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Prediction of Agricultural Products Logistics Demand in Five Provinces of North China Based on BP Neural Network

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Introduction

The demand for agricultural product logistics is affected by many factors, which increases the complexity of forecasting the demand for agricultural product logistics. North China includes two municipalities directly under the central government, Beijing and Tianjin, and three provinces, Hebei, Shanxi, and Inner Mongolia. It has a certain influence on both economic development and logistics scale. And since the five provinces of North China are geographically adjacent and supply food to each other, they share some common factors in agricultural products logistics demand. Therefore, it is very necessary to predict the logistics demand of agricultural products in the five provinces of North China. This paper applies BP neural network model to predict the logistics demand of agricultural products in the five provinces of North China, to provide a basis for the rational allocation of agricultural products logistics resources, future development planning, and policy formulation in the five provinces of North China.

Datasets and Index

This paper uses the number of permanent residents in each province multiplied by the per capita consumption of agricultural products in each province as the dependent variable, which is the logistics demand of agricultural products. The per capita consumption of agricultural products is the sum of the per capita consumption of eight types of agricultural products. Using 14 influencing factors highly related to the logistics demand of agricultural products as independent variables, a prediction model for the logistics demand of agricultural products in the five provinces of North China is established. The datasets example is presented in Table 1.

Table 1. Sample datasets of indicators affecting agricultural products logistics demand in five provinces of North China

Year	Province	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
2019	Beijing	800.04	161776	67756	114.4	5667.4	29663.4	27338.22	901	22365.94	233.619	12.58	122.8	2190.1	43038
2019	Tianjin	574.08	101557	42404	185.41	4947.18	8922.87	56941	2244	16132	625.59	43.42	359.84	1385	31854
2019	Hebei	2656.56	47036	25665	3518.4	13597.3	17988.8	374501	14179.53	196983	11308.37	813.27	7830.73	7446.56	17987
2019	Shanxi	1189.04	48468.67	23828	825.34	7466.3	8669.97	219312	4690	144283	3311.25	352.44	1517.57	3496.88	15863
2019	Inner Mongolia	861.19	71170	30555	1863.26	6763.14	8586.13	182706.62	4586.84	206089	5940.48	888.5	3866.42	2415.3	20743
2020	Beijing	840.79	164889	69434	107.6	5716.4	30278.6	26345.86	843	22264	251.4	13.57	120.2	2189	38903
2020	Tianjin	573.36	101614	43854	210.18	4804.08	9069.47	53566	2371	16411.02	655.67	44.29	365.08	1386.6	28461
2020	Hebei	2838.72	48564	27136	3880.1	13597.2	18729.6	368246	13735.52	204737	11542.50	808.9	7965.74	7463.84	18037
2020	Shanxi	1345.80	50527.92	25214	946.68	7675.44	9029.81	190238	5712	144323	3491.73	354.15	1595.26	3490.5	15733
2020	Inner Mongolia	935.48	72062	31497	2025.12	6868.03	8466.66	170550.26	4431.47	210217	5961.32	888.3	4057.14	2402.8	19794
2021	Beijing	868.42	183980	75002	111.3	7268.6	32889.6	28132	881	22290	265.81	13.04	111.55	2188.6	43640
2021	Tianjin	591.95	113732	47449	225.41	5854.27	9615.37	57568	2682	16895.45	638.55	56.07	340.4	1373	33188
2021	Hebei	2831.07	54172	29383	4030.3	16364.2	19996.7	388868	14774.6	206989	11844.35	816.8	8096.81	7448	19954
2021	Shanxi	1339.15	64821	27426	1286.87	11213.13	10090.16	217637	6444.7	147069.57	3358.14	351.51	1487.86	3480.48	17191
2021	Inner Mongolia	923.37	85422	34108	2225.2	9374.2	8914.8	211904	4891.7	212603	6048.89	902	4239.4	2400	22658

Model Structure

Figure 1 shows the BP neural network structure of logistics demand prediction of agricultural products in five provinces of North China.

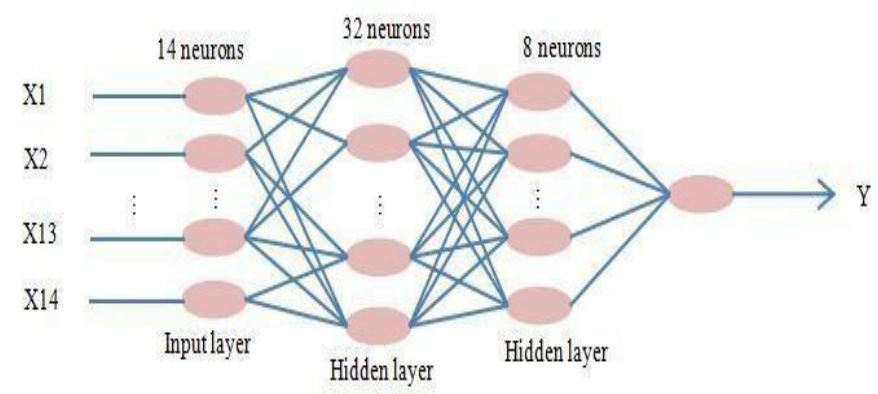

Figure 1. BP neural network structure for forecasting the logistics demand of agricultural products in the five provinces of North China

Model Training

We apply 5-fold cross-validation for the model training. More specifically, the original dataset is divided into 5 approximate average folds. At each training procedure, it selects 4 folds as the training set, and the remaining 1 fold as the testing set. The training is repeated 5 times, and the selected training sets and testing sets are different each time.

Table 2. Training parameter setting

Parameters	Parameter Setting
Dropout	[0.1,**0.2**,0.5]
Activation	Sigmoid, **Relu**, Tanh
loss	MAE, **MSE**, RMSD
Optimizer	AdaGrad, **Adam**, RMSProp, AdaDelta
Epochs	[100,**1000**]
Batch_size	4
Learning rate	[0.001, **0.01**, 0,1]

*The finally chosen parameters are labeled with BOLD.

Result

The 5 training results are shown in Figure 2. It can be seen from Table 3 that the absolute error of each training set is 28.49 in the 5-fold training set and 40.91 in the 5-fold test set, indicating that there is little difference between the predicted value and the actual value. In the training set, the average error rate of 5-fold cross-validation is 3.17%, and in the test set, the average error rate of 5-fold cross-validation is 4.60%, and the percentage of training and testing has reached about 96%. This shows that the BP neural network prediction model has high prediction accuracy and practical value, and can be used to predict the logistics demand of agricultural products in the five provinces of North China.

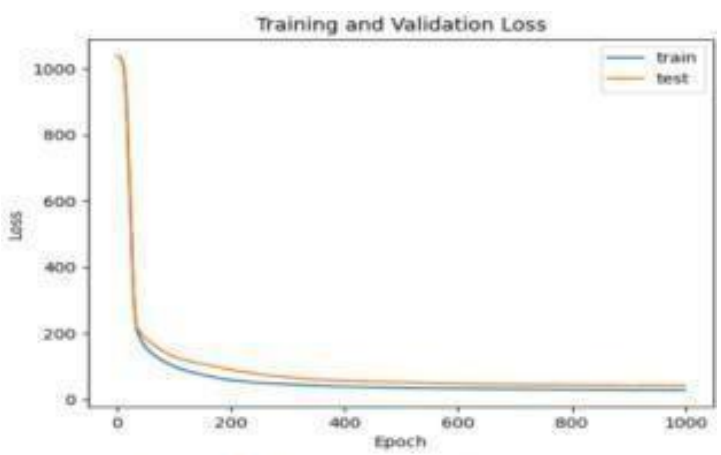

Figure 2. Training and Validation Loss

Table 3. BP neural network training and test error

Fold Number	Training error		Test error	
	Absolute error	Percent error	Absolute error	Percent error
1-fold	31.14	3.21%	33.24	4.23%
2-fold	27.36	3.23%	47.03	4.23%
3-fold	33.35	3.43%	28.51	3.80%
4-fold	24.6	2.69%	37.9	5.33%
5-fold	25.98	3.28%	57.84	5.40%
Average	28.49	3.17%	40.91	4.60%