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Forecasting Supply Chain Demand by using Fuzzy Neural Network Approach, The Case Study of Kaleh Company

KosarMostafaviShahandasht[a], Hassan Shavandi[b]

[a]Department of Industrial and Mechanical Engineering, Qazvin Branch, Islamic Azad University, Qazvin, Iran
[b]Deparment of Industrial Engineering, Sharif University of Technology, Tehran, Iran

ABSTRACT

The aim of this paper is introduce a new model as modulation both of fuzzy logic and Neural Network for forecasting supply chain demand of Kaleh Production. This paper has forecasted demand by using three methods of ANFIS, FSOM and Neural Network. We have used MSE, MAD and MAPE for assessment of forecasting models. Results indicate that the ANFIS model with modulation both of fuzzy logic and Neural Network has a better performance in forecasting demand rather than other models.
KEYWORDS: Forecasting, Supply Chain Demand, Fuzzy Neural Network, Kaleh Company.

INTRODUCTION

There are many researches about supply chain demand. The most studies in this area are: Lummus and Alber, (1997), Quinn (1997), Ellram and Cooper (1993) and Monczka and Morgan (1997). In recent decade, there are a rapidly growing numbers of hybrids fuzzy with neural network studies in the engineering field, estimation, modeling and control. Proper operation of these models was incentive for the researches.

Neural and fuzzy applications have been successfully applied to the chemical engineering processes [1], and several control strategies have been reported in literature for the distillation plant modeling and control tasks [2]. Recent years have seen a rapidly growing number of neurofuzzy control applications [3]. Beside this, several software products are currently available to help with neurofuzzy problems.

A fuzzy system is composed of if-then rules. An Adaptive Neuro Fuzzy Inference System is a type of network in which each node acts a specific function of the inputing signals, with parameters upgrated according to given data and a gradient-descent learning method. This hybrid system has been applied to the control of nonlinear systems.

The aim of this paper is introduce a new model as modulation both of fuzzy logic and Neural Network for forecasting supply chain demand of Kaleh Production. This paper has forecasted demand by using three methods of ANFIS, FSOM and Neural Network.

RESEARCH METHOD

First of all, we have used following model for considering effective factors on demand of Kaleh Production (Cheese):

$$Y = a + b_1X1 + b_2X2 + b_3X3 + b_4X4 + b_5X5 + b_6X6 + b_7X7 + b_8X8$$

Y is quantity of demand of Kaleh Production. X1 is quantity of produced goods, x2 is total of production cost, x3 is price of these goods relative to other prices of similar goods, x4 is the number of candidates of corporation in cities, x5 is total of marketing cost, x6 is the number of competitive productions, x7 is the total of competitive production and x8 is the quantity of exported goods.

ANFIS structure

ANFIS is a type of network in which each node acts a specific function of the inputing signals, with parameters upgrated according to given data and a gradient-descent learning method. This hybrid system has been applied to the modeling and control of multiple-input single-output systems. [1, 2]

* **Corresponding Author:** KosarMostafaviShahandasht, Department of Industrial and Mechanical Engineering, Qazvin Branch, Islamic Azad University, Qazvin, Iran.

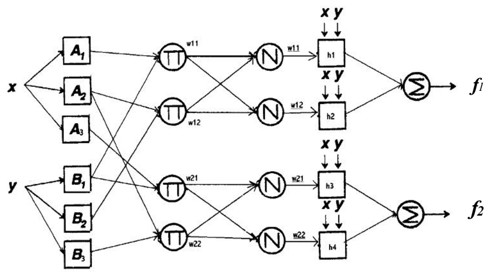


Figure 1. ANFIS structure

The structure of the ANFIS is produced by several layers as figure 2.

we consider two inputs *a* and *b* and two outputs f_1 and f_2 for a fuzzy model, with X_i and Y_j being the linguistic label associated with *a* and *b* respectively, every node in first layer represents a bell-shaped membership function $\mu_{X_i}(a)$ or $\mu_{Y_i}(b)$ with variable membership parameters. Usually we choose the bell-shaped functions. Nodes of second layer output the firing strength defined as the product $\omega_{ji} = \mu_{X_i}(a) \times \mu_{Y_i}(b)$, where the set of nodes in this layer are grouped for each output *j*.[3, 4]

Normalization process is calculated in third layer with the normalized $\overline{\omega}_{ji}$, and the Sugeno-type consequent of each rule with variable parameters p_i, q_i and r_i is implemented in fourth layer. Finally the single node of layer 5 calculates overall output as a summation of all incoming signals. [1, 5, 6, 7]

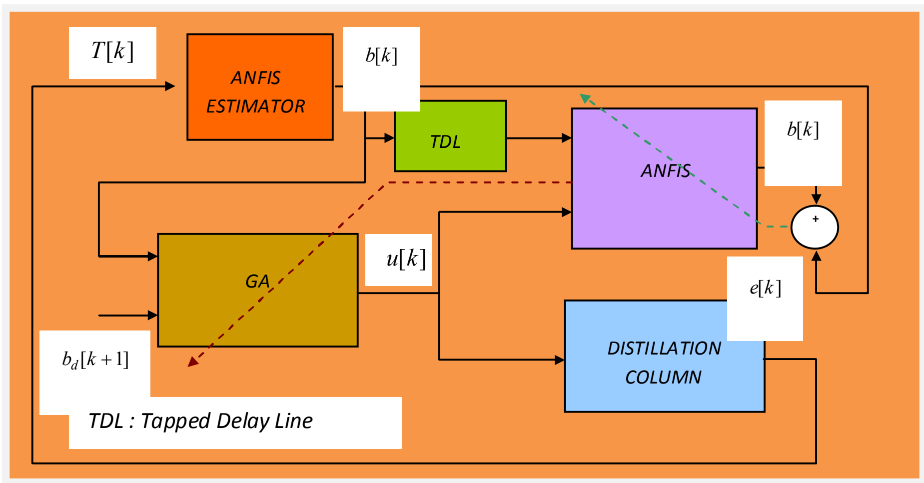


Figure 2.Estimation and Control ANFIS

EMPIRICAL RESULTS

First of all, we have estimated the regression model for identifying the effective factors on demand of Kaleh production. Table 1 indicates estimation results of regression model.

Table 1. Estimation of Regression

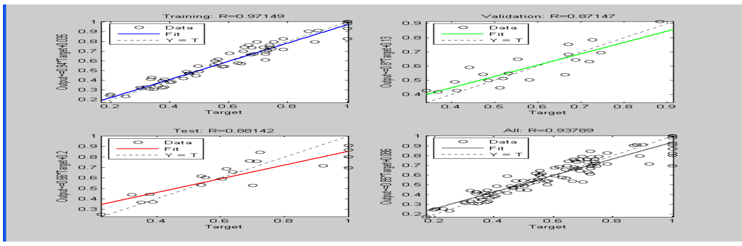
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**
		B	Std. Error	Beta		
1	(Constant)	3.435	.869		3.955	.000
	X1	.682	.284	.599	3.390	.001
	X2	.540	.500	.481	4.108	.000
	X3	-.742	.270	-.693	-3.995	.000
	X4	.512	.379	.480	5.357	.000
	X5	.211	.495	.181	1.310	.094
	X6	-.433	.360	-.392	-2.975	.009
	X7	-.321	.495	-.277	3.310	.004
	X8	.054	.1112	.044	0.975	.834

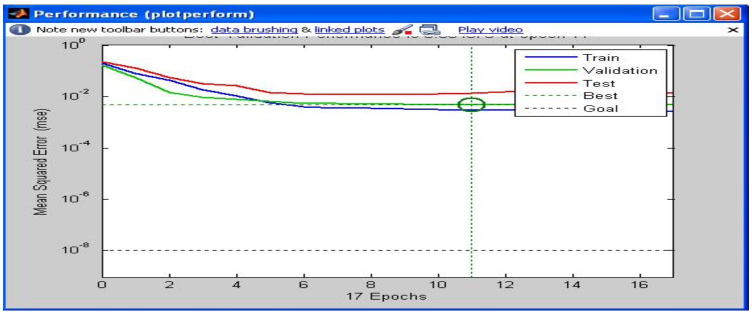
Based on above results, after remove the redundant variables, we have written regression model as following:

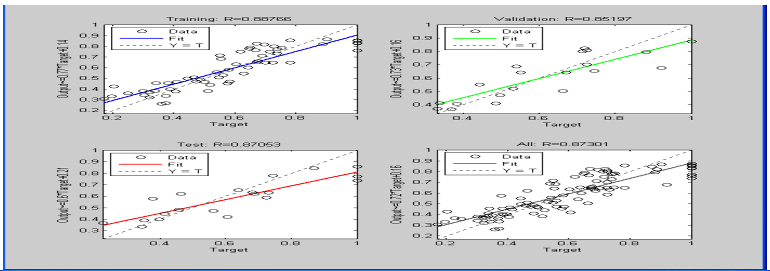
Y= 3.43+ 0.68 X1 + 0.54 X2 - 0.74 X3 + 0.51 X4 - 0.43 X6- 0.32 X7

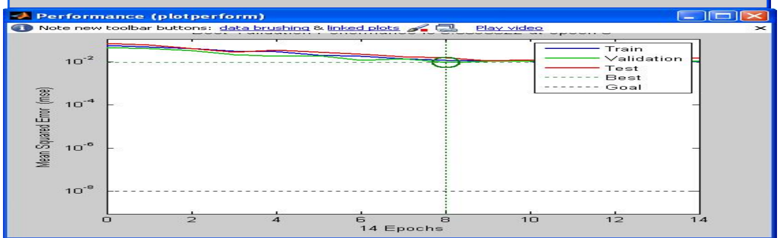
X5 and x6 have not significant effect on demand. Other variables have a significant effect on demand. So, quantity of produced goods, total of production cost, price of these goods relative to other prices of similar goods, the number of candidates of corporation in cities, the number of competitive productions and the total of competitive production have a significant impact on demand. X1, x2 and x4 have a positive impact on demand but x3, x6 and x7 have a negative impact on demand.

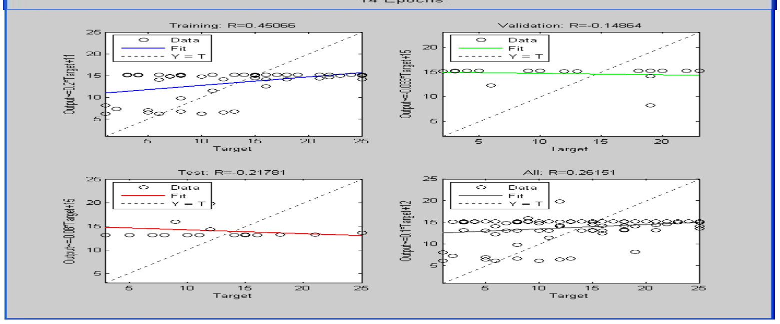
Second, we forecasted demand based on ANFIS method as following:











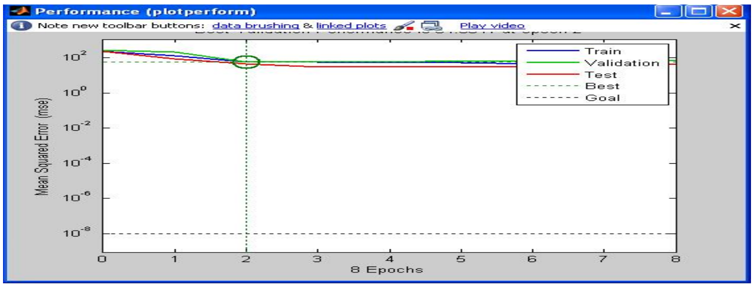


Table 2. Comparative results between three functions of Neural Networks

Average Time of Test	Average Time of Education	Average percent of Error	Structure of Network
0.104	11.48	4.5	Newff
0.127	13.72	8.8	Newelm
0.201	**12.30**	**9.7**	**Newcf**

Table 2 indicates Comparative results between three functions of Neural Networks. Then, we introduced final model for forecasting demand based on FSOM as following Code:

```
function [optnet mse succratio]=test2(ner1,ner2);

p=xlsread('d:\data.xls',1);
T=xlsread('d:\data.xls',2);
for i=1:ner1
for    j=1:ner2
   net(i,j)={newff(p,T,[i,j],{'logsig','logsig'})};
   net{i,j}.trainparam.lr=0.1;
   net{i,j}.trainparam.lr_inc=1.05;
   net{i,j}.trainparam.lr_dec=0.7;
   net{i,j}.trainparam.epochs=200;
   net{i,j}.trainparam.show=100;
   net{i,j}.trainparam.goal=1e-8;
   trainednet(i,j)={train(net{i,j},p,T)};
   that=sim(trainednet{i,j},p);
    mse(i,j)=(sum((T-that).^2)/100)^0.5;
end
end
    for i=1:ner1;
   for j=1:ner2;
      if mse(i,j)==min(min(mse));
         optner1=i
         optner2=j
      end
   end
end
optnet=trainednet{optner1,optner2};
% dadehaye bron nemoneei%
that2=zeros(1,100);
succratio=1-sum(abs(T-that))/100;
```

Table 3. comparative forecasting assessment between three methods

R^2	MAD	MAPE	NMSE	MSE	RMSE	Methods of Demand Forecasting
0.99999	4.0646	0.84830	0.000001	69.65	6.453	**ANFIS**
0.99998	8.774	2.655	0.000027	78.88	8.095	**FSOM**
0.99765	99.995	153.52	0.00775	1854.04	65.65	**Neural Network**

In following table, we shows bias of forecasting for the methods:

Table 4. Bias of Forecasting

TS	bias	Methods of Demand Forecasting
2.1	8.526	ANFIS
4.32	36.5904	FSOM
-10.65	-1060.63	Neural Network

Table 5. comparative forecasting for three methods with actual demand

Week	Real Demand	ANFIS	FSOM	Neural Network
1	137604	130718.034	127580.8012	173653.315
2	158669	150814.044	147194.5069	199837.11
3	179734	170910.054	166808.2127	226020.905
4	200799	191006.064	186421.9185	252204.7
5	221864	211102.074	206035.6242	278388.495
6	242929	231198.084	225649.33	304572.29
7	263994	251294.094	245263.0357	330756.085
8	285059	271390.104	264876.7415	356939.88
9	306124	291486.114	284490.4473	383123.675
10	327189	311582.124	304104.153	409307.47
11	290393.4	276479.1216	269843.6227	363570.5392
12	313564.9	298584.7326	291418.699	392372.7137
13	336736.4	320690.3436	312993.7754	421174.8882
14	359907.9	342795.9546	334568.8517	449977.0627
15	319432.74	304182.652	296882.2683	399666.4388
16	344921.39	328498.8241	320614.8523	431348.8308
17	370410.04	352814.9962	344347.4363	463031.2227
18	395898.69	377131.1683	368080.0202	494713.6147
19	364920.8056	347578.2665	339236.3881	456208.1044
20	391429.0016	372867.0855	363918.2755	489157.792
21	417937.1976	398155.9045	388600.1628	522107.4796
22	385720.1978	367420.8867	358602.7854	482061.7489
23	413288.7217	393721.2585	384271.9483	516329.424
24	440857.2455	420021.6302	409941.1111	550597.0992
25	407351.5657	388057.2117	378743.8386	508949.5392
26	436022.8305	415409.5983	405439.768	544587.9213
27	464694.0953	442761.9849	432135.6973	580226.3035
28	429848.1884	409518.9897	399690.5339	536912.8411
29	459666.3038	437965.4718	427454.3005	573976.7586
30	489484.4191	466411.9539	455218.067	611040.676
31	453244.6759	431839.2388	421475.0971	565994.6751
32	484255.5159	461423.5802	450349.4142	604541.1493
33	515266.3559	491007.9215	479223.7314	643087.6234
34	477577.0229	455052.2979	444131.0427	596239.7825
35	509828.2965	485820.0129	474160.3326	636328.1156
36	542079.5701	516587.7279	504189.6224	676416.4487
37	502882.6639	479193.8793	467693.2262	627694.6942
38	536423.9884	511192.3029	498923.6877	669386.5606
39	569965.3129	543190.7265	530154.1491	711078.427
40	529200.5304	504301.124	492197.897	660407.8023
41	564083.5079	537579.4846	524677.5769	703767.3434
42	598966.4855	570857.8451	557157.2568	747126.8844
43	556571.1116	530412.6585	517682.7547	694429.4348
44	592849.4083	565022.1535	551461.6218	739523.3575
45	629127.7049	599631.6485	585240.4889	784617.2802
46	627359.6854	597944.9578	583594.2788	782419.6319
47	583415.2498	556021.9663	542677.4391	727796.6985
48	621019.0996	591896.039	577690.534	774538.2837
49	632748.7933	603086.1668	588612.0988	789118.2931
50	587046.5803	559486.2556	546058.5855	732310.4424
51	626154.5841	596795.2912	582472.2042	780921.691
52	665262.5879	634104.3268	618885.823	829532.9397
53	663356.6628	632286.0743	617111.2085	827163.8749
54	615984.5613	587093.0894	573002.8553	768280.3527

55	656521.5113	625765.3398	610746.9716	818667.7816
56	669166.1212	637828.2976	622520.4185	834385.0317
57	619899.1356	590827.5934	576647.7311	773146.1685
58	662057.5637	631046.7337	615901.6121	825549.0946
59	704215.9917	671265.8741	655155.4931	877952.0207
60	702161.4045	669305.7979	653242.4588	875398.1688
61	651094.279	620587.7602	605693.654	811921.7318
62	694793.1112	662276.4461	646381.8114	866239.3802
63	708424.0007	675280.3146	659073.5871	883182.5758
64	655314.1902	624613.5554	609622.8301	817167.0814
65	732025.1316	697795.7936	681048.6945	912518.7816
66	777471.9171	741152.0269	723364.3782	969009.1359
67	775257.0721	739039.0647	721302.1272	966256.0836
68	720206.7108	686521.0201	670044.5156	897828.4845
69	767314.0519	731461.4235	713906.3493	956382.9095
70	782008.1507	745479.5938	727588.0835	974647.6743
71	724755.775	690860.8274	674280.1675	903482.9713
72	807450.1699	769751.2801	751277.2494	1006272.104
73	856441.8046	816489.2996	796893.5564	1067168.706
74	769938.3945	733965.0463	716349.8852	959644.9673
75	716099.1412	682602.3987	666219.9411	892722.7755
76	762170.1207	726554.1132	709116.8145	949989.0031
77	776540.9494	740263.8837	722497.5505	967851.9431
78	720548.126	686846.7302	670362.4086	898252.8636
79	801423.2442	764001.5929	745665.5547	998780.6355
80	849337.0629	809711.376	790278.303	1058337.512

In table 5, we show forecasting of three methods with comparative with actual demand. Results indicate that ANFIS method is the best model for forecasting of demand.

Conclusion

Supply chain is the processes from the initial raw materials to the ultimate consumption of the finished product linking across supplier-user companies; and the functions within and outside a company that enable the value chain to make products and provide services to the customer.

The aim of this paper is introduce a new model as modulation both of fuzzy logic and Neural Network for forecasting supply chain demand of Kaleh Production. This paper has forecasted demand by using three methods of ANFIS, FSOM and Neural Network. We have used MSE, MAD and MAPE for assessment of forecasting models. Results indicate that the ANFIS model with modulation both of fuzzy logic and Neural Network has a better performance in forecasting demand rather than other models.

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