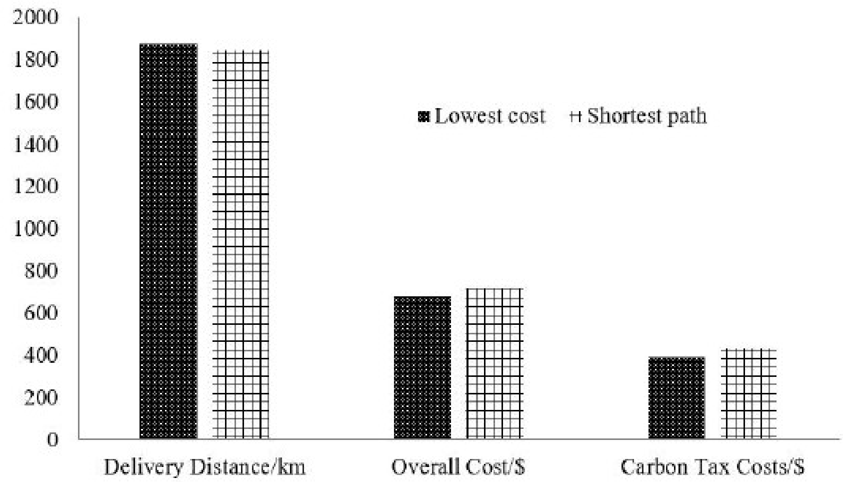

Fig. 6. Comparison of results for different objective functions

Using the following experimental parameters, the carbon tax cost and comprehensive cost of this paper's algorithm are compared and assessed with ACT algorithm and QACT algorithm, and the method is compared after randomizing 20, and the experimental results are displayed in Figure 7

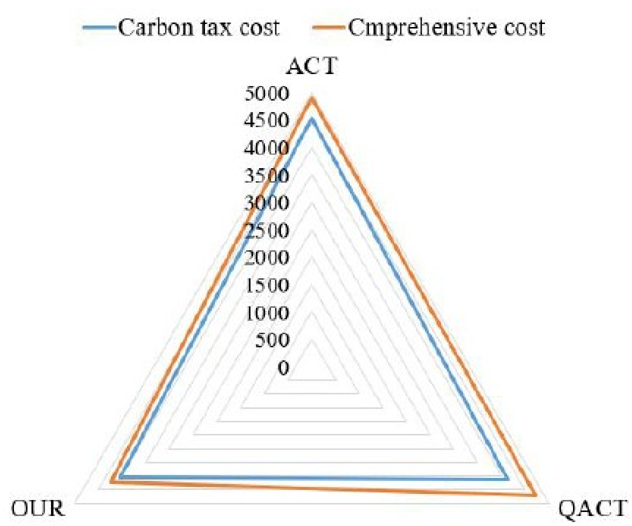

Fig. 7. Comparison of different methods with different costs

5. Conclusion

The reform of higher mathematics teaching in colleges and universities is influenced by multiple factors, making it a prominent area of current research. To improve the quality assessment of these reforms, big data technology is incorporated, leading to the proposal of a new evaluation method based on a big data-driven information model. The approach begins with a review and analysis of existing literature on the quality assessment ofhigher mathematics teaching, identifying the key factors that influence quality. Next, data on these influencing factors is collected, and a model combining BPNN and DC is developed to optimize the quality evaluation. The findings demonstrate that the proposed model is both highly precise and efficient, offering significant value for assessing the quality of higher mathematics teaching reform with broad applicability.

Reference

[1] Kiraly A, Abonyi J. Optimization of multiple traveling salesmen problem by a novel representation based genetic algorithm[M]//Intelligent computational optimization in engineering. Springer, Berlin, Heidelberg, 2o11: 241-269.

[2] Gen M, Cheng R, Lin L. Network models and optimization: Multiobjective genetic algorithm approach[M]. Springer Science & Business Media, 2oo8.

[3] Kiraly A, Farsang B, Chovan T, et al. Minimization of Off-Grade Production in Multisite Multiproduct Plants by Solving Multiple Traveling Salesman Problem[J]. CHEMICAL ENGINEERING, 2014, 39.

[4] Saleem R, Suer G A, Huang J. Dual-stage genetic algorithm approach for capacitated lot sizing problem[J]. International Journal of Advanced Operations Management, 2013, 5(4): 299-319.

[5] Gao Z, Ye C. Reverse logistics vehicle routing optimization problem based on multivehicle recycling[J]. Mathematical Problems in Engineering, 2021.

[6] Bagherinejad J, Shoeib M. Dynamic capacitated maximal covering location problem by considering dynamic capacity[J]. International Journal of Industrial Engineering Computations, 2018, 9(2): 249-264.

[7] De Santis E, Rizzi A, Sadeghian A. Hierarchical genetic optimization of a fuzzy logic system for energy flows management in microgrids[J]. Applied Soft Computing, 2017, 60: 135-149.

[8] Evans D L, Hlongwane T T, Joshi S V, et al. The sugarcane mitochondrial genome: assembly, phylogenetics and transcriptomics[J]. PeerJ, 2019, 7: e7558.

[9] Zhao W, Wang J, Yu D, et al. Prediction of daily pollen concentration using support vector machine and particle swarm optimization algorithm[J]. International Journal of Performability Engineering, 2018, 14(11): 2808.

[10] Abdul-Rahaim L A. Design and simulation of Proportional-Derivative Controller of A servo systems based on Fuzzy Logic and Hybrid Fuzzy Neural[J]. Journal of University of Babylon, 2012, 20(1).

[11] Kulcsar T. Adatbanyaszati es gepi tanulasi algoritmusok szoftver szenzorok fejlesztesere= Data mining and machine learning algorithms for soft sensor development[D]. Pannon Egyetem, 2017.

[12] Zhang L, Fu M, Fei T, et al. Application of FWA-Artificial Fish Swarm Algorithm in the Location of Low-Carbon Cold Chain Logistics Distribution Center in Beijing-Tianjin-Hebei Metropolitan Area[J]. Scientific Programming, 2021, 2021.

[13] Liang K, Zhang W, Zhang M. Optimization model of cold-chain logistics network for fresh agricultural products—taking guangdong province as an example[J]. Journal of Applied Mathematics and Physics, 2019, 7(03): 476.

[14] Wei R. The Optimization of Distribution Path in Cold Food Chain Based on Genetic Algorithm[J]. Frontiers in Economics and Management, 2020, 1(8): 54-67.

[15] Zhang Y, Ge X. Study on risk assessment modeling and solution method of fresh agricultural products cold chain logistics[C]//Journal of Physics: Conference Series. IOP Publishing, 2019, 1324(1): 012020.

[16] Zhang Z, Huang J, Cao S. Marine cold chain transportation monitoring and route scheduling optimization based on IoV-BDS[J]. IEEE Access, 2021, 9: 20557-20574.

[17] Wang Y. Cost Optimization of Cold-Frozen Pork Cold Chain Distribution System[J]. Revista Cientifica de la Facultad de Ciencias Veterinarias, 2020, 30(1): 497-508.

[18] Leng L, Zhang J, Zhang C, et al. A novel bi-objective model of cold chain logistics considering location-routing decision and environmental effects[J]. PloS one, 2020, 15(4): e0230867.

[19] Zhang L. Research on Optimizing the Distribution Path of Agricultural Cold Chain Logistics in Green Consumption Era[J]. Scientific Journal of E-Business, 2o19, 8.

[20] Khan S, Khan M I, Haleem A. Towards effective management of cold chain: A DEMATEL approach[C]//IOP conference series: materials science and engineering. IOP Publishing, 2o18, 4o4(1): o12o19.

[21] Lorenc A, Czuba M, Szarata J. Big data analytics and anomaly prediction in the cold chain to supply chain resilience[J]. FME Transactions, 2o21, 49(2): 315-326.

[22] Hu B, Huang B, Liu Z, et al. Optimization Model of Carbon Footprint of Fresh Products in Cold Chain from the Energy Conservation and Emission Reduction Perspective[J]. Mathematical Problems in Engineering, 2o21.

[23] Li Y, Li C. Research on cold chain logistics distribution path optimization based on real-time road condition information[C]//2o21 13th International Conference on Intelligent Human-Machine Systems and Cybernetics (IHMSC). IEEE, 2o21: 19o-195.

[24] Sujaree K. Artificial Carbon Nanotube Synthesis Optimization to Address the Vaccine Cold Chain Network Problem[J]. International Journal of Modeling and Optimization, 2o2o, 1o(1): 32-4o.

[25] Boyang Z. Research on Dynamic Path Planning of Cold Chain Logistics Based on Bp Neural Network Optimization[J]. Solid State Technology, 2o2o, 63(4): 5638-5646.

[26] Wang X, Cao W. Research on optimization of distribution route for cold chain logistics cooperative distribution of fresh e-commerce based on price discount[C]//Journal of Physics: Conference Series. IOPPublishing, 2o21, 1732(1): o12o41.

[27] Wang X, Cao W. Research on optimization of distribution route for cold chain logistics cooperative distribution of fresh e-commerce based on price discount[C]//Journal of Physics: Conference Series. IOPPublishing, 2o21, 1732(1): o12o41.

[28] Liu Y. Design of Dynamic Programming Model for Multi-Objective Cold Chain Logistics Deployment Path Based on Meme Algorithm[J]. Iranian Journal of Science and Technology, Transactions of Civil Engineering, 2o21: 1-8.

[29] Li L X, Yang Y, Qin G Y. Analyzing the Impact of Vehicle Speed on Distribution Cost for Cold Chain Logistics[C]//2o19 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM). IEEE, 2o19: 263-267.

[30] Vakili P, Hosseini-Motlagh S M, Gholamian M R, et al. A developed model and heuristic algorithm for inventory routing problem in a cold chain with pharmaceutical products[J]. Industrial Management Journal, 2o17, 9(2): 383-4o7.

[31] Hsiao Y H, Chen M C, Chin C L. Distribution planning for perishable foods in cold chains with quality concerns: Formulation and solution procedure[J]. Trends in food science & technology, 2o17, 61: 8o-93.

[32] Ma Q, Ma B, He Y, et al. An optimization approach to the scale of port cold-chain dedicated terminals considering uncertainties[J]. Engineering Optimization, 2o21: 1-16.

[33] Bamakan S M H, Moghaddam S G, Manshadi S D. Blockchain-enabled pharmaceutical cold chain: Applications, key challenges, and future trends[J]. Journal of Cleaner Production, 2021, 302: 127021.

[34] Zhao W, Zhou X, Shi J, et al. Research on Multi-Objective Optimal Design of Plate Heat Exchanger in Nuclear Power Plant Cold Chain System[C]//International Conference on Nuclear Engineering. American Society ofMechanical Engineers, 2021, 85246: V001T02A014.

[35] Ren X Y, Chen C F, Xiao Y L, et al. Path optimization of cold chain distribution with multiple distribution centers considering carbon emissions[J]. Appl. Ecol. Environ. Res, 2019, 17: 9437-9453.