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ORIGINAL CONTRIBUTION

Study on the Cost Control of Enterprise Activity Chain Based on Big Data

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Abstract The control of cost expenditures during the operation of enterprises is crucial. This paper briefly introduces the big data-based model for activity chain cost management. A back-propagation (BP) neural network was used to process big data. Resource data were classified into respective activity centers. Then, company X, which is engaged in logistics in Hefei Economic Development Zone, Anhui Province, was analyzed. The big data-based activity chain cost management model was compared with the traditional cost method. The results showed that the accounting costs of the three contracts obtained by using the traditional cost method were the same and the traditional method significantly underestimated the cost of Contract A (small tomatoes), but overestimated Contract B (cherries) and Contract C (red dates). The cost proportion of goods transportation was the largest in all three logistics contracts. In order to reduce the proportion of distribution costs in Contracts B and C, negotiating with customers to adjust the single transportation volume was proposed. After implementing the operational chain cost method, company X had significantly reduced logistic costs and significantly increased revenue.

Keywords Big data · Activity chain cost · back-propagation · Traditional cost method

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Introduction

In modern social development, the exchange of information is becoming more and more important, for both individual and collective development. The more timely and effective the sharing of information is, the greater its role in individual or collective development is [1]. Especially for companies, groups gathered for common interests, information sharing and exchange between internal and external parties play an important role in the development of companies. The big data are superficially generated from daily information exchange and resource sharing in enterprise development [2] but need to be mined to summarize valuable information for enterprise development. The cost of managing the activity chain in the development process is inevitable. For an enterprise, its profit is obtained by subtracting the cost from the revenue, which means that if an enterprise wants to improve the profit, it has to improve the revenue volume or compress the cost [3]. Excellent business operation management can reduce management costs while improving operational efficiency. Rezaie et al. [4] studied the feasibility of implementing the operation costing method in the nursing department of social security institutions. The results showed that it was feasible to implement and sustain the activity-based costing method in the nursing department of social security institutions. Tchamdja et al. [5] used the activity costing method to analyze the daily hospitalization costs in the neonatal unit of the main hospital in Dakar. The results showed that a more detailed and accurate estimation of activity and service costs could be achieved using the activity-based costing method. Fu et al. [6] proposed an activity-based costing method for estimating the ecological costs of split air conditioners. The simulation results showed that the proposed method could estimate the ecological costs of air conditioning systems, thus helping air conditioning companies to improve their

competitiveness in a future where energy saving and emission reduction are increasingly important. This paper briefly introduces a big data-based model for activity chain cost management, in which a back-propagation (BP) neural network was used to process big data and classify resource data into respective activity centers. An analysis was carried out on company X in Hefei Economic Development Zone, Anhui Province, which is engaged in logistics.

Big Data-Based Model for Activity Chain Cost Management

In the process of business management, in addition to finding ways to increase revenue, reducing the activity cost in the activity chain can also improve the profitability of business operations. Activity chain cost management takes the activity costing method as the core to accurately measure the cost of every activity in the process of enterprise operation and obtain costs of enterprise products, analyze the activity chain cost and guide enterprises to identify value-added and non-value-added activities and reduce costs [7].

Figure 1 shows the cost allocation model under the activity costing method. The cost allocation path in the traditional cost calculation method is "resource → department → cost object," i.e., the traditional costing method takes the department as the object and calculates the cost by counting the consumption of resources and product production cost by different departments [8]. However, this calculation method only uses departments as the unit when analyzing costs. Every department contains different activities. Even if a department is found to have problems through calculation and analysis, it is difficult to position the corresponding activity in the department and make accurate management. In the activity costing method, the cost allocation path is "resource → activity → cost object," and the cost statistics are carried out based on activity items so that the activity items can be directly positioned to realize precise management after the problems are found through calculation and analysis.

When accounting for activity costs, traditional and activity chain costing methods require sufficient data. For a company, the amount of data used for cost accounting is very large, and external data are also needed when costs are accounted for using the activity chain costing method, which further increases the amount of data. The external data can more fully reflect market changes, and the hidden rules can make the costing more accurate.

The process of big data-based activity chain costing is shown in Fig. 2. The large data quantity increases difficulties in manual distribution and processing. A BP neural network [9] is introduced to process the collected big data. Its specific steps are as follows:

- The activity chain is planned according to work done by the enterprise. Then, an activity center is established in the activity chain according to the flow of the activity chain. In short, the work is divided into process steps, and an activity center is set up for every step to store the corresponding data.
- The data relating to the enterprise activity chain are collected and pre-processed [10]. The collected data include not only internal activity data (e.g., resources and capabilities), but also data information from outside

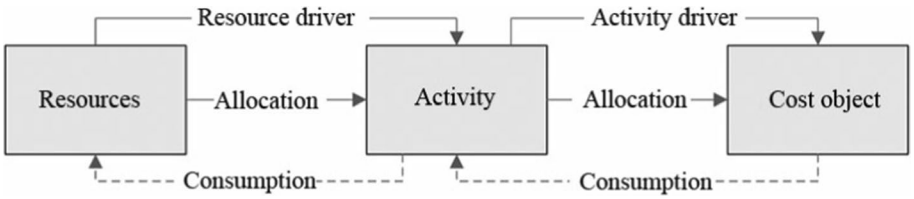

Fig. 1 Cost allocation model under the activity costing method

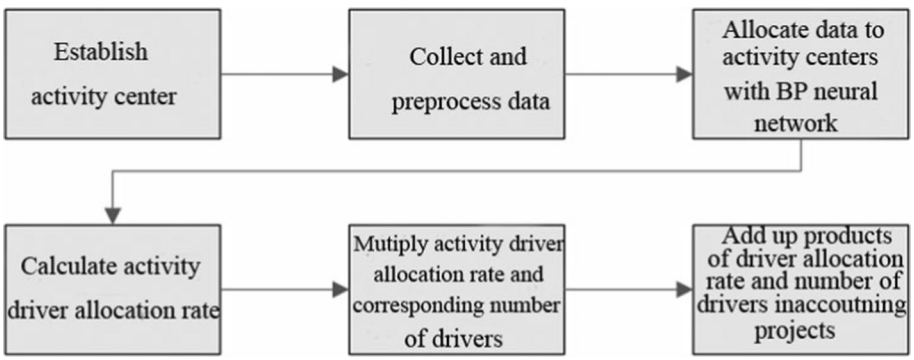

Fig. 2 The process of big data-based activity chain costing

the enterprise (e.g., industry and competitor status, cost drivers of different cost items). Due to the huge amount of data collected, they may be mixed with noisy data, so it is necessary to pre-process the data to guarantee the integrity of the data.

- The collected data are allocated by a BP neural network. The collected resource data are allocated to different activity centers for storage according to different types. The BP neural network is divided into an input layer, a hidden layer and an output layer. In this paper, the collected activity resource data are input in the input layer and then processed by forward calculation in the hidden layer. The calculation formula is:

$$a = f\left(\sum_{i=1}^{n} \omega x_i - \beta\right) \tag{1}$$

where a is the output of every layer, β is the adjustment item of every layer, $f(\cdot)$ is the activation function and ω is the weights between layers. The BP neural network needs training by training samples before formal use. In the training process, the samples are input, followed by forward calculation; then, the calculation results are compared with the sample results. As it is about data classification, the difference between the calculation results and actual results was measured using cross-entropy [11]. The weight value and adjustment item in Eq. (1) of the hidden layer are reversely adjusted according to the difference. The calculation is repeated using training samples to adjust the parameters of the hidden layer until they satisfy requirements.

- The resource costs allocated by the BP neural network within an activity center are aggregated to obtain the total cost of that activity center. The cost drivers within every activity center are analyzed. The total cost of that activity center is divided by the number of cost drivers in that activity center to obtain the activity driver allocation rate.

- The types of cost drivers contained in the cost object and their respective quantities are analyzed. The activity driver allocation rate calculated in the previous step is multiplied by the corresponding number of drivers in the cost object. The products of cost drivers in the cost object are added up, and the result is the cost of the cost object [12].Example Analysis

Object Overview

Company X is a logistics company in Hefei Economic Development Zone, Anhui Province, which was established in 2000 and initially undertook logistics projects similar to the work of postal companies. However, since the rise of e-commerce platforms such as Taobao, the number of logistics projects received by Company X has increased rapidly. The increase in the number of logistics projects undertaken has increased the company's revenue, but at the same time, the cost of maintaining the quality of logistics services has also increased, so it is necessary to calculate the cost of logistics projects to make adjustments to the logistics process, reduce costs and improve the company's revenue. The logistics cost accounting method adopted by Company X is the traditional cost method. In the traditional cost method, costs are divided into direct costs [13] and indirect costs. Direct costs can be included in the costs of logistics projects, which are usually fixed values in a logistics project. Indirect costs need allocation calculation before being included in logistics projects, which will be affected by factors such as the number of workers and working hours in the logistics project analyzed in this paper. Direct costs will be added to the cost of a logistics project at the end, while indirect costs will be calculated based on the labor time, equipment quantity, or order quantity that is most relevant to the change in cost [14].

The traditional costing method described above uses a single cost allocation standard to calculate indirect costs. The calculation is less difficult but is more suitable for activity costing in companies with a small proportion of indirect costs. The reason is that a single measurement standard cannot be adapted to the costing of every activity link, and the accumulation of cost errors makes the final calculation results inaccurate. The logistics company discussed in this paper contains many indirect costs in its logistics process, which will generate a large number of errors if the costs are calculated according to the traditional costing method. Moreover, the single allocation standard is also unable to locate activity links with high costs. Therefore, more accurate management cannot be realized.

Data Setup

In this paper, the three logistics contracts of Company X in August 2021 were used for big data-based activity chain costing. Company X carried out only three contracts in August 2021, and the basic content is shown in Table 1. The three products for transportation were small tomatoes, cherries and dates, and the total amount of the three goods was the same. The big data-based activity chain costing method needed to process a large number of cost data, and resource drivers and activity drivers in every link of the activity chain needed analysis, which was very complicated. Therefore, the distance difference between the departure point and the destination in different contracts was ignored (although the destination warehouse was different, the goods were all transported to Changsha, and the departure point was in Guangzhou), and the same transportation distance was set for the three logistics. Limited by space, the big data such

Table 1 Logistics contracts of Company X in August 2021

Logistics contract number	A	B	C
Logistics transportation content	Small tomatoes	Cherries	Red dates
Total logistics transportation/package	50,000	50,000	50,000
Logistics transportation period/day	3	4	5
Transportation volume per shipment (package/time)	2000	2500	5000
Number of logistics shipments/time	25	20	10
Logistics storage area/m^2	800	700	600
Logistics starting point	Guangzhou warehouse		
Logistics destination	Warehouse A in Changsha	Warehouse B in Changsha	Warehouse C in Changsha

as labor cost, communication cost and vehicle-related cost were not described in detail here but would be summarized in the final results.

The big data-based activity chain costing method needed to set up activity centers according to the activity chain. The activity chain of Company A was "order processing → transportation and distribution → acceptance check → enter/out of warehouse → storage," so six activity centers were set up. The collected resource drivers, i.e., cost-related big data, were allocated to six activity centers using the BP neural network, and direct and indirect costs were distinguished. Direct costs are costs that can be charged directly to the costing objective, while indirect costs are costs that require further allocation before being charged to cost. For example, fuel fees, annual vehicle inspection fees and highway tolls are direct costs in the freight transportation segment, which are fixed expenses; driver's salary, vehicle depreciation costs, insurance and tire fees are indirect costs. As every driver's salary and the depreciation cost, insurance and extent of tire wear of every vehicle are different, it is impossible to generalize different costs, and allocation is needed before costing. The BP neural network was a three-layer structure, and the sigmoid function was used as the activation function for the hidden layer [15]; the number of nodes in the input layer, output layer and hidden layer was 36, 6 and 120, respectively. The most relevant influence factors for every activity center were screened from the financial information stored in the past using principal component analysis as cost drivers.

In order to further verify the superiority of the big data-based activity chain costing method for cost control, it was compared with the traditional costing method. The two methods were consistent when calculating direct costs. The difference between the two methods was that the traditional costing method used a single criterion in the calculation, and the big data-based activity chain costing method measured indirect costs with the unit price of good transportation. Since the total amount of transportation and the distance of transportation were the same in the three contracts, the costs of the three contracts obtained by the traditional costing method were the same. The cost of every contract under the traditional costing method was obtained by equally dividing the total cost of the three contracts after collection based on big data.

In addition, in order to verify the optimization effect of the big data-based method on the cost expenditure after cost control, in addition to the three specific contracts listed above, this paper also compared the actual cost expenditure and revenue of Company X before and after the adoption of the method. Company X started to adopt the activity chain costing method in January 2010; therefore, this paper selected the costs and revenues from January to December in 2009 and 2010 for analysis. The logistics contracts in these 2 years were preliminarily compared. As 2009 was close to 2010 and they were both in the steady development period, the distribution of logistics order contracts in these 2 years did not differ much. The effect of the activity costing method on logistics cost control was tested by the logistics contracts of these 2 years.

Calculation Results

This paper used the big data-based activity chain costing method to calculate the cost of the three logistics contracts and used the traditional costing method as a comparison. The final accounting results are shown in Fig. 3. It is seen from Fig. 3 that the accounting cost of the three contracts obtained using the traditional cost method was the same (100,159.5 yuan), the accounting cost of Contract A (small tomato) obtained using the activity chain costing method was 104,393.5 yuan, the accounting cost of Contract B (cherry) was 98,238.9 yuan and the accounting cost of Contract C (red date) was 97,846.1 yuan. It was intuitively seen that the traditional costing method clearly underestimated the cost of Contract A, but overestimated Contracts B and C. The reason for the underestimation and overestimation is as follows. The traditional cost method used a single allocation standard to calculate costs, and the allocation standard

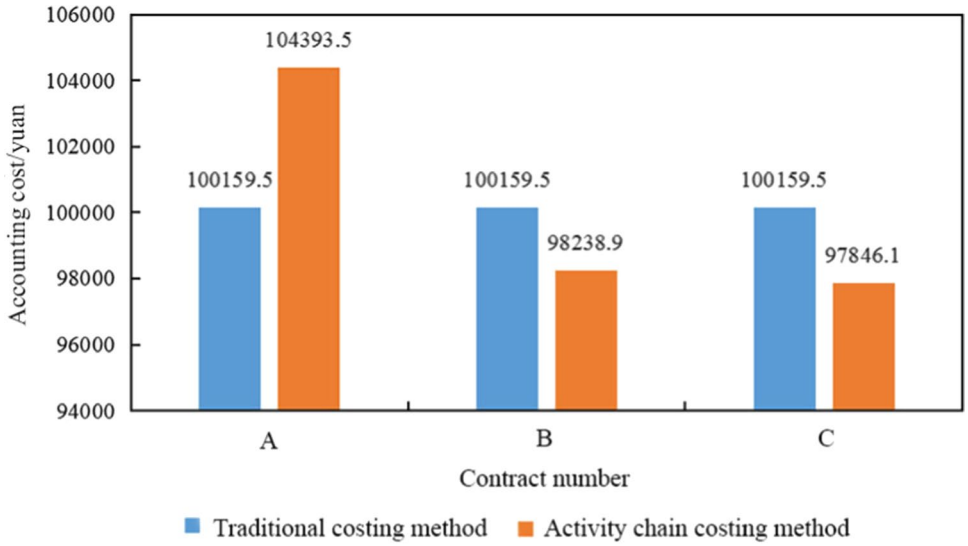

Fig. 3 Accounting costs for three contracts under two costing methods

Table 2 Costs of different links in the three contracts under the big data-based activity chain costing method

Contract number	Cost	Order processing/yuan	Cargo transportation/yuan	Acceptance check/yuan	Enter/out of warehouse/yuan	Storage/yuan	Distribution/yuan	Total/yuan
Contract A	Direct costs	/	25,895	/	/	3567	1258	30,720
	Indirect costs	5129.6	39,490	1690	4715.3	12,633	10,015.6	73,673.5
	Total	5129.6	65,385	1690	4715.3	16,200	11,273.6	104,393.5
Contract B	Direct costs	/	25,895	/	/	3567	1258	30,720
	Indirect costs	3258.9	39,490	1690	3086.8	7993	12,000.2	67,518.9
	Total	3258.9	65,385	1690	3086.8	11,560	13,258.2	98,238.9
Contract C	Direct costs	/	25,895	/	/	3567	1258	30,720
	Indirect costs	2587.6	39,490	1690	3235.9	8793	11,329.6	67,126.1
	Total	2587.6	65,385	1690	3235.9	12,360	12,587.6	97,846.1

used for the three contracts was the same; therefore, the final accounting costs were the same. Because of the single allocation standard, the calculation of every link in the activity chain produced deviations, and the accumulation of deviations led to the overestimation and underestimation of costs for different contracts.

The costs of different activity centers of the three contracts calculated using the big data-based activity chain costing method are shown in Table 2, and their corresponding proportions are shown in Figs. 4, 5 and 6. It is seen from Figs. 4, 5 and 6 that the cost of cargo transportation was the largest in all three contracts, followed by storage and distribution, and the costs of storage and distribution were close. It was seen from the proportions that the key cost of the three logistics contracts was cargo transportation, i.e., the idea of cost control could be obtained by analyzing cargo transportation.

Company X fully implemented the activity chain costing method in 2010 to calculate logistics costs and then control logistics costs. The changes in logistics cost and revenue in 2009 before implementing the activity chain cost method were compared with the changes in logistics cost

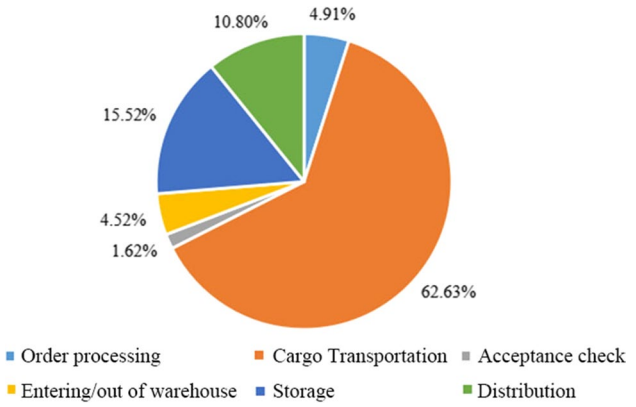

Fig. 4 Cost shares of different activity centers of contract A

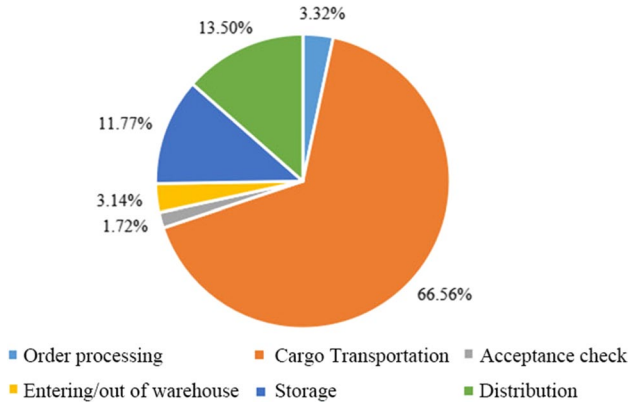

Fig. 5 Cost shares of different activity centers of contract B

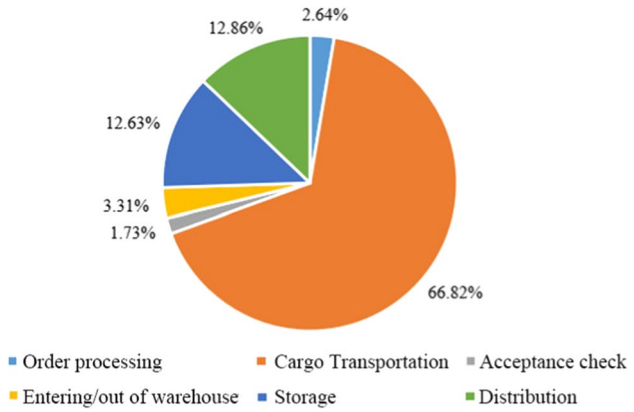

Fig. 6 Cost shares of different activity centers of contract C

and revenue in 2010 after implementing the activity chain cost method. The final results are shown in Fig. 7. The first one is the changes in cost. It is seen from Fig. 7 that before the company implemented the activity chain cost method, although the amplitude was small, the overall trend was rising, while after the implementation, the logistics cost had a significant reduction and stabilized in the last few months of the year. Then, it is the changes in revenue. It is seen from Fig. 7 that the logistics revenue slightly decreased with the increase of month before implementing the activity chain costing method and significantly increased with the increase of month after the implementation.

Discussion and Analysis

In this paper, the big data-based activity chain costing method was proposed to calculate the activity cost of enterprises, and the distribution of costs in different activity links was analyzed to make more accurate control of costs. Then, Company X, which was engaged in logistics in Hefei Economic Development Zone, Anhui Province, was analyzed. The analysis objects were three logistics contracts signed in August 2021. To further verify the effectiveness of the activity chain costing method, it was compared with the traditional costing method. The final results have shown above. The traditional costing method calculated costs according to a single allocation criterion. Since the allocation criterion was the same in all the three contracts, the calculation results of the three contracts obtained by the traditional costing method were the same; moreover, it underestimated the cost of Contract A and overestimated Contracts B and C.

Then, the cost and proportion of every activity center under the activity chain cost method were analyzed, and the results are shown in the previous section. Figure 8 shows the comparison of cost shares of different activity centers between three contracts. The proportion of cargo transportation was the largest in all the three contracts, i.e., the cost focus of all the three contracts was on cargo transportation. Contract A had a higher proportion of cargo transportation

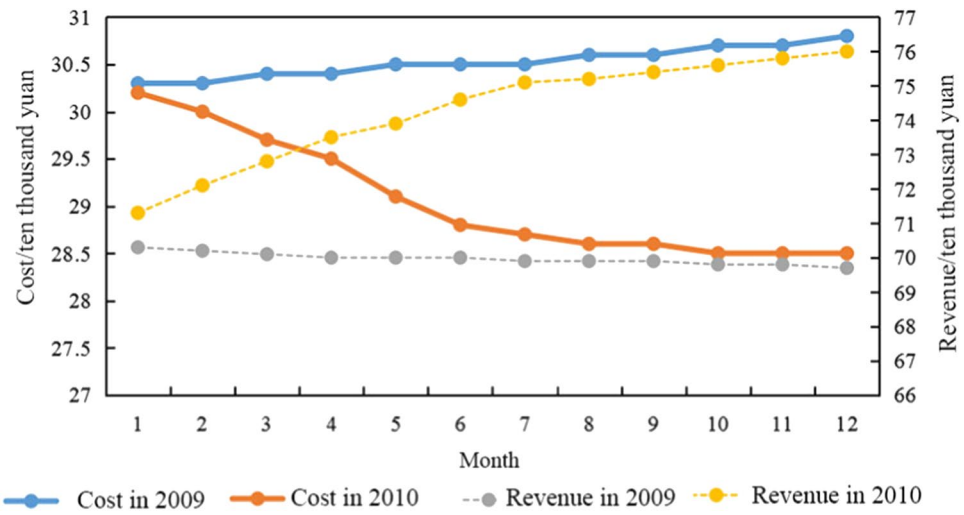

Fig. 7 Change in cost and revenue of company X in 1 year before and after using the job chain costing method

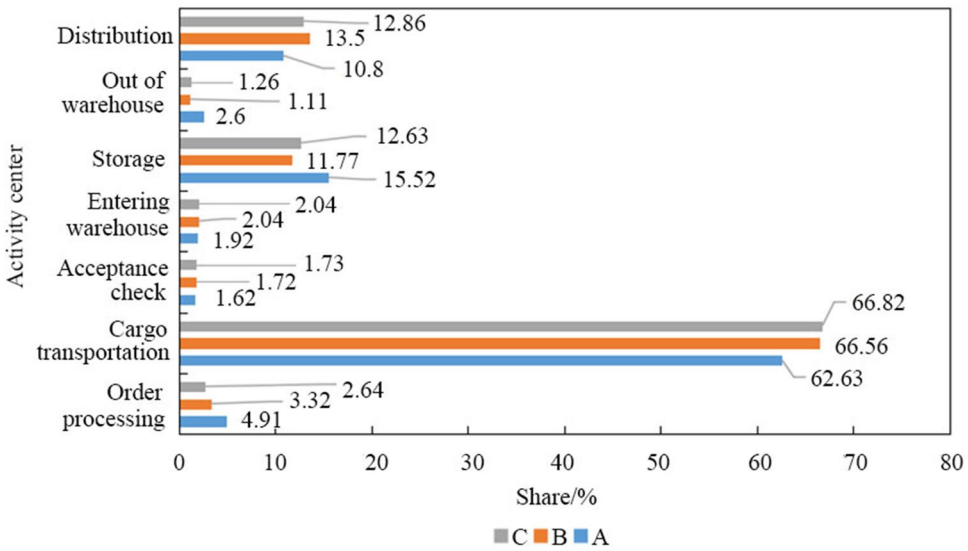

Fig. 8 Comparison of cost shares of different activity centers between three contracts

than Contracts B and C, while the proportion of cargo transportation in Contracts B and C was relatively similar. The comparison of the actual cost of cargo transportation in Table 2 showed that the cost of cargo transportation in the three contracts was the same in terms of specific values, and the specific value of the total cost was higher in Contract A and closer between Contracts B and C. The above results meant that the other parts of Contract A, except for cargo transportation, were relatively more complicated in operation and required more costs.

Then, it is the proportion of distribution link. Although Contract A had a higher total cost, its cost proportion in the distribution link was lower than the other two contracts, which was due to the number of out of warehouse and the loading capacity of the distribution vehicle in the distribution process. The load capacity of distribution vehicles of Company X was 2000 pieces/vehicle. In Contract A, a single vehicle could meet the distribution requirements, but Contract B required a single delivery of 2500 pieces, and Contract C required a single delivery of 5000 pieces; thus, Contract B needed two vehicles, and Contract C needed three vehicles for a single delivery. Moreover, one of the vehicles was not fully loaded, i.e., vehicle resources were not fully utilized, leading to an increase in costs. To reduce the cost proportion of the distribution link, Company X could negotiate with clients when executing contracts to reduce the single delivery volume to 2000 pieces or multiples of 2000 pieces.

The comparison of the changes in logistics costs and revenues showed that the logistics costs tended to increase slightly and revenues tended to decrease slightly before implementing the activity chain costing method, while the logistics costs decreased significantly and revenues increased significantly after the implementation. The reason for the above results is as follows. Before implementing the activity chain costing method, the traditional costing method used by the company relied solely on a single allocation standard to calculate costs, which failed to locate abnormal cost links and accurately calculate different logistics contracts; therefore, ineffective costs accumulated in different links accumulated, increasing cost expenditures and reducing revenue. After implementing the activity chain costing method, since the whole logistics was clearly divided into activity centers, the calculation was clearer, and the abnormal cost links could be positioned more accurately in the face of different orders to make an accurate adjustment, reduce costs and improve revenues.

Conclusion

This paper constructed a big data-based activity chain cost management model, which used the BP neural network to process big data and accurately classify resource data to activity centers in the activity chain. An analysis was carried out on three logistics contracts of company X engaged in logistics in Hefei Economic Development Zone, Anhui Province, which were signed in August 2021. The big data-based activity chain costing method was compared with the traditional costing method. The final results are as follows:

(1) The accounting cost of the three contracts obtained using the traditional costing method was the same; when the activity chain costing method was used, the accounting costs of Contracts A, B and C were different, and the cost of Contract A was the highest, followed by Contract B and Contract C.
(2) In the activity chain cost method, the cost proportion of the goods transportation link was the largest in all three

contracts, followed by storage and distribution, and the cost proportion of storage and distribution was close.

(3) Changing the single delivery volume was proposed to reduce the cost proportion of distribution in Contract B and C and fully utilize vehicle resources after analyzing the results.

(4) After implementing the activity chain costing method, the logistics cost of company X significantly reduced, and the revenue increased.

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Declarations

Conflict of interest The authors have not disclosed any competing interests.

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