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# BP Neural Network for the Preservation and Identification of Service Quality in the Cold Chain Logistics of Agricultural Products

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***Abstract***

Wireless communication transmission in the cold chain logistics of agricultural products plays an essential role in food preservation and is also the premise of transportation services and product quality assurance. Currently, the construction of the Internet of Things and 4G wireless network communication network promotes the development of cold chain logistics of agricultural products. In the process of 4G wireless network communication, it contains massive amounts of information, such as location and cargo identification, resulting in problems such as delay and data loss in wireless communication and seriously affecting the preservation effect of agricultural products. Therefore, this paper proposes a 4G wireless network optimisation method based on BP neural network to detect problems such as cold chain transportation and agricultural product preservation and verify the final optimisation effect. The calculation results show that the combination of the BP neural network and 4G wireless network can improve the information recognition effect in cold chain transportation, accurately determine the location, freshness, service evaluation and other information, and realise the optimisation of wireless information network transmission. The overall optimisation rate is more than 90%. Therefore, the method proposed in this paper can meet the needs of cold chain logistics and transportation of agricultural products.

***Keywords: 4G Wireless Network, BP Neural Network Algorithm, Cold Chain Logistics, Agricultural Products: Quality of Service, Preservation of Agricultural Products***

## 1. Introduction

Wireless communication in cold chain transportation is an essential part of fresh-keeping transportation, but meteorology [1], transportation, agricultural products and other related data are complex and involve a wide range of content [2], resulting in delays and data loss in the Internet of Things and cold chain communication [3]. This research integrates wireless communication network technology, BP neural network, and computer technology into the cold chain logistics of agricultural products. It leverages the power of intelligent algorithms for massive data processing by calculating weights and probabilities [4], and enhances the feedback frequency of wireless networks [5]. The amalgamation of wireless network technology and BP neural network algorithms, though complex, is crucial for analyzing the diversity of agricultural products and cold chain transport routes to elevate logistics services [6]. The paper focuses on optimizing wireless network technology using the BP neural network algorithm to ensure efficient data transmission in the cold chain logistics of agricultural products. Currently, the primary challenges in cold chain logistics and transportation include data delays, loss, and communication failures, leading to issues like food spoilage, cargo damage, negative reviews, complaints, and transportation delays. These issues and their impacts are detailed in Figure 1.

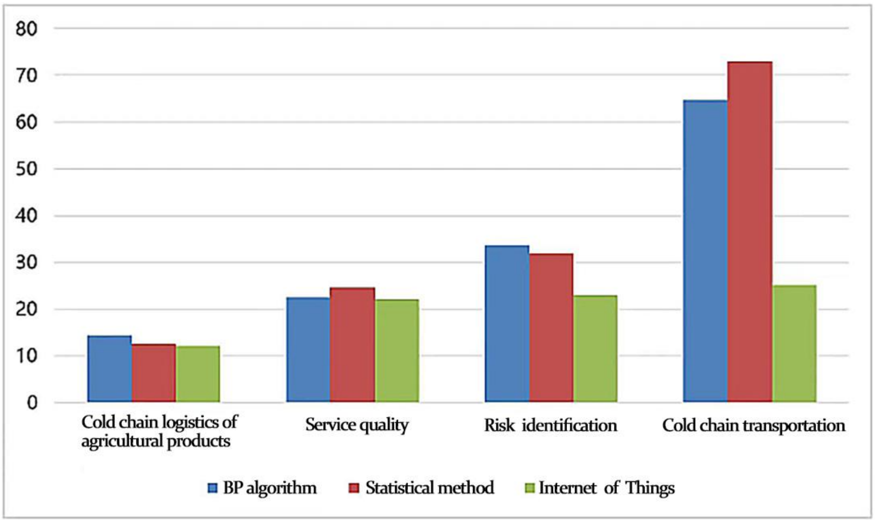


*Figure 1. Research Status of Cold Chain Logistics of Agricultural Products*

In cold chain logistics, the application of wireless communication and ultra-broadband technologies is pivotal [7], enabling the tracking and identification of agricultural product information [8]. However, environmental and weather conditions can lead to data loss in this context [9]. The use of information sensors, radio frequency identification (RFID) technology, the global positioning system (GPS), infrared sensors, and laser code scanners in the cold chain transportation of agricultural products facilitates the collection and linkage of data. It also allows for the wireless transmission of sound, heat [10], light, and other information related to agricultural products, ensuring real-time tracking in cold chain logistics with comprehensive information and effective tracking capabilities [11]. The complexity of data involved in cold chain transportation requires the use of other intelligent algorithms to simplify data structures, with specific outcomes presented in Table 1.

*Table 1. Advantages of Internet of Things and Wireless Network Technology*

| **Index** | **Internet of Things** | **Wireless network** | **Internet of Things + wireless network** |
|---|---|---|---|
| Transfer rate | 14.9% increase | 15% increase | 35% increase |
| Stability | low stability | low stability | high stability |
| Security | high security | high security | high security |
| Accuracy | 80% | 70% | 90% |

The process of cold chain transportation of agricultural products is shown in Figure 2.

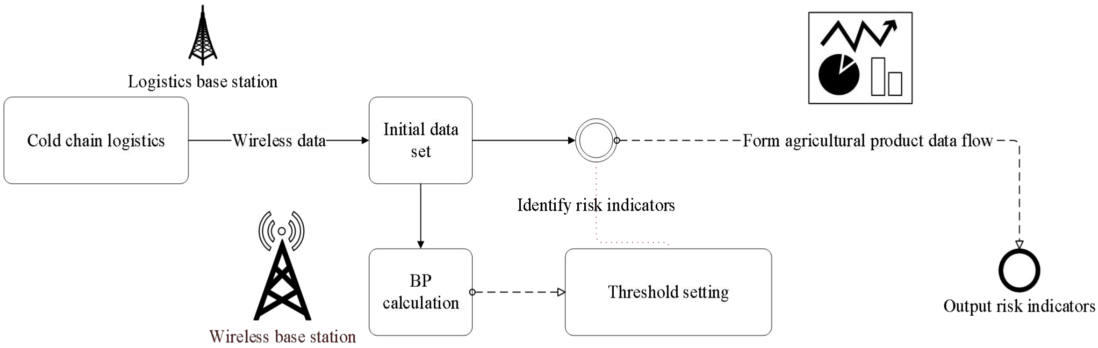


*Figure 2. Data Acquisition Process of the Wireless Network in the Internet of Things Environment*

Wireless network technology and ultra-broadband technology transmit food parameters, transportation parameters and feedback parameters in the Internet of Things [12] and realise the all-around collection of cold chain transportation based on the Internet of Things [13]. After processing by BP neural network algorithm, the parameters of agricultural products, transportation and cold chain are summarised to simplify the transmission volume of wireless networks [14], the occurrence rate of abnormal transportation points, and improve the utilisation rate of ultra-broadband. This research also delves into the extraction and examination of data related to the quality and transportation routes of agricultural products within the Internet of Things (IoT) framework, aiming to gather pertinent cold chain logistics transport data [15]. Studies indicate that data processed via BP neural networks can be transmitted in multi-dimensional and large-scale formats under consistent storage conditions [16]. By integrating BP neural networks with wireless network technology, the efficiency of ultra-broadband usage can be enhanced, facilitating effective management within the IoT sphere. The scope of adaptability for wireless network transmission in this context is detailed in Table 2.

*Table 2. The Scope of Effect of Wireless Network Technology on Cold Chain Logistics*

| **Agricultural products** | **Amount of cold chain transport paths** | **Ultra-wideband action parameters** | **Wireless transmission action parameters** |
|---|---|---|---|
| Green agricultural products | 5 | 10~20km, 4.5G/s | 6.3G/s, 16 clients |
| Economic, agricultural products | 22 | 6~13km, 2.5G/s | 5.1G/s, 6 clients |
| Other agricultural products | 32 | 10~15km, 3.2G/s | 3.2G/s, 4 clients |

Table 2 illustrates that in the cold chain transportation of various agricultural products, wireless network technology facilitates enhanced transmission and processing capabilities, enabling the adjustment of specific parameters. It shows that the parameters and routes used in cold chain logistics are consistent across different types of agricultural products, thereby ensuring the stability of transportation while allowing for necessary parameter adjustments.

## 2. Related Concepts

### *2.1 Identification of Wireless Transmission in Different Cold Chains*

Wireless transmission mainly starts from logistics services, agricultural products, and cold chain, and BP neural networks mine logistics service data and service quality, reduce the freshness index of the cold chain, and add correlation values, impact values, and implied values in different service quality sets [17]. Integrating the Internet of Things (IoT) with wireless network technology and BP neural networks enables the collection of extensive quality of service data while minimizing network data gathering requirements [18]. The BP neural networks are capable of optimizing bandwidth matching, logistics, and data collection volume settings for service quality, streamlining the overall data acquisition process. The specifics of this collection methodology are outlined as follows.

Cold chain data of service quality: agricultural product data $ax_i$, logistics service $sb_i$, cold chain location $ln_i$, cold chain calculation function $kl(x_i)$, the logistics service type $w_i$, and cold chain data collection for service quality are shown in Equation (1).

$$kl(k) = w_i \cdot \overline{[\sum a_i \to b_i \leftarrow c_i]} / i \quad (1)$$

BP calculation of risk indicators: BP calculation function is $BP(ax)$, risk indicator calculation function is $sa(sx)$, BP neural network calculation result is $P$, the ranking of risk indicators is shown in Equation (2).

$$P = \frac{BP(ax) \cdot sa(sx)}{i} \quad (2)$$

Internet of things and wireless network technology standardisation of service quality data: cold chain $ser_i$, Internet of things function $IO(x)$, service quality data $yin(x)$, and the processing process of service quality is shown in Equation (3).

$$yin(x) = \frac{IO(x) \times ser_i}{i} \cdot P(ax) \quad (3)$$

## 3. Methodology

### *3.1 IoT Collection and Processing of Service Quality Data*

Agricultural product's cold chain logistics service data and the transportation path shows cross-change, so the service quality data should be encrypted to determine the service quality logistics service and the correlation of logistics services. In addition, signal emission and GPS delay in the Internet of Things impact the collection of service quality data [11], so it is necessary to identify the leading preservation indicators and realise the simplified processing of service quality data. For a more effective execution of cold chain logistics and transportation of agricultural products, it's essential to fine-tune the indicators related to wireless network transmission. The outcomes of this adjustment process are presented in Table 3.

*Table 3. Selection Rate of Wireless Network Indicators in Cold Chain*

| **Collection of logistics services / The type of data** | **Cold chain path** | **The freshness of agricultural products** | **Path optimisation rate** | **Product damage** | **Ultra-wideband utilisation** | **Number of IoT switchovers** |
|---|---|---|---|---|---|---|
| Fruit and vegetable data | 1 | 77.64 | 74.32 | 76.63 | 77.64 | 4 |
| | 3 | 74.72 | 75.64 | 73.38 | 74.72 | 5 |
| | 9 | 75.43 | 74.14 | 76.57 | 75.43 | 7 |
| | 7 | 68.24 | 75.93 | 73.18 | 68.24 | 4 |
| | 5 | 78.53 | 78.04 | 71.02 | 78.53 | 2 |
| Food data | 8 | 71.52 | 75.42 | 70.07 | 71.52 | 3 |
| | 5 | 72.30 | 76.94 | 75.21 | 72.30 | 2 |
| | 3 | 79.17 | 78.83 | 72.92 | 79.17 | 3 |
| | 2 | 77.67 | 72.22 | 75.10 | 77.67 | 2 |
| | 6 | 79.43 | 80.54 | 76.09 | 79.43 | 3 |
| Cash crop data | 8 | 73.02 | 76.67 | 75.51 | 73.02 | 3 |
| | 3 | 76.87 | 70.89 | 74.37 | 76.87 | 2 |
| | 7 | 79.39 | 72.31 | 76.63 | 79.39 | 3 |
| | 3 | 77.64 | 74.32 | 76.63 | 77.64 | 3 |
| The BP neural network algorithm | 4.5 | 78.23 | 81.36 | 81.63 | 73.56 | 3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| processes the results | | | | | | |

It can be seen from Table 3 that the data processed by the BP neural network algorithm, such as fruits and vegetables, grain, and cash crops, are more reasonable, and the ultra-broadband utilisation rate and Internet of Things switching times are better processed, which realises the optimisation of wireless networks.

*3.2 Point of Failure Threshold in Wireless Network Transmission*

The data in Table 2 is identified, and the corresponding fault point threshold is calculated, and the results are shown in Table 4.

*Table 4. Threshold Points of Failure in Wireless Network Transmission*

| Test / Cold chain logistics path | Path | | | The threshold for the point of failure in the wireless network |
|---|---|---|---|---|
| | Fruit and vegetable data | Food data | Cash crop data | |
| 2→3 | 0.14 | 0.56 | 0.33 | 9.25 |
| 5→5 | 0.57 | 0.73 | 0.19 | 6.56 |
| 4→5 | 0.44 | 0.03 | 0.68 | 4.03 |
| 1→2→3→4→7→9→9 | 0.15 | 0.27 | 0.43 | 9.68 |
| 0→6→8 | 0.30 | 0.08 | 0.26 | 9.42 |
| 0→1→4→5→6→6→7→8 | 0.51 | 0.06 | 0.95 | 8.47 |
| 0→2→3→3→4→4→6→6 | 0.62 | 0.20 | 0.73 | 5.79 |
| 1→4→7→8→9 | 0.83 | 0.19 | 0.50 | 1.80 |
| 0→1→6→6 | 0.42 | 0.57 | 0.43 | 7.26 |
| 0→5→7→8 | 0.66 | 0.16 | 0.10 | 2.59 |
| 1→3→4→8→9 | 0.14 | 0.56 | 0.33 | 2.88 |
| 2→3 | 0.75 | 0.55 | 0.57 | 4.73 |

According to the data in Table 4, after processing by BP neural network, the fault threshold in wireless network transmission is less than 1, indicating that the utilisation rate of ultra-broadband is higher and the number of switching times of the Internet of Things is less. Although the cold chain logistics path is complex and the proportion of uncertain data is large, after the BP neural network's standardised processing, the data change is relatively stable and shows the distribution of both sides. It also indirectly shows that using the Internet of Things and wireless network technology is more reasonable after BP neural network processing.

## 4. Results and Discussion

*4.1 Implementation Conditions of Wireless Network Technology and BP Neural Network Algorithm*

This paper uses BP neural network algorithm to optimise wireless network technology and judge food quality in cold chain logistics. The specific implementation conditions are shown in Table 5.

*Table 5. Implementation Conditions of Internet of Things and Wireless Network Technology*

| Parameter | Implementation conditions | Dispersion | Viability |
|---|---|---|---|
| Fruit | Internet of Things | 0.41 | normal |
| Grain | Internet of Things | 0.89 | normal |
| Cash crop | Internet of Things, wireless network | 0.20 | normal |

| | | | |
|---|---|---|---|
| | technology | | |
| Mode of transportation | Mixed transport | none | normal |

The transmission scenario of wireless network technology in cold chain logistics is shown in Figure 3.

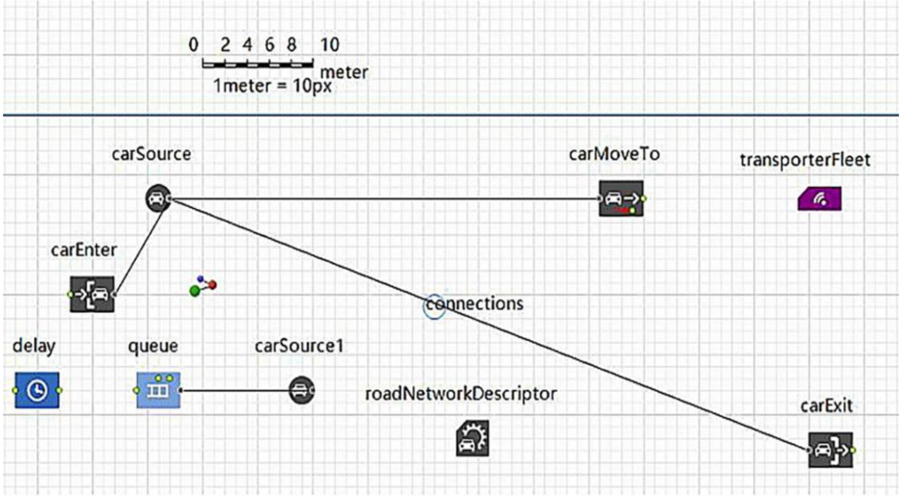


*Figure 3. Implementation Scenario of Wireless Network Technology*

In Figure 3, the application of wireless network technology is relatively deep, the accuracy of fault point identification, and the primary data as the framework for risk identification, mainly including agricultural product preservation, logistics and transportation. Figure 3's scenario settings demonstrate that the integration of the Internet of Things (IoT) with wireless network technology enhances the precision in identifying fault points and effectively presents the quality of cold chain logistics services. Additionally, the BP neural network algorithm plays a pivotal role in accurately identifying risks associated with service quality. This indicates that the algorithm refines wireless network technology, thereby improving the analysis accuracy of cold chain logistics in agricultural products and elevating service quality. A detailed overview of the specific data can be found in Table 6.

*Table 6. Cold Chain Logistics Service Quality Analysis*

| Quality of service | Logistics | Quality of service indicators | The weight of the failure risk point |
|---|---|---|---|
| Fruit | normal | 38 | 0.4 |
| | normal | 24 | 0.9 |
| Grain | normal | 6 | 0.2 |
| | normal | 3 | 0.5 |
| | normal | 32 | 0.5 |
| Cash crop | normal | 15 | 0.9 |
| | normal | 24 | 0.3 |

### *4.2 Wireless Network Transmission of Cold Chain Logistics*

The wireless network transmission process is a critical analysis index of service quality, which can analyse service quality in multiple dimensions, and the specific analysis results are shown in Table 7.

*Table 7. Wireless Network Transmission Process of Cold Chain Logistics*

| Process service content | Service metrics | Failure risk analysis rate |
|---|---|---|
| Agricultural products | metamorphism | 0.91 |

| | | |
|---|---|---|
| | lose | 0.83 |
| | quality | 0.55 |
| | moisture content | 0.37 |
| | bad reviews | 0.62 |
| | damage | 0.74 |
| Cold chain logistics | delay | 0.17 |
| | shipping costs | 0.26 |
| | preservation | 0.97 |
| | the utilisation of logistics networks | 0.13 |
| | wireless network utilisation | 69.13 |
| Risk indicators | 10 | |
| Maximum risk | 77.62 | |
| Maximum range of change | 1.14±.45 | |

The risk analysis results in Table 7 show that among the main service quality indicators, such as deterioration and loss, the risk of failure point is close to 0.91, indicating that wireless network technology can meet the actual cold chain logistics analysis requirements and improve service levels. The reason is that BP neural network optimises the cold chain logistics of agricultural products, simplifies the amount of data transmitted by wireless networks, adjusts the corresponding parameters, and realises the utilisation rate of the Internet of Things and ultra-broadband networks. The wireless network process of agricultural cold chain logistics is shown in Figure 4.

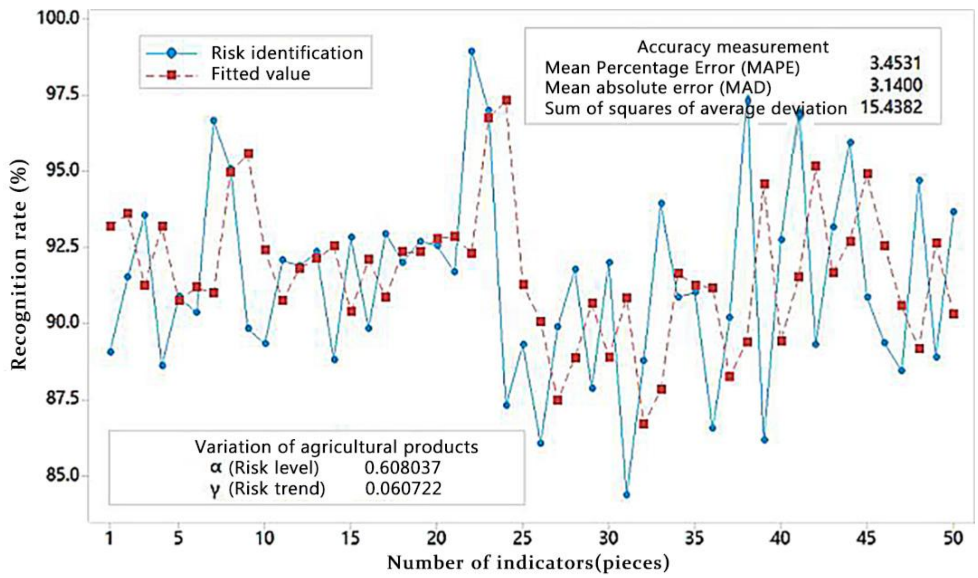


*Figure 4. Wireless Transmission Process of Agricultural Cold Chain*

Figure 4 indicates that the methodology presented in this study exhibits a high effectiveness in identifying risks pertaining to service quality in the agricultural products' cold chain logistics, with the significance of these risks exceeding 70% and showing an upward trend. This proficiency primarily stems from the integration of BP neural networks, which simplifies the collection of service quality data. Furthermore, the utilization of the Internet of Things (IoT) and wireless network technology enhances the rate of data collection, reduces the burden on cold chain resources, and enables the real-time replication of service quality data.

### *4.3 Operation Analysis of Wireless Transmission Servers in Cold Chain Transportation of Agricultural Products*

The wireless transmission server is the foundation of wireless transmission, which impacts agricultural product presentation, data collection, port compatibility, wireless collection rate, and frequency band usage, so it is necessary to reduce the idle rate of services, as shown in Table 8.

*Table 8. Server Utilisation in Wireless Transmission*

| Index | Logistics services | Quality of agricultural products | Quality | Moisture content | Bad reviews | Lose |
|---|---|---|---|---|---|---|
| Transport | local shipping | 78.88 | 73.72 | 72.63 | 75.78 | 74.77 |
| | inter-provincial transportation | 74.50 | 73.64 | 74.01 | 76.49 | 77.17 |
| Serve | transportation services | 79.98 | 75.82 | 76.72 | 77.12 | 70.77 |
| | auxiliary measures | 70.54 | 70.24 | 79.95 | 76.61 | 76.63 |
| IoT transmission volume | 15.4G/s | | | | | |
| Node switching time | 0.23 seconds | | | | | |
| Ultra-wideband rate of change | 2~8% | | | | | |
| Indicator stability | 16.3% | | | | | |

Table 8 shows that in the wireless transmission process, the utilisation rate of the server is high, the evaluation index of service quality, the auxiliary index of agricultural products, and the utilisation rate of the Internet of Things, the ultra-broadband utilisation rate changes little, and the overall parameters are better. The changes in the BP neural network are shown in Figure 5.

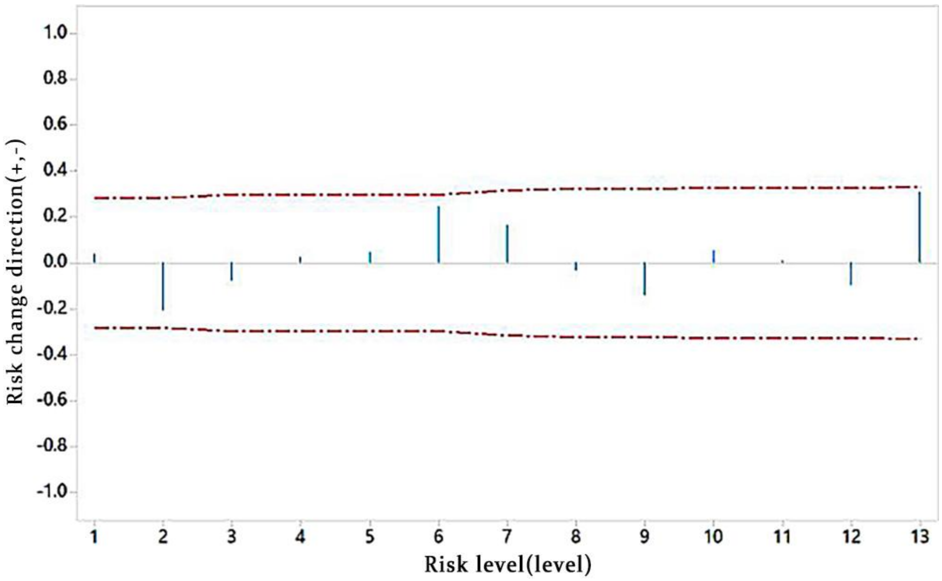


*Figure 5. Changes in Servers in Wireless Transmission Services*

It can be seen from Figure 5 that there are no significant changes in service quality, ultra-broadband, and Internet of Things in different cold chain transportation parameters, indicating that the impact of cold chain logistics services for agricultural products is small. In addition, the transportation change is a fundamental change that has not impacted the quality of service, further proving that BP neural networks can effectively identify cold chain logistics risks. The effectiveness of the BP neural network in this context lies in its ability to decrease the error rate in wireless networks and ultra-wideband transmissions. This is achieved by streamlining the data collection process, which in turn shortens the time required for analyzing service quality data. Additionally, the neural network facilitates larger single data collections, sufficiently catering to the analytical requirements necessary for precise risk identification.

*4.4 Accuracy of Collection of Cold Chain Logistics Data for Agricultural Products*

The accuracy of selection forms the foundation for analyzing cold chain logistics in agricultural products. This involves conducting sample identifications at various logistics service points, recording the data of each IoT-enabled cold chain service, and then performing comparative analyses. The details of these findings are presented in Figure 6.

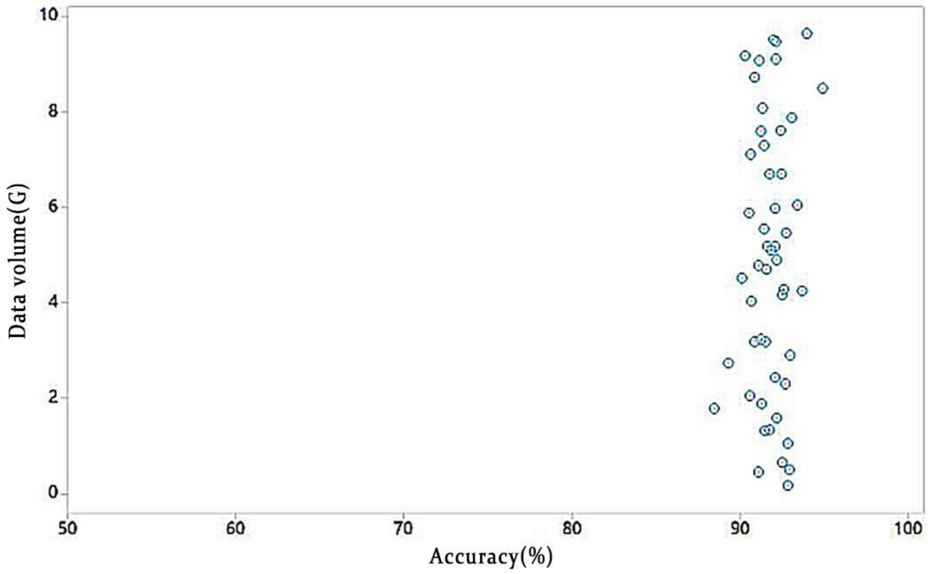


*Figure 6. Selection Accuracy of Quality of Service Data*

As can be seen from Figure 6, the service quality logistics service is scattered, and the selection accuracy data is relatively concentrated. This result shows that the difference between the quality of service logistics service and the logistics service volume is significant, indicating that the extraction accuracy of the logistics service of the service quality is better, and the interference of redundant data is minor. In the collection process, the service quality data is scattered on both sides; the reason is that because the service quality is scattered in different cold chains, the data is collected according to its transmission mode, and a better preservation calculation is realised. The above data shows that BP neural network can effectively identify service quality and improve the ability of wireless network data processing. Summarising the data in Figure 6, the following calculation results are obtained, as shown in Table 9.

*Table 9. Accuracy of Data Processing in Cold Chain Logistics of Agricultural Products*

| Logistics | Parameter | Cold chain selection accuracy | Estimation of the quality of agricultural products | Logistics indicators |
|---|---|---|---|---|
| Stochastic | preservation | 81.48 | 77.51 | 82.47 |
| | serve | 84.61 | 85.47 | 78.11 |
| | transport | 81.14 | 80.93 | 83.98 |
| Key indicators | preservation | 83.84 | 78.31 | 82.74 |
| | serve | 82.20 | 79.08 | 78.70 |
| | transport | 83.67 | 88.24 | 81.91 |

The key indicators and random indicator results are identified, preservation, service, and transportation are greater than 60%, the cold chain selection accuracy is 68%, and the analysis accuracy is greater than 70%, indicating that in different cold chain logistics, the Internet of Things and wireless network technology can realise the preservation and identification of service quality data and provide support for service quality research.

### *4.5 Accuracy of Risk Identification in Quality of Service*

The varied nature of cold chain logistics for agricultural products, along with the intricate details of cold chain processes and the amalgamation of various indicators, necessitates the use of highly precise analytical methods. The outcomes of these analyses are depicted in Figure 7.

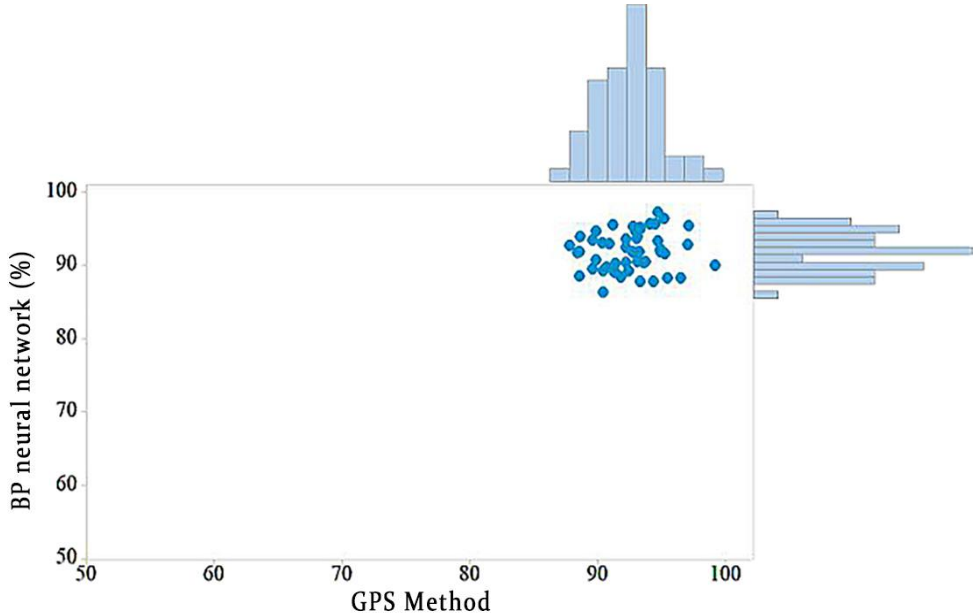


*Figure 7. Collection Accuracy of Cold Chain Logistics Analysis of Agricultural Products*

It can be seen from Figure 7 that the collection accuracy of the BP neural network is higher than that of the GPS Method. The collection results of each index are less different from the actual presentation, indicating that the collection of Internet of Things and wireless network technology can accurately complete the extraction of logistics services and provide comprehensive support for service quality. The results are shown in Table 10.

*Table 10. Accuracy of Risk Identification in Service Quality*

| **Retrieve the cold chain number** | **BP neural networks process the results** | | **Internet of things, wireless network technology processing** | |
|---|---|---|---|---|
| | Serve | Preservation | Serve | Preservation |
| 3 | 93.49 | 89.05 | 90.35 | 93.51 |
| 11 | 89.62 | 91.51 | 88.32 | 96.45 |
| 8 | 88.19 | 93.56 | 90.24 | 91.32 |
| 16 | 90.73 | 88.61 | 93.75 | 93.00 |
| 3 | 89.69 | 90.88 | 94.97 | 93.24 |
| 12 | 97.19 | 90.35 | 88.32 | 95.37 |
| 15 | 80.53 | 96.65 | 90.46 | 93.03 |
| 16 | 91.52 | 95.08 | 92.76 | 87.71 |
| 8 | 93.91 | 89.82 | 89.58 | 89.57 |

Table 10's analysis of the identification process reveals that the accuracy in pinpointing logistics aspects of the agricultural product cold chain is commendably high. The data collection efficiency achieved through the Internet of Things (IoT) and wireless network technology exceeds 60%. This efficiency is largely attributed to the BP neural network's capability to extract risk identification data, simplifying the complexity inherent in IoT and wireless network data. This evidence supports the conclusion that IoT and wireless network technology's data collection aligns well with practical needs. Additionally, the absence of abnormal disruptions in the cold chain selection process suggests that the accuracy in processing agricultural product cold chain logistics is notably satisfactory.

## 5. Conclusion and Future Work

Addressing the challenges of ineffective wireless transmission, underutilized ultra-broadband, and low Internet of Things (IoT) efficiency in the cold chain transportation of agricultural products, this study introduces a risk identification and extraction approach using BP neural networks, focusing specifically on the risk assessment of service quality in agricultural products.This method processes the data in cold chain logistics transportation, such as quality, route and service. Simplify the corresponding data to support the adaptation of wireless network technology. The results show that BP neural network can optimise wireless network technology, improve the utilisation rate of servers, ultra-wideband, and Internet of Things, reduce the failure rate of wireless transmission servers, improve the identification rate of fault risk points, and achieve a processing accuracy rate of more than 80%. Therefore, BP neural network can realise the optimisation of wireless network technology, improve the utilisation rate of the Internet of Things and ultra-wideband technology, and meet service quality risk identification requirements.

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2. Zhengzhou City 2023 Social Research Topic (Project Number: ZSLX2023-0024).

3. Henan Provincial Social Science Federation 2023 Research Topic (Project Number: SKL-2023-2868).

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