INTERNATIONAL JOURNAL OF
TRANSFORMATIONS IN BUSINESS MANAGEMENT
e-ISSN: 2231-6868, p-ISSN:2454-468X

EVALUATING THE PERFORMANCE OF THE SUPPLY CHAIN USING ARTIFICIAL INTELLIGENCE TECHNIQUES: A CASE STUDY IN THE DAIRY INDUSTRY

Ali Rehman Musa, Assist. Prof. Harith Yarub Maan
Department of Industrial Management -College of Administration and Economics. University of Baghdad, Iraq

Paper Received: 05th January, 2022; **Paper Accepted:** 06th February, 2022; **Paper Published:** 12th February, 2022

How to cite the article:
Musa A.R., Maan H.Y (2022), Evaluating The Performance of The Supply Chain Using Artificial Intelligence Techniques: A Case Study In The Dairy Industry, IJTBM, January-March 2022, Vol 12, Issue 1; 64-79, DOI: http://doi.org/10.37648/ijtbm.v12i01.004

ABSTRACT

The issues of evaluating and improving supply chains are among the complex issues due to the diversity of factors affecting performance, as well as the gap between these factors and how they are applied. The current study aims to evaluate the performance of the Supply chains of the dairy factory, College of Agriculture, using artificial neural networks and fuzzy logic by relying on the balanced scorecard as a basic methodology for evaluation, which consists of five main aspects (financial - customer - internal processes - learning and growth - Suppliers). Each aspect has several sub-criteria and by obtaining the opinions of experts in evaluating these criteria for several days and then training the network to make a decision related to evaluating the supply chain and processing the outputs of the neural network with fuzzy logic to classify performance into four main categories, each of which represents the state of the supply chain and what distinguishes the model its ability to continuously evaluate the supply chain and employ artificial intelligence tools in managing the supply chain.

Keywords: *Neural networks, Fuzzy logic, balanced scorecard, Supply Chain, Performance Evaluation.*

INTRODUCTION

The complex and ever-changing business environment, customer demands, and the need for flexibility and response in organizations are turning the spotlight on modern innovations and advanced technology, so organizations have realized the importance of technological progress and considering technology as a strategic weapon in sustainable performance (1,31).

The process of evaluating the performance of supply chains is evident in its importance through the requirements of modern, dynamic, and competitive high quality in the markets. Therefore, assessing the performance of food supply chains is a challenge because it is unique and different from the rest of the general supply chains due to its distinctive characteristics such as rapid perishability, short shelf life, seasonal production, and variation in quality, quantity, and special transportation requirements, so managers of supply chains of this typeface a special challenge in production, storage, and transportation (2,26). Also, investment in agricultural and animal projects plays an effective role in improving and raising the capabilities of human and financial resources. It is considered the ideal solution to many economic problems and raise the living and political reality.(43,46,47). Performance appraisal reflects the maturity of the rationality of the administrative system. It is also a tool through which to know how the organization can address obstacles.(44,45)

Increasing competition, the uncertainty of demand, and short product life lead to high complexity in the supply chain management, so it is imperative to use a flexible and highly efficient methodology capable of simplifying the complexities facing decision-makers. (28,29,30)

Researches in the evaluation and improvement of supply chain performance have included many different approaches, it varied from simulation, optimization, statistics, and empirical studies for both qualitative and quantitative approaches(32,33). Many studies included the use of artificial intelligence methods to deal with supply chains(15,18,19)

Many studies have discussed the use of artificial intelligence in managing supply chains because of its efficiency in processing large data, and artificial neural networks were the most used tool in classifying patterns, modeling problems better, and building models of ecosystems, as well as being used in modeling small stores within multiple chains. (42, 39,40,41,27)

The main objective of this study aims to apply the integration of artificial intelligence with fuzzy logic to evaluate and improve the performance of the supply chain

MATERIALS AND METHODS

Balanced Scorecard

The balanced scorecard was proposed in 1990 by a group from the Nolan Norton Institute. The group's goal was to create a tool for measuring performance in the organizations of the future. The leader of this group was David Norton, Executive Director of the Norton Institute, and he worked alongside Robert Kaplan as a consultant academics at 12 manufacturing companies where industry and high technology were combined to develop a new performance measurement model (6, 7). The balanced scorecard is defined as a strategic approach to performance management that organizations can use to achieve their goals and implement their strategies (8).

The generally balanced scorecard consists of four aspects (the financial aspect - the customer-aspect - the internal operations aspect - the learning and growth aspect) (5) (9):

- The financial aspect: It is the traditional approach to measuring the performance of organizations by defining the financial goal and measuring it by one of the financial measures and the most famous of these "profitability" measures.
- Customer aspect: Customer satisfaction is considered the most influential factor on the customer aspect as a measure of the extent to which the customer is satisfied with the performance of the organization
- The internal operations aspect: The operations aspect helps managers understand how the manufacturing process works and meet demand through production

- The learning and growth aspect: The learning aspect prepares employees and cultural expectations of individuals and organizations

Artificial neural networks

An artificial neural network is one of the primary ways to solve optimization problems. In the past decade, artificial neural networks have played a vital role in solving problems in engineering and science. The use of artificial neural networks in many cases is successful and the results are suitable for comparison with other solution approaches (13)

In simple terms, neural networks are a biologically inspired computational model consisting of processing elements (called neurons) and connections between them with coefficients (weights) associated with the connections. These connections form the neural structure and associated with this structure are the training and recall algorithms. Neural networks are called communication models because of the connections between neurons (16).One of the most famous algorithms used with neural networks is the backpropagation algorithm, which consists of multiple layers with a forward feed and uses backpropagation in the error correction process and Figure (1) shows the general design of backpropagated neural networks (14). Backpropagation artificial neural networks are used in four functions follow as : (15)

1- Estimation function: training the neural network by specifying an input vector to estimate a given output
2- Pattern recognition function: It is related to training the neural network on an input vector and an associated output vector
3- Classification function: classifying data into parameters through training on specific inputs and outputs
4- Forecasting function: predicting specific outcomes based on training on previous data of the same type

The structure of a backpropagated neural network and consist of the input layer, which represents the input, the hidden layer, and the output layer, as in figure (1)

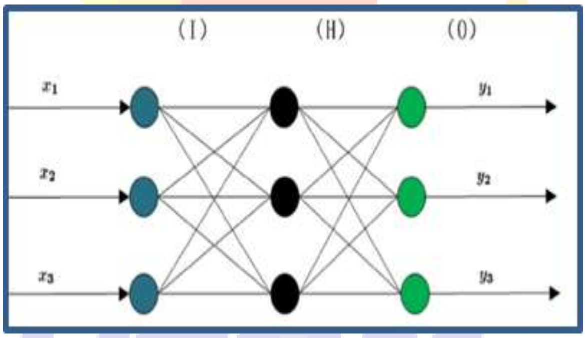

Fig.1 BP Neural network

Learning steps in backpropagated artificial neural networks

Neural networks of different uses share the following steps (10)

1- Network Design
2- Define the input
3- Divide the data into training, verification, and test data

4- Determine the output
5- Choosing a training algorithm
6- Network training

Processing logic in backpropagated artificial neural networks

1- Determine the inputs: the number of inputs is determined by the number of inputs to the model, so the neurons are equal to the number of inputs
2- Determining the number of hidden layers and the number of neurons in a layer: This process is mainly subject to “trial and error” in experimenting with a certain number of hidden layers, as well as the number of neurons in each of the hidden layers, but there is some law that deals with that (11)

$$M = \sqrt{nl} \; , m = \frac{n+l}{2} \; , m = log_2 \ldots (1)$$

The latter its meaning in the above formulas are: M is the number of the neuron in the hidden layer, n is the number of input neurons in the input layer and l is the number of neurons in the output layer. The quiet way to quixotic the number of the neurons in the hidden layer is (trial and error) because the best way to show who the error network changing

1- Determining the activation function: The sigmoid function is often used

$$y_i = \frac{1}{1+e^{-x_j}} \ldots\ldots (2)$$

2- Determining the number of neurons in the output layer: The number of neurons is determined based on the outputs of the real model, and it is possible to choose either a specific vector or classify the outputs in a case.
3- Usually an equation is used to make the inputs one-dimensional when they are multi-dimensional, such as prices, quantities, values, etc. Therefore, the following equation will work in standardizing or unifying the dimensions with one dimension (17)

$$X_i{}' = \frac{x_i - x_{min}}{x_{max} - x_{min}} \ldots\ldots (3)$$

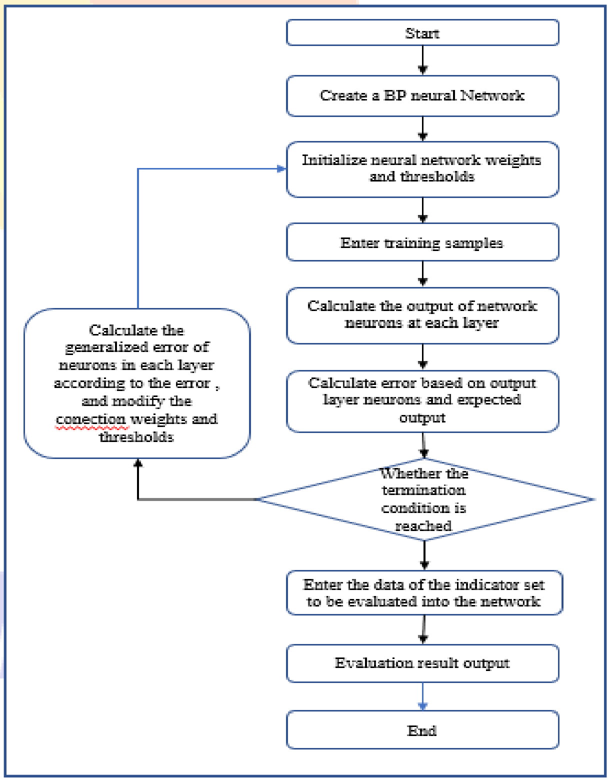

Fig.2 BP Algorithm

Fuzzy logic

The fuzzy logic arises from an attempt to explain the ambiguity inherent in the language we use when discussing our world.

The first to define the fuzzy logic is Zadeh by defining the fuzzy group as a group of elements whose degree of membership is determined through membership functions that determine the degree of belonging of each element to the fuzzy group where it was named "Zadeh notation", which writes as follows (20):

$Where\ X\ is\ a\ space\ of\ points\ (Uinverse\ of\ Discourse)$

$with\ elemnt\ x, X = \{x\}$

$A\ fuzzy\ set\ A\ in\ X\ has\ a\ characteristic$

$membership\ of$

$Function\ f_A = (x)$

$Where\ \{f_A(x)|x \rightarrow [0,1], x \in A\}$

As the fuzzy logic differs from the classical logic in explaining the relationship of the elements to the group to which they belong, which appeared in Zadeh's work in 1965, where the crisp system deals as a logical expression of the element belonging to a value of 1 and not belonging to a value of 0, which constitutes a real problem with human choices and decisions. He added it through the fuzzy groups as a function of belonging to a particular group, which was called the membership function or the degree of membership (24 Paper 2).

Membership functions in fuzzy logic

Membership functions are the building blocks of fuzzy sets, and one of the basic elements of any fuzzy inference system because any fuzzy set is defined by membership functions (The Mathworks, 2017).

Membership functions are represented in a graphic way, where the linguistic variables are expressed with their corresponding mathematical values on the horizontal axis using three mathematical values for each linguistic variable and the vertical axis represents the degree of belonging to this function where the highest value is 1 and the lowest value is 0. Through its mathematical value and the degree of its affiliation, there are many functions of membership, such as: triangular, trapezoidal, Gaussian, sigmoid and Figure (3) shows the membership function of type triangular (2,22)

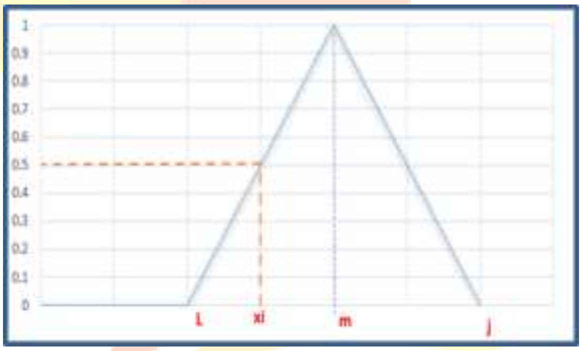

Fig.3 Triangle membership function

The value of the function $\mu A(x)$expresses the degree to which the variable x ∈ X belongs to the fuzzy subset A. For example, a triangular membership function is determined by the following formula and represented by the graph in Fig(3)

$\mu_A : X \rightarrow [0,1]$

$$\mu_A = \begin{cases} 0 & x \le i \\ \frac{x-i}{m-i} & i < x \le m \\ \frac{j-x}{j-m} & m < x \le j \\ 0 & x \ge i \end{cases} \ldots\ldots (4)$$

Operations in fuzzy logic

Through the use of membership functions, there are mathematical operations performed on them that do not differ much from algebraic mathematics, but they are experiments on the numbers of membership functions, which are as follows (21):

Let $\tilde{A}$ andbe two positive TFNs then $\tilde{B}$ fuzzy Operation are: Addition, Subtraction, Multiplication and division are sequentially defined by the following:

$$\tilde{A}\oplus\tilde{B} = (l_1\oplus l_2, m_1\oplus m_2, u_1\oplus u_2) \ldots(5)$$

$$\tilde{A} \ominus \tilde{B} = (l_1 \ominus l_2, m_1 \ominus m_2, u_1 \ominus u_2)\ldots(6)$$

$$\tilde{A}\otimes\tilde{B} = (l_1\otimes l_2, m_1\otimes m_2, u_1\otimes u_2)\ldots\ldots\ldots(7)$$

$$\tilde{A} \oslash \tilde{B} = (l_1 \oslash l_2, m_1 \oslash m_2, u_1 \oslash u_2)\ldots(8)$$

Logical Operation in Fuzzy set

Fuzzy logic needs a mathematical representation to work on building inferential rules to treat membership functions. In addition to mathematical operations, mathematical logic is used represented by the following logical expressions and the table shows these operations.(12,23)

Logical	Operation	Fuzzy notation
AND	Intersection	$\mu_{A\cap B} = min(\mu_A, \mu_B)$
OR	Union	$\mu_{A\cup B} = max(\mu_A, \mu_B)$
NOT	Complement	$\mu_{\tilde{A}} = 1 - \mu_A$

To apply any fuzzy system despite the different field of application, it must be done through these three stages as follows (25):

1- Fuzzification

This step involves converting the input from Crisp into fuzzy sets or appropriate membership functions

2- Inference Engine

Membership functions are worked on through the fuzzy rules that are placed in this step to obtain the fuzzy outputs

3- Defuzzification

This stage is in contrast to the first stage, where it works to defuzzification the fuzzy groups of the outputs to convert them to Crisp values, as in figure (4)

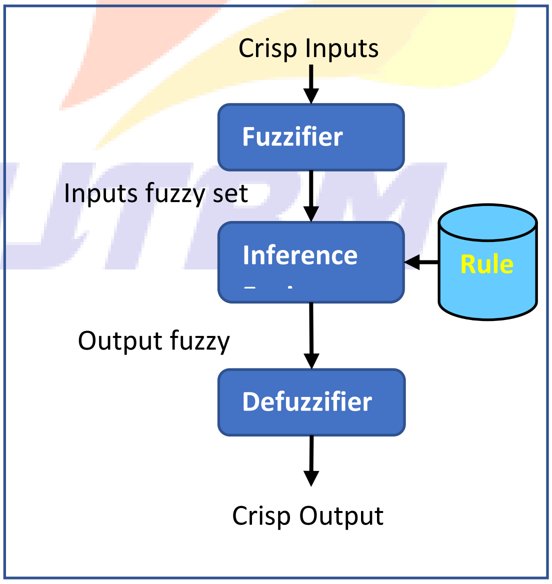

Fig.4 fuzzy logic

Supply chain

Food security is one of the critical issues that require work to overcome difficulties and build advanced models in the field of managing food supply chains in the field of food flow to the consumer in a smooth, continuous, and high quality (33) The supply chain is defined as a sequence of organizations, their facilities, functions, and activities, that participate in the production and provision of a product or service to consumers. This sequence starts from the supplier, transportation, manufacturing, storage, transportation, and distribution, all the way to the final consumer. Figure (5) illustrates this (34,3). While supply chain management is defined as the management of the design chain and management of smooth and value-added operations across organizational boundaries to meet the real needs of the end customer (35,36)

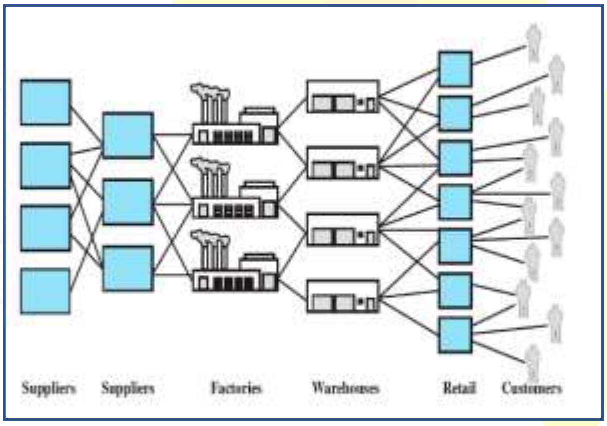

Fig.5 supply chain

Flow in supply chains

There are three types of flows for all types of supply chains:

1- Products flow
2- Money flow
3- Information flow

Performance evaluation in supply chains

Performance evaluation can be described as a process of measuring the efficiency and effectiveness of the procedure or the process of using measurement information to support managers in decision-making situations and linking strategy to operations (36). The evaluation of the performance of the supply chain is shortening lead time, improving customer service level, efficient operations, and efficient use of assets. (37)

Types of performance appraisal

Performance evaluation can be classified into several important groups as follows (38):

1- Financial
2- The customer and the market
3- Quality
4- time
5- Innovation and learning
6- Productivity and operational efficiency
7- Sustainability

The balanced scorecard can be used as a methodology in the performance evaluation process by employing the main aspects and using appropriate secondary criteria to evaluate the performance of the supply chain

RESULTS AND DISCUSSION

The Balanced Scorecard methodology was used as a methodology based on which performance was evaluated in the supply chain of the dairy factory of the College of Agriculture, which is located in the northwest of the city of Baghdad and affiliated to the College of Agriculture, the University of Baghdad, where the factory produces several types of dairy products, namely (processed cheese - cream - milk - butter - Fat) where the factory represents a suitable environment for the case study due to the short lifespan of the product (the supply chain cycle), the clarity of the sources of supply and the factory's dependence on the nearby environment in marketing its products.

The factory depends mainly on raw cow's milk to produce its products, which represent the main raw material in production. It relies on sources of supply close to it, consisting of several villages for cow breeders, which are called (the land of white gold). The factory consists of senior management, production management, marketing and sales team, procurement team, and a team Laboratory and warehouse officials (refrigerators) and stores of auxiliary materials and packaging.

The modified balanced scorecard methodology was adopted to suit modernity in supply chains and ways to measure it, as it was adopted in five main aspects (the financial aspect - the customer-aspect- the internal operations aspect - the learning and growth aspect - the supplier's aspect) and each of these five aspects included several sub-criteria based on which the performance of the supply chain was evaluated, the table (1) shows the main aspects and sub-criteria.

The criteria used were divided into quantitative criteria and qualitative criteria, and this explains the reason for choosing the balanced scorecard as a methodology in evaluating performance because of the diversity in criteria in terms of using tangible and intangible criteria or quantitative and qualitative criteria.

By classifying the criteria, the quantitative criteria can be limited to (net profit - return on investment - supply chain response time - capacity utilization - daily inventory – the rate of profit increase) and qualitative criteria are (customer satisfaction - flexibility of services provided to meet customer needs – the quality of delivery performance - Information sharing - quality - flexibility - on-time delivery rate).

These criteria were selected based on taking the opinions of academics and experts in the field of supply chain management, as well as the management of the laboratory to work with these Indicators and their validity in evaluating the performance of the supply chain for the dairy firm plant, Faculty of Agriculture.

Performance evaluation using artificial neural networks

Artificial neural networks are one of the machine learning tools under the umbrella of artificial intelligence, and they have met with great success at the level of prediction and classification of patterns in the last decade and the use of these algorithms, whose work is similar to the work of neural networks in the human brain in the business world has appeared in two aspects more clearly than the rest of the aspects They are (forecasting and prediction), as Forecasting is a special case of prediction that uses time series, in contrast to a prediction that is not specific to a specific period. What distinguishes this study is the employment of artificial neural networks in the performance evaluation process.

Table (1): The aspects and sub-criteria of BSC

Perspective	Indicators		Description	Indicator type	Range
financial aspect	F1	Net Profit	It represents the value of sales after subtracting all costs from it daily.	quantitative	0-1
	F2	ROI	Shows the investment value for every one dollar	quantitative	0-1
Customer aspect	C1	Customer Satisfaction	The degree of customer satisfaction with the overall performance of the plant	qualitative	0-4
	C2	The flexibility of services provided to meet customer needs	The ability of the plant to adapt to the needs of the customer	qualitative	0-4
	C3	Delivery quality	Delivery efficiency through a certain number of sales	qualitative	0-4
Internal process	P1	Supply Chain Response Time	The time needed by the supply chain to make the change in the plan along the chain	quantitative	15-30
	P2	capacity utilization	The capacity invested in the factory as a percentage of the total capacity of the factory	quantitative	0-2
	P3	Daily Inventory	The value of the daily stock of products	quantitative	1.5-5
Learning and growth	L1	Information sharing	The quality of information shared in the organizational structure	qualitative	9.00
	L2	profit increase rate	A rate that represents the increase in profit,	quantitative	0-2.5
Suppliers	S1	Quality	The quality of the material provided by the suppliers	qualitative	6.00
	S2	Flexibility	Supplier flexibility with factory orders	qualitative	7.00
	S3	On-time delivery rate	Commitment to delivering within an agreed time	quantitative	8.00

How does the model work?

The model works based on supervisory learning, which is done by training the neural network using inputs and outputs with us and for a set of samples until the network is trained. In this study, by collecting data and presenting this data to the factory management, the factory management evaluated the supply chain on a daily based on these data, the evaluation vector was chosen as [weak - acceptable - good - very good] and this corresponds to this evaluation when the supply chain is weak [1] and when it is acceptable [2] and when it is good [3] and when it is very good [4] and through This model will enable the artificial neural network. Using this data for learning and training, and then making a decision based on what you learned from the training data

The Matlab software2012 was used to build, train and use the neural network in the performance evaluation process for the dairy factory, College of Agriculture, University of Baghdad, as follows:

1- Data collection: The values of these data were collected daily for the period extending from 6-1 to 7-3 and the supply chain was evaluated daily by the factory administration and on the basis mentioned above. The highest and lowest value for quantitative indicators were determined based on the work of the factory and the indicators Quality is a measure that shows the performance of indicators from bad to very good [1-2-3-4]

2- Data preparation: After the data collection process, the data is prepared by performing the profiling process using equation (3) to unify the dimension in the data within the range [0-1], which is suitable for working with artificial neural networks and the table (3) represents the data for a period of 49 A day when the daily stock criterion was excluded due to the lack of accurate data

3- Determining the input and output neurons The number of input neurons was determined based on the number of criteria used in the evaluation process, which is 12 criteria, which means that the input layer contained 12 neurons and the output layer contained 4 neurons shown in the table (2)

Table (2): The value of SC performance

Value	The SC performance
1	Supply chain (weak) performance
2	Supply Chain (Acceptable) Performance
3	Supply chain (good) performance
4	Supply Chain (Very Good) Performance

4- Define the training algorithm an algorithm has been selected

" Levenberg-Marquardt Back propagation"

As a training algorithm, which represents the strength in the process of adjusting weights for error correction and learning

5- Determining the number of hidden layers: The trial and error method was used to depend on the number of hidden layers and the number of neurons in them by comparing with the sum of the squares of error each time, where a number from 1 to 60 neurons was tried each time and it was found that the number of 8 neurons was the best among them

6- The sigmoid activation function was selected in the hidden layer and the Pureline activation function was selected in the output layer.

7- Matlab 2012 software was used to train the artificial neural network through the Neural Toolbox, and figure (6) shows that

8- Through figure (6) it is clear that the data division between training, verification and testing was random and using the (LMBP) algorithm in training. The performance of the network was measured using the sum of the squares of error, the number of epoch was 1000, and the model reached the best performance at epoch 23 after the training process

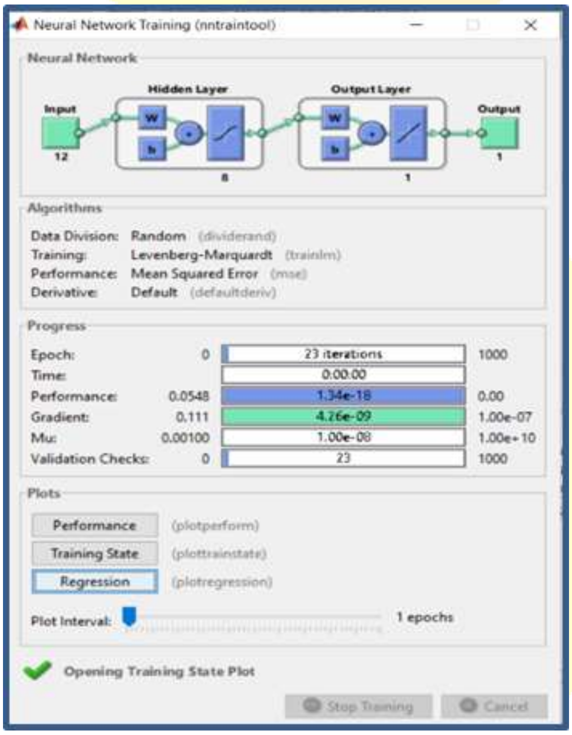

Fig.6 The net information

The performance figure was extracted for the three data and the figure (7) illustrates this, as was the extraction of the correlation in the network performance, where figure (8) shows that the correlation was for all data (training - verification and learning) (0.93) while the correlation of training data was (0.93) and the correlation of test data (0.98) and validation data link (0.78)

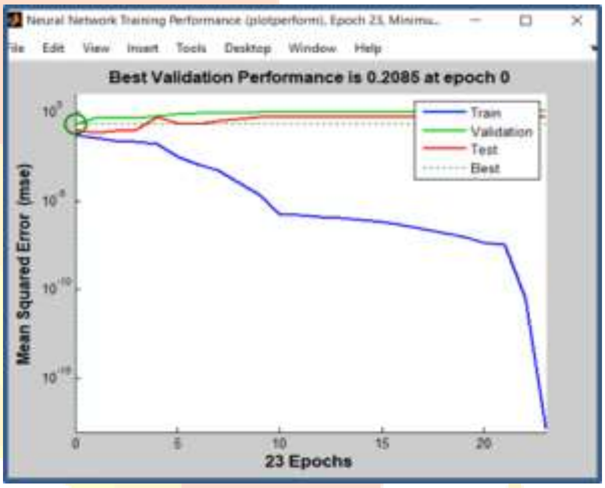

Fig.7 Performance of net

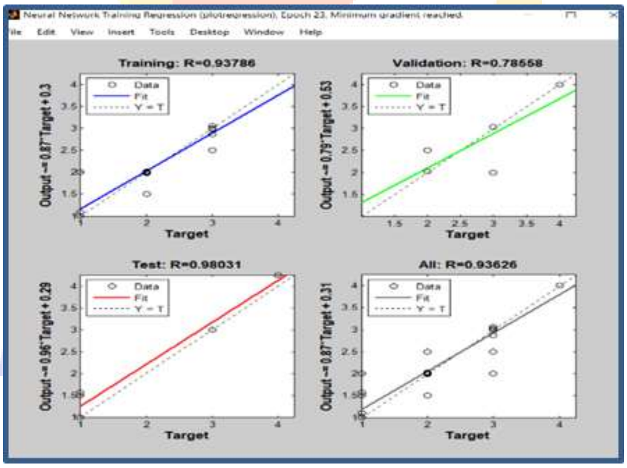

Fig.8 Correlations of net

Comparing the outputs of the neural network in the training process with the real outputs: Through the outputs of the Matlab software, we can compare the real management evaluation of the supply chain for the forty days with the outputs of the artificial neural network of the training data, as Figure (9) shows these data.

The blue circle shape (O) represents the real outputs (management evaluation) and the red (X) sign of the network outputs (network evaluation) and notes the slight difference between the two evaluations. Through this figure, the researcher concludes that this artificial neural network is almost more accurate in the performance evaluation process.

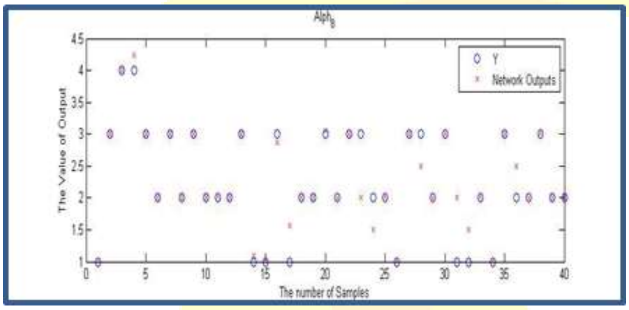

Fig.9 the real and net output

The neural network can be more flexible in evaluating performance and to draw a clearer picture of the performance of the decision maker and to overcome the obstacle of the presence of decimal numbers in the evaluation process of the supply chain of the dairy factory of the Faculty of Agriculture, fuzzy logic was used by classifying performance into four main categories (A) And (B), (C) and (D) (A) represents the best rating as very good, and (B) the second category is good, and (C) is acceptable and the category (D) is the worst rating and the use of this process is to link the outputs of the artificial neural network with logic The fuzzy evaluation process is characterized by great accuracy and the figure (10) shows the membership functions to evaluate the performance of the processing chain of the dairy factory, College of Agriculture

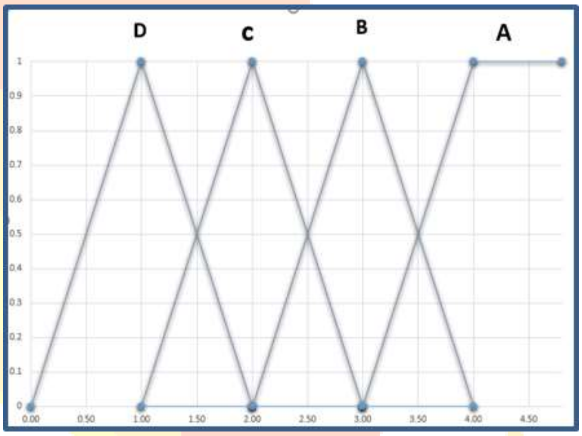

Fig.10 the membership functions

9- Use neural network

The neural network was used to evaluating the performance of the supply chain for the dairy factory, College of Agriculture, using 9 days of work data and figure(11) show the value of net output(NO)

NO	S3	S2	S1	L2	L1	P2	P1	C3	C2	C1	F2	F1	Day
3.85	1.00	0.67	1.00	1.00	0.58	0.34	0.00	0.67	1.00	1.00	0.01	1.12	1
2.87	0.67	0.67	1.00	1.00	0.27	0.34	0.00	0.67	1.00	1.00	0.01	0.77	2
3.59	1.00	0.67	1.00	1.00	0.42	0.34	0.00	0.67	1.00	1.00	0.01	1.11	3
2.49	1.00	0.67	1.00	1.00	0.22	0.36	0.00	1.00	1.00	0.67	0.01	0.53	4
4.33	0.67	0.67	1.00	1.00	0.50	0.36	0.00	1.00	1.00	1.00	0.01	1.10	5
2.98	0.67	0.67	1.00	1.00	0.29	0.36	0.00	1.00	1.00	1.00	0.01	0.89	6
2.49	1.00	0.67	1.00	1.00	0.25	0.36	0.00	1.00	1.00	0.67	0.01	0.54	7
2.52	1.00	0.67	1.00	1.00	0.38	0.41	0.00	1.00	1.00	1.00	0.01	0.71	8
2.31	1.00	0.67	1.00	1.00	0.33	0.31	0.00	1.00	1.00	1.00	0.01	0.68	9

Fig.11 The value of 9 sample use of neural network

After knowing the performance of the supply chain through the artificial neural network, the same network was used in the evaluation, and the outputs of the artificial neural network were entered into the fuzzy logic processor using the (Excel) program figure(12) show the result.

Value of neural network	The value of membership function	performance level
3.85	FALSE	D
	FALSE	C
	0.15	B
	0.85	A
Value of neural network	The value of membership function	performance level
2.87	FALSE	D
	0.13	C
	0.87	B
	FALSE	A
Value of neural network	The value of membership function	performance level
3.59	FALSE	D
	FALSE	C
	0.41	B
	0.59	A
Value of neural network	The value of membership function	performance level
2.49	FALSE	D
	0.51	C
	0.49	B
	FALSE	A
Value of neural network	The value of membership function	performance level
4.33	FALSE	D
	FALSE	C
	FALSE	B
	100	A

Fig.12 the output of fuzzy logic

REFERENCES

1- Armstrong, M. (2021). Performance management.

2- Ramos, E., Coles, P. S., Chavez, M., & Hazen, B. (2021). Measuring agri-food supply chain performance: insights from the Peruvian kiwicha industry. Benchmarking: An International Journal.

3- Hofmann, E., & Locker, A. (2009). Value-based performance measurement in supply chains: a case study from the packaging industry. Production Planning and Control, 20(1), 68-81.

4- Dubey, R., Bryde, D. J., Foropon, C., Tiwari, M., Dwivedi, Y., & Schiffling, S. (2021). An investigation of information alignment and collaboration as complements to supply chain agility in humanitarian supply chain. International Journal of Production Research, 59(5), 1586-1605.

5- Balaji, M., Dinesh, S. N., Kumar, P. M., & Ram, K. H. (2021). Balanced Scorecard approach in deducing supply chain performance. Materials Today: Proceedings.

6- Fatima, T., & Elbanna, S. (2020). Balanced scorecard in the hospitality and tourism industry: Past, present and future. International Journal of hospitality management, 91, 102656.

7- Frederico, G. F., Garza-Reyes, J. A., Kumar, A., & Kumar, V. (2020). Performance measurement for supply chains in the Industry 4.0 era: a balanced scorecard approach. International Journal of Productivity and Performance Management.

8- Rashidi, S. F. (2020). Studying productivity using a synergy between the balanced scorecard and analytic network process. OPSEARCH, 57(4), 1404-1421.

9- Fan, H. (2020, February). Data Monitoring and Anomaly Analysis for Information Systems based on Balanced Scorecard and Fuzzy Neural Network. In 2020 International Conference on Inventive Computation Technologies (ICICT) (pp. 117-120). IEEE.

10- Han, C., & Zhang, Q. (2021). Optimization of supply chain efficiency management based on machine learning and neural network. Neural Computing and Applications, 33, 1419-1433.
11- Chen, J., & Huang, S. (2021). Evaluation model of green supply chain cooperation credit based on BP neural network. Neural Computing and Applications, 33(3), 1007-1015.
12- van Krieken, E., Acar, E., & van Harmelen, F. (2022). Analyzing differentiable fuzzy logic operators. Artificial Intelligence, 302, 103602.
13- Pooya, A., Mansoori, A., Eshaghnezhad, M., & Ebrahimpour, S. M. (2021). Neural Network for a Novel Disturbance Optimal Control Model for Inventory and Production Planning in a Four-Echelon Supply Chain with Reverse Logistic. Neural Processing Letters, 53(6), 4549-4570.
14- Wu, Y., Li, X., Liu, Q., & Tong, G. (2021). The Analysis of Credit Risks in Agricultural Supply Chain Finance Assessment Model Based on Genetic Algorithm and Backpropagation Neural Network. Computational Economics, 1-24.
15- Zhang, Y. (2019). Application of improved BP neural network based on e-commerce supply chain network data in the forecast of aquatic product export volume. Cognitive Systems Research, 57, 228-235.
16- Shanmuganathan, S. (2016). Artificial neural network modelling: An introduction. In Artificial neural network modelling (pp. 1-14). Springer, Cham.
17- Liu, L., & Ran, W. (2020). Research on supply chain partner selection method based on BP neural network. Neural Computing and Applications, 32(6), 1543-1553.
18- Tkáč, M., & Verner, R. (2016). Artificial neural networks in business: Two decades of research. Applied Soft Computing, 38, 788-804.
19- Collins, C., Dennehy, D., Conboy, K., & Mikalef, P. (2021). Artificial intelligence in information systems research: A systematic literature review and research agenda. International Journal of Information Management, 60, 102383.
20- Carter, J. (2021). Fuzzy Logic: Recent Applications and Developments. Springer Nature.
21- El Alaoui, M. (2021). Fuzzy TOPSIS: Logic, Approaches, and Case Studies. CRC Press.
22- Guidara, A. (2021). Policy Decision Modeling with Fuzzy Logic: Theoretical and Computational Aspects (Vol. 405). Springer Nature.
23- Nguyen, H. T., Walker, C., & Walker, E. A. (2018). A first course in fuzzy logic. Chapman and Hall/CRC.
24- Castillo, O. (2021). Fuzzy Logic Hybrid Extensions of Neural and Optimization Algorithms: Theory and Applications (Vol. 940). Springer Nature.
25- Kambalimath, S., & Deka, P. C. (2020). A basic review of fuzzy logic applications in hydrology and water resources. Applied Water Science, 10(8), 1-14.
26- Thulasiraman, V., Nandagopal, M. G., & Kothakota, A. (2021). Need for a balance between short food supply chains and integrated food processing sectors: COVID-19 takeaways from India. Journal of Food Science and Technology, 1-9.
27- Muñoz, E. G., Cossío, N. S., Cedeño, S. D. M. R., Ricardo, S. E. L., Hernández, Y. C., & Crespo, E. O. (2020). Application of neural networks in predicting the level of integration in supply chains. Journal of Industrial Engineering and Management, 13(1), 120-132.
28- Horská, E., Petriľák, M., Šedík, P., & Nagyová, Ľ. (2020). Factors influencing the sale of local products through short supply chains: A case of family dairy farms in Slovakia. Sustainability, 12(20), 8499.
29- Glover, J. (2020). The dark side of sustainable dairy supply chains. International Journal of Operations & Production Management.
30- Thomé, K. M., Cappellesso, G., Ramos, E. L. A., & de Lima Duarte, S. C. (2021). Food supply chains and short food supply chains: coexistence conceptual framework. Journal of Cleaner Production, 278, 123207.

31- Yang, Y., Huisman, W., Hettinga, K. A., Zhang, L., & van Ruth, S. M. (2020). The Chinese milk supply chain: A fraud perspective. Food Control, 113, 107211.
32- Kazancoglu, Y., Ekinci, E., Mangla, S. K., Sezer, M. D., & Kayikci, Y. (2021). Performance evaluation of reverse logistics in food supply chains in a circular economy using system dynamics. Business Strategy and the Environment, 30(1), 71-91.
33- Aktas, E., & Bourlakis, M. (2020). Food Supply Chains in Cities. Springer.
34- Stevenson, WJ (2018). Operations management. THI RT EENTHEDITION, McGraw-hill
35- Schroeder, R. G., Goldstein, S. M., & Rungtusanatham, M. J. (2013). Operations management in the supply chain: Decisions and cases. McGraw-Hill Education.
36- Dey, P. K., Yang, G. L., Malesios, C., De, D., & Evangelinos, K. (2019). Performance management of supply chain sustainability in small and medium-sized enterprises using a combined structural equation modelling and data envelopment analysis. Computational Economics, 1-41.
37- Nakano, M. (2019). Supply Chain Management: Strategy and Organization. Springer.
38- Collier, D. A., & Evans, J. R. (2020). Operations and supply chain management. Cengage Learning.
39- Toorajipour, R., Sohrabpour, V., Nazarpour, A., Oghazi, P., & Fischl, M. (2021). Artificial intelligence in supply chain management: A systematic literature review. Journal of Business Research, 122, 502-517.
40- Kasabov, N. (2019). Evolving and spiking connectionist systems for brain-inspired artificial intelligence. In Artificial Intelligence in the Age of Neural Networks and Brain Computing (pp. 111-138). Academic Press.
41- Chen, S. H., Jakeman, A. J., & Norton, J. P. (2008). Artificial intelligence techniques: an introduction to their use for modelling environmental systems. Mathematics and computers in simulation, 78(2-3), 379-400.
42- Byun, S. E., Han, S., Kim, H., & Centrallo, C. (2020). US small retail businesses' perception of competition: Looking through a lens of fear, confidence, or cooperation. Journal of Retailing and Consumer Services, 52, 101925.
43- Barbaz & Al-Hiyali, B. & A.-H. (2020). ECONOMIC EVALUATION OF SOME AGRICULTURAL INITIATIVE PROJECTS IN IRAQ. IRAQI JOURNAL OF AGRICULTURAL SCIENCES, 51(3), 797-804. https://doi.org/10.36103/ijas.v51i3.1035
44- Al khazeli, M., & Al-Badri, B. (2021). FINANCIAL AND ECONOMIC EVALUATION OF THE LIVESTOCK FUND OF THE AGRICULTURAL INITIATIVE IN IRAQ FOR THE PERIOD (2009-2018). IRAQI JOURNAL OF AGRICULTURAL SCIENCES, 52(3), 647-657. https://doi.org/10.36103/ijas.v52i3.1355
45- Al-Wasity, R., Mahmood, Z., & Ali, S. (2021). MEASURING QUALITATIVE RESPONSE OF THE MOST IMPORTANT FACTORS AFFECTING THE ECONOMIC EFFICIENCY OF RICE FARMS IN NAJAF GOVERNORATE SEASON 2017. IRAQI JOURNAL OF AGRICULTURAL SCIENCES, 52(1), 79-87. https://doi.org/10.36103/ijas.v52i1.1238
46- Muhammed & Alhiyali, M. (2018). ESTIMATION OF THE IMPACT OF SOME VARIABLES OF AGRICULTURAL ECONOMIC POLICY ON THE IRAQI DOMESTIC AGRICULTURAL PRODUCT FOR THE PERIOD 1994-2015 USING THE METHOD OF COINTEGRATION AND THE ARDL MODEL. IRAQI JOURNAL OF AGRICULTURAL SCIENCES, 49(6). https://doi.org/10.36103/ijas.v49i6.146
47- Alsudani & Al-Hiyali, A. (2021). AN ECONOMIC ANALYSIS OF THE EFFECT OF SOME ECONOMIC VARIABLES ON THE STRUCTURE OF AGRICULTURAL EMPLOYMENT IN IRAQ FOR THE PERIOD 1990-2017. IRAQI JOURNAL OF AGRICULTURAL SCIENCES, 52(3), 682-690. https://doi.org/10.36103/ijas.v52i3.1359