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Demand Forecast Analysis for Bagel Sales in the Food Industry

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Abstract: For all living things, including plants and animals, food has become the means of ensuring their growth, survival, and protection of health. Life requires eating enough food in a balanced manner in order to continue. As a result, the food industry is made up of all these food-related operations, from the lowest stages (fisheries, agriculture, and animal husbandry) to the final stages (production, execution, and maintenance). In 1995, this industry was valued at 680 billion dollars, while in 2018, it was valued at 1.5 trillion dollars. A major factor in the food industry's recent more than twofold growth in size is production and consumption. Like everything else, the food business has benefited from the unification and simpler extension of a worldwide transportation network. The goal of this programming is to make it possible for artificial intelligence to anticipate with ease both the demand for bagels for the upcoming month and the annual sales amounts of a company that manufactures, supplies, and sells bagels. The CNN (Convolutional Neural Network) and LSTM (Long Short Term Memory) neural networks were used in the research as estimates of artificial intelligence. The prediction findings' accuracy was assessed using the Mean Squared Error (MSE) and Root Mean Square Error (RMSE). Software tests of the artificial intelligence techniques CNN and LSTM have shown nearly identical accuracy results. As a result, improvements in the findings of the precise estimation of the amount that may be sold will benefit sustainability, profitability, and market competition.

Keywords: demand forecasting, artificial intelligence, food industry, software

1. Introduction

Every living person, including even plants and animals, needs food to maintain their health, sustain their lives and ensure their development. Consuming balanced and sufficient amounts of food is a necessity for the continuity of life. Therefore, all the processes of these foodstuffs, starting from the lowest level (agriculture, animal husbandry, and fishing), through activities such as production, distribution, processing, until they are delivered to the end consumer, constitute the food sector. While the commercial value of this sector was 680 billion dollars in 1995, it reached 1.5 trillion dollars in 2018. Distribution as well as production and consumption plays a major role in the fact that the volume of the food industry has more than doubled in a few years. The existence of a global transportation network and the ease and spread of its use have made a positive contribution to the food industry, as in every sector.

Bagel; it has great importance in our eating habits because it is economical, satisfying, delicious and easily accessible. As a result of the research conducted on the nutrition of students at all levels from primary school to university, bagel took the first place among the products examined in almost all

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studies. Studies have shown that bagel, which can be consumed at every meal, is the first choice of those working in other jobs. If we look at the bagel industry in our country, bagels and similar products can be sold in bakeries where production is carried out, as well as in mobile carts at points determined by the municipalities of the bakeries. Or certain people can make sales by traveling in a certain region [1].

Today, with increasing competitive conditions, almost all companies are trying to maximize their revenues. For this reason, they try to increase their profits and reduce their losses. In such a situation, in order to minimize losses, managers must make an analysis of future demands in order to make decisions more easily without experiencing uncertainty and to reduce risks. While performing this analysis, studies are generally carried out based on demands from previous periods.

One of the most important decisions to be made or investments to be made in businesses is the future sales of the goods or services to be produced. These sales quantities are called demand. As a result of determining this future demand through analysis, the decisions to be taken with the information obtained in the business will be more accurate, the investments to be made will be planned more soundly, and the risks will be reduced as much as possible. A feasibility study is required for the products or services to be produced in businesses in today's economy, it is determined whether the product or service can be sold in the market and, accordingly, it is estimated how much demand the product or service will receive. In the stage of making these predictions, the outputs obtained as a result of demand forecast analysis using a certain amount of data provide information that can be considered reliable in the decision-making stage.

Artificial intelligence-based methods are powerful methods for solving complex problems. The most commonly used artificial intelligence methods in demand forecasting are artificial neural networks, fuzzy logic and genetic algorithm. Artificial neural networks work and learn in a way similar to the human brain. By drawing conclusions from past data, it can make similar inferences when faced with similar situations. Therefore, it can produce more successful solutions than traditional methods. Learned information is stored in the connections between neurons. That is, the information is distributed within the network. Many basic processing units evaluate this information separately. This ensures that, unlike traditional methods with a single central processor, the entire system is not affected when an error occurs in one unit. Therefore, the system has a flexible structure and damage to one part of the network does not affect the entire system. Thanks to its self-learning ability, the system can generalize when a situation occurs that it has not encountered before. This also means that when there is missing or incorrect data, it can be replaced by generalization.

In this study, in the demand forecast analysis for the food sector, it is argued that parameters such as the day of the week, sales price, weather, humidity rate, Dollar and Euro exchange rates, gram and ounce prices of gold, bitcoin price, interest rate, weekly expenditure amount and fear index affect the demand. In addition, when the literature is examined, it has been seen that artificial intelligence methods can make more accurate predictions and it has been argued that realistic predictions can be made with the help of artificial intelligence.

In this study, predictions were made using LSTM and CNN methods, which are among the demand forecasting methods with artificial intelligence. An estimate was made for a one-month period using one-year data on the bagel product produced by a business operating in the food industry. It was found that both artificial intelligence methods made close predictions as a result of their low error rates.

As a result of many literature studies, it has been seen that there are demand forecasting studies using artificial intelligence methods. In this study, a demand forecast was made for bagel, which is produced daily and should be consumed daily, in order to contribute to the literature. Since bagel uses a lot of raw materials during its production and must be consumed within a few hours after cooking, it is of great importance to make consistent demand forecasting. In addition, it is difficult to forecast demand because it is affected by rain, humidity, wind, both during production and consumption, its redness or whiteness, its price, and sales quantities are affected by weather events.

2. Literature Summary

In their study, Özüdoğru and Görener (2015) made a demand forecast for syringes, angiocath, patches and gloves using data received from a hospital in Istanbul between 2009 and 2014. It has been said that especially in the healthcare sector, the distress caused by not having the product needed and the high cost of unnecessary stock materials can lead to major problems. In this forecasting study in the health sector, where few studies have been conducted, a statistical program called Minitab17 was used and time series methods were applied to the data, thus the most appropriate forecasting method was found. By looking at the Average Absolute Error, Average Square Error and Average Absolute Percent Error values, it was seen that the most appropriate forecasting methods were the 5-Month Moving Average method and the Additive Holt-Winters Method. The predicted values were calculated by taking the average of the results of these two methods [2].

Sarı (2016) made sales demand prediction of engine bearings using Artificial Neural Networks. It has been observed that factors such as dollar exchange rate, gross domestic product, number of vehicle parks and interest rate affect sales demand. The results obtained were compared with the prediction results made with regression analysis and time series, and it was seen that the prediction made with artificial neural networks was closer to reality. In addition, the Average Absolute Percentage Error value was much lower in the predictions made with artificial neural networks compared to others [3].

Bayramoğlu, Pabuçcu and Boz (2017) tried to determine Turkey's energy demand between 2016 and 2030 with the Adaptive Neuro Fuzzy Inference System (ANFIS) method, one of the artificial intelligence techniques. It has also been stated that the ANFIS model produces very successful results in many fields, especially engineering. As a result, it was observed that the energy consumed per unit of output remained approximately the same from 2016 to 2030. This situation has been explained as countries will increase their use of renewable energy resources. The energy demand forecast for Turkey in the study showed that our country will switch to more environmentally friendly sources, on the grounds that the amount of energy consumed per unit of income does not increase [4].

Yiğiter, Sarı and Başakın (2017) predicted stock closing prices with artificial neural networks and fuzzy logic inference systems. In the study, stock closing prices between 2006 and 2016 were estimated using multiple linear regression, artificial neural networks and fuzzy logic methods. It has been observed that predictions made with artificial neural networks and fuzzy logic methods produce more realistic results than predictions made with regression analysis. It has been said that new models to be established with the help of these methods will help to make more accurate decisions [5].

Haliloğlu and Tutu (2018) determined the factors affecting electricity consumption in Turkey and developed a demand forecast model that would ensure supply-demand balance using the Multiple Least Squares Method (EKK). As a result of comparing the monthly prediction made with the established model with the actual daily values, it was seen that the monthly deviations were very low. When the prediction result made with the established model and the actual total consumption amount are compared, Turkey's total consumption was calculated almost correctly [6].

Yıldırım (2019) conducted Demand Forecast Analysis with Artificial Neural Networks, which has become increasingly important in recent years. He worked in a company that imports walnuts in the food industry. In practice, Feed Forward Backpropagation Neural Network, which is frequently preferred in prediction studies, was used and its model was created in the Matlab R2019 program. Exchange rate, inflation, competitor, customer and price variables were added as input to the artificial neural network and as a result, the network outputs and real values were quite close. In the application, single, binary and Winters' exponential correction methods were also used and Mean Square Error and Mean Absolute Percent Error values were calculated. According to the results, it was seen that the Artificial Neural Networks method was better than other methods [7].

Nasuhoğlu (2019) made predictions for 100 drugs using data between 2015 and 2018 in a pharmacy in Istanbul. Artificial Neural Networks, Moving Average, Exponential Smoothing, Binary Exponential Smoothing and Holt-Winters Methods were used. The results were checked by the Mean Square Error method. According to the results, it was seen that Artificial Neural Networks made the closest prediction [8].

In their study, Nebati, Taş and Ertaş (2021) made a demand forecast in electricity consumption using the electricity usage amounts in Turkey. They did this by using regression analysis and time series techniques. As a result, it was seen that the estimated values were close to the real values [9].
Çoban and Demir L (2021) made demand prediction for products in a food business using artificial neural networks and support vector regression methods. As a result, it has been seen that the artificial neural networks method can make better predictions than the support vector regression method [10].
Bilisik (2021) made a demand forecast for a company importing walnuts. It has been observed that the artificial neural network model gives the best results in the prediction made using multiple regression, 3-way, 4-way, 6-way moving averages, single, double and winters method exponential smoothing methods and artificial neural networks method [11].
In this context, after the sample studies examined, it was seen that artificial intelligence is not used much in demand forecasting and a few new studies have been conducted. It has been observed that there are not many demand forecasting applications in the food industry, and especially in the food industry, applications where demand forecasting is made using artificial intelligence are rare. For these reasons, this study was conducted to make a demand forecast using artificial intelligence in the food industry.

3. Demand Forecasting with Artificial Neural Networks

Artificial intelligence is generally the imitation of the cognitive learning process of the human brain in a virtual environment. It is used to solve complex problems and has been observed to generally give the most appropriate results. It is possible to produce solutions to problems thanks to the technique of gaining ideas by using historical data and learning by example. They are computer programs written to use a mathematical formula that can adapt parameters to examples in the simplest and shortest way, without going into technical details. It has human concepts such as perception, thinking, decision-making, and obtaining information. It tries to minimize the disadvantages of traditional computers by trying to imitate the human brain [7].
There are many basic processing units in artificial intelligence. All of these units are connected to each other, but the operations they perform individually are different. However, the transactions carried out by the units separately are ultimately considered as a whole. This situation also allows parallel operation, unlike classical algorithms. Therefore, problems can be resolved much faster [7].
Artificial intelligence-based methods are powerful methods for solving complex problems. The most commonly used artificial intelligence methods in demand forecasting are artificial neural networks, fuzzy logic and genetic algorithm. Artificial Neural Networks (ANN) are very flexible and powerful tools due to their ability to learn and generalize. The fuzzy logic method is widely used especially in interpreting data based on experience or non-numerical data. The state of uncertainty or imprecision is defined as blurriness. It is used in cases where there are no exact values and approximate thinking is used. Linguistic expressions such as big and small are used and everything takes values between 0 and 1. It is suitable for systems that are difficult to express with mathematical models. Genetic algorithm, another frequently used method, is used to calculate complex problems that are difficult to solve. In the genetic algorithm, each point in the solution is called a chromosome and a new entity is created using genetic factors such as crossover and mutation. First, in the genetic algorithm, all possible solutions are encoded as a sequence. Then, a random solution set is selected as a starting point. A fitness value is calculated for each sequence and random multiplication is performed. The fitness value is recalculated and the mutation process is applied. These processes are continued for a predetermined number of generations and the result that best suits the objective function is selected. Genetic algorithms can be used successfully in areas such as optimization, scheduling, mechanical learning, and cellular production [12].
Artificial neural networks are similar to biological neural networks and take the working principle of the human brain as an example. Artificial neural networks are widely used in the literature for different purposes such as; providing accurate soil moisture estimation [13], predicting employee turnover [14], sales forecasting for computer wholesalers [15], sales forecasting for oral-care goods [16], forecasting the temperature of a building-integrated photovoltaic panel [17], short term wind speed forecasting

[18], predicting air traffic demand [19], and so on. Artificial Neural Networks consists of many interconnected linear and non-linear elements. Artificial neurons generally consist of five parts called inputs, weights, summation function, activation function and output (Figure 1).

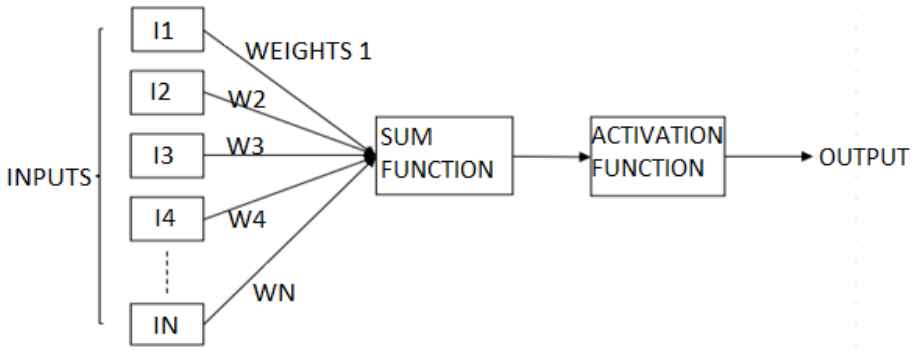

Figure 1. Artificial Nerve Cell.

The most important advantage of artificial neural networks is their ability to learn. This learning is the adjustment of weights to perform a desired function. Adjusting the weights is done with the help of examples of the problem. The weights are changed for each problem. This changing process continues until the correct weight is reached. Therefore, the most appropriate result is tried to be found by a constant trial and error method. The process stops when the error rate between the actual value and the result reaches an acceptable level. Each of these processes is called an Epoch. A high number of cycles may reduce the performance of the artificial neural network. Therefore, when choosing the number of cycles, the values between the activation function, learning method and network architecture should be chosen in the most appropriate way. ANN learning algorithms are divided into three groups: supervised, unsupervised and reinforcement learning [12].

In order for networks to work, the data that the network will process must first be collected. For this purpose, examples that have occurred before are discussed. Then, the number of layers of the network, the number of processing elements to be found in these layers, and accordingly the learning coefficient and aggregation and activation functions are determined. Weights for input values and intermediate layers are given random values between -0.1 and +0.1. Examples are selected from the learning set and shown to the network. There are output values based on input values and error values that occur accordingly. According to these values, the actual output is compared with the expected output. Finally, the weights are changed and control is regained [12].

4. Application

The demand forecasting application was carried out by using artificial neural networks and Python software by considering the annual bagel sales data of a company. Codes were written and run on Google TPUs in Colab. A sales forecast was made for the next 1-month period using 1-year historical data. In Python software, first LSTM (Long Short Term Memory) Neural Network and then CNN (Convolutional Neural Network) Neural Network were used. The resulting values were compared with each other and it was determined that similar results were found.

Deep learning technology has produced impressive time series prediction outcomes in recent years. Particularly, the long and short-term memory network (LSTM) and convolutional neural network (CNN) have shown great performance in processing temporal data. Deep learning models are appropriate for processing non-linear, smooth, and high-dimensional temporal data since they can automatically learn from patterns and properties of the data. Consequently, its application is extensive in various domains such as stock price prediction, crude oil price prediction, carbon trading price prediction, financial time-series analysis, and others. These models are capable of quite accurate prediction and have their own memory [20].

LSTM is one of the most advanced artificial neural network models for time series forecasting. This model allows the learning of additional parameters compared to others, thus adding long-term memory with more performance. LSTM can learn long-term transactions [21].
CNN, or the weight-value sharing structure of convolution, prevents overfitting and significantly lowers the number of parameters in the neural network, hence reducing the complexity of the neural network model. CNNs, however, are limited to training on and identifying static features in the data. CNNs are limited in their ability to handle lengthy sequences because of their structure, which disregards the long-term connections between sequential data at the temporal level [22].
The application was first tried in LSTM Neural Network. To read the data in the application; Pandas Library, Keras Library and Sklearn Library from Python were used.
Sales data of a company operating in the sector in Istanbul was taken and a model was established together with other variables. This company has been operating in the food industry for approximately 30 years and at 25 sales points. Daily sales data of 25 sales points were collected and the total value was written as input. In addition, data such as the day of the week, sales price, weather forecast, humidity percentage, Dollar and Euro exchange rate, gold gram and ounce price, bitcoin price, monetary policy interest rate, weekly TL spending amount, fear index are given to the program numerically on a daily basis. Using all of this data that consists of a total of 396 rows and 31 columns was loaded into the neural network (Figure 2).

	HAFTANIN_GUNU	SATIS_FIYATI	HAVA_DURUMU_AB	HAVA_DURUMU_B	HAVA_DURUMU_BG	HAVA_DURUMU_CB	HAVA_DURUMU_CG	HAVA_DURUMU_G	HAVA_DURUMU_HK	HAVA_DURUMU_HY	...	NEM_YUZDESI	DOLAR_KURU	EURO_KURU	ALTIN_GRAM_FIYATI	ALTIN_ONS_FIYATI	BITCOIN_FIYATI	PARA_POLITIKASI_FAIZ_ORANI	HAFTALIK_HARCAMA	KORKU_ENDEKSI	TOPLAM_SATIS
0	6	3.5	0	0	0	0	0	0	0	0	...	75	13.35	15.11	781	1811	45249	14.0	43668987	17.22	2690
1	7	3.5	0	0	0	0	0	0	0	0	...	68	13.35	15.11	781	1811	47795	14.0	43668987	17.22	3665
2	1	3.5	0	0	0	1	0	0	0	0	...	77	13.35	15.11	782	1811	47327	14.0	43668987	16.60	7660
3	2	3.5	0	0	1	0	0	0	0	0	...	79	13.45	15.26	759	1811	46441	14.0	43668987	16.91	7665
4	3	3.5	0	0	0	0	1	0	0	0	...	76	13.21	14.92	783	1826	45882	14.0	43668987	19.73	7505
5	4	3.5	0	0	1	0	0	0	0	0	...	70	13.39	15.14	794	1789	43436	14.0	43668987	19.61	7655
6	5	3.5	0	0	0	0	0	0	0	0	...	73	13.66	15.44	794	1792	43120	14.0	36481815	18.76	7170
7	6	3.5	0	0	1	0	0	0	0	0	...	75	13.66	15.44	799	1792	41528	14.0	36481815	18.76	6315
8	7	3.5	1	0	0	0	0	0	0	0	...	68	13.66	15.44	799	1792	41690	14.0	36481815	18.76	3865
9	1	3.5	0	1	0	0	0	0	0	0	...	68	13.78	15.58	800	1794	41884	14.0	36481815	19.40	7325

Figure 2. Numerical Information in the Program.

Then, the daily total sales number of the lines was converted into a graph by the program. With the help of this graph, fluctuations between sales were observed. According to these fluctuations, it has been observed that whether it is a weekday or a weekend has a serious impact on sales, or that sales decrease significantly during times such as Ramadan and holidays. It has been understood that special days or holidays affect the sales and therefore the forecast. Fluctuations are seen in Figure 3.

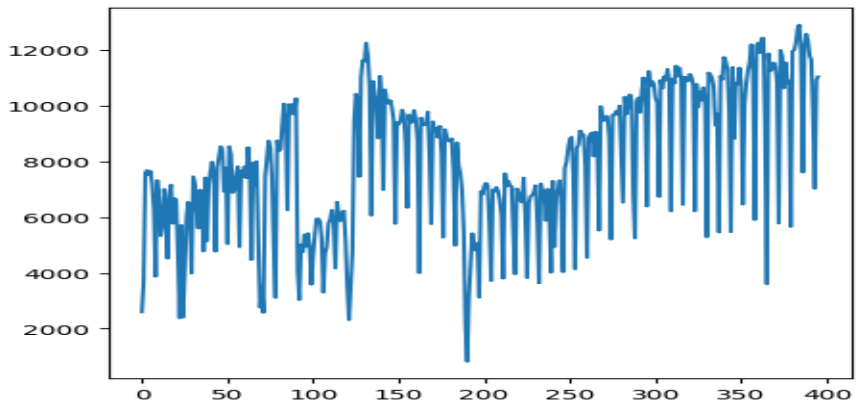

Figure 3. Daily Sales Number.

According to this data, 80% of 396 lines, that is, 316 lines, were used to train the artificial neural network, and it was expected to predict the remaining 20%, that is, 80 lines of data
In the light of this data, a Dropout and Dense are determined in the model in order to reach the result. Dropout; it decides by what percentage the parameters should be reduced when passing through the layers between neurons. Dense indicates how many values are desired to be found in the result. A total of 2776 parameters were created for the study data and as a result, 1 data was searched.

After the model is created, the Mean Squared Error (MSE) value is calculated while running the neural network and thus the margin of error is observed. In the model created based on the data, the Epoch value was randomly taken as 70 and thus it was decided that the model would be trained by making 70 iterations. Accordingly, it was understood that the MSE value was 0.1709 in the first model, and this value decreased as of the second model, that is, the model learned. As a result of approximately the 40th Epoch, it was observed that the MSE value was around 2%. Accordingly, it was concluded that the model learned in the 40th Epoch. The conclusion to be drawn here is that if there is no problem with time, the last 30 Epochs can be completed, but if there is a time constraint, there is no need for training. Since there is no time constraint in terms of this working model and each Epoch is very short, the training continued. According to the results, it is seen that the prediction of the model is close to normal. This can be seen in figure 4.

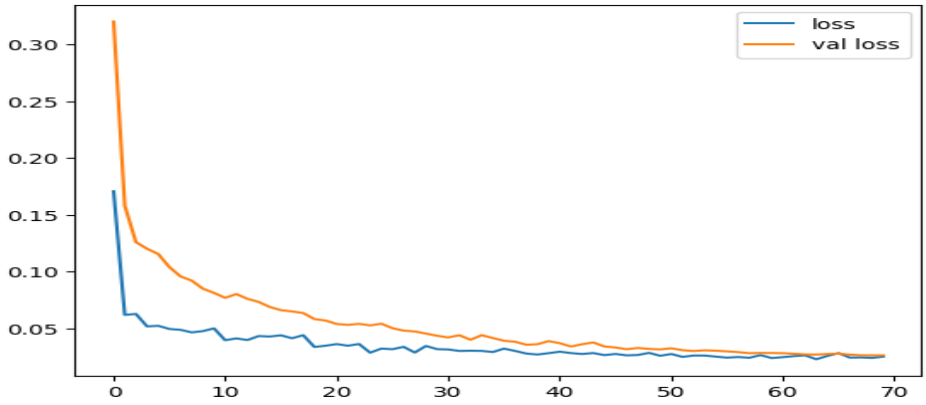

Figure 4. Model Estimated and Actual Value.

According to these results, a prediction is made in the model and the MSE value is calculated according to the result. RMSE (Root Mean Square Error) is obtained by taking the square root of this value. Thanks to the RMSE value, the success of the model can be measured. According to calculations, the RMSE value of the model is 0.1626. This value tells us that an accurate prediction was made with a margin of error of 16.26% (Figure 5).

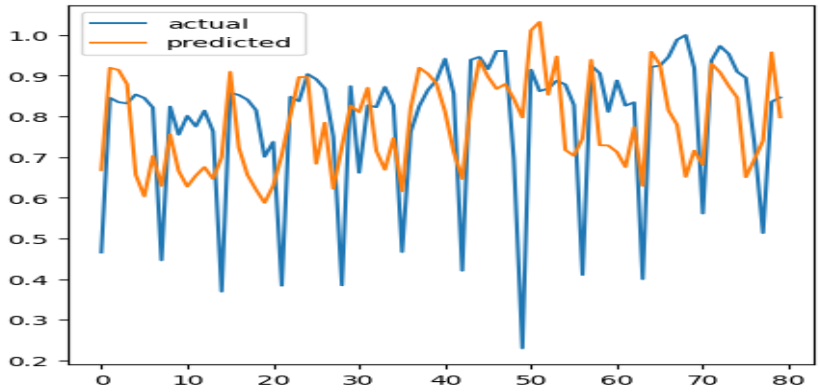

Figure 5. LSTM Estimation Results and Actual Values.

When the prediction results of the model and the actual values are compared, Figure 5 is formed. When this graph is examined, it is seen that the model cannot capture extreme points but can make generally consistent predictions. This is evident in the graph in Figure 5.

Loss and validation loss are calculated by looking at the values of the Epochs. According to the results, it is seen that the prediction of the model is similar to normal. This is clearly seen in figure 6.

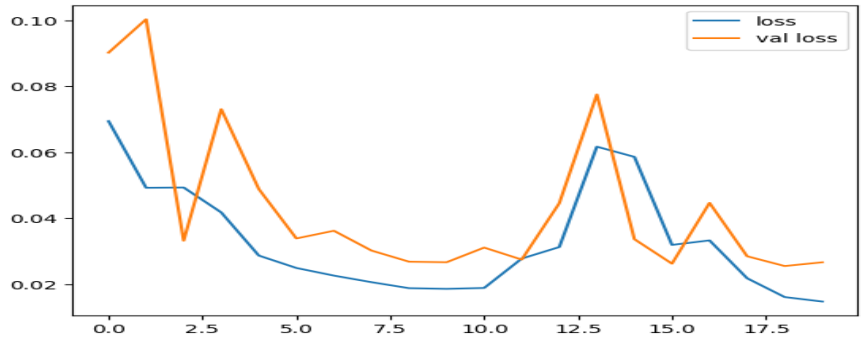

Figure 6. CNN Estimation Results and Actual Values.

According to these results, a prediction is made in the model and the MSE value is calculated according to the result. RMSE (Root Mean Square Error) is obtained by taking the square root of this value. Thanks to the RMSE value, the success of the model can be measured. According to calculations, it can be seen from Figure 6 that the RMSE value of the model is 0.1633. This value indicates that a correct prediction was made with a margin of error of 16.33%. Considering that the error rate in the LSTM model is 16.26%, it can be said that both artificial neural networks make predictions with a similar margin of error.

When the prediction results of the model and the actual values are compared, the graph in Figure 7 appears. Looking at this graph, it can be seen that the model cannot capture extreme points as in the LSTM model, but can still make consistent predictions in general.

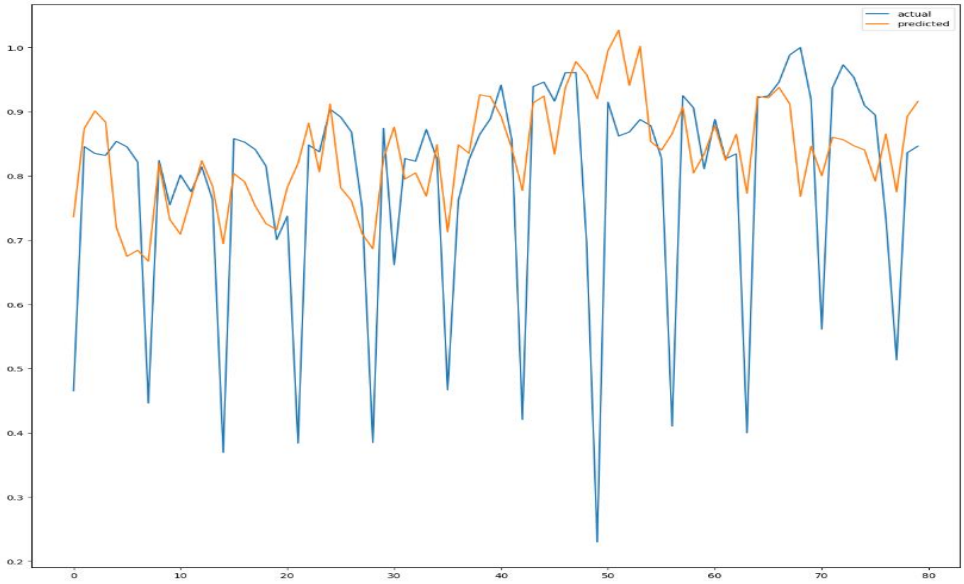

Figure 7. CNN Estimation Results and Actual Values.

It is seen that the error margins of LSTM and CNN artificial neural network models are almost the same and it is concluded that they make similar predictions. However, with LSTM each Epoch takes about 5ms, while with CNN it takes about 17ms. If there is no time restriction, both of these two methods can be used for applications.

5. Conclusions

Food is necessary for the upkeep of all living things, including plants and animals, as well as for their development and health. Life requires eating enough food in a balanced manner in order to continue. As a result, the food sector has a sizable share of this sector when taking production into account.

In these times of heightened competition, nearly every business is attempting to increase sales. They therefore make an effort to boost their earnings and lower their losses. Under such circumstances, managers have to analyze future demands to minimize losses, reduce risks, and make decisions more

readily without feeling uncertain. Demand forecast analysis is so crucial. Studies are typically conducted using data from earlier times in order to perform this analysis. Seasonal, economic, political, and other aspects should be taken into account when analyzing historical consumption data, and their effects should be taken into account when forecasting demand.

Upon reviewing the literature, it was discovered that demand forecasting research had been conducted and that artificial intelligence-based forecasts produced more reliable outcomes. Once more, the food industry is hardly ever covered by demand forecasting research, according to the literature assessment. This is the reason a corporation in the food industry performed a demand forecast study. First, a year's worth of data was used to analyze and debate the elements influencing sales. Using the data provided as input to the ANN, a prediction for the upcoming month was made. It has been noted that the predictions produced by CNN and LSTM neural networks are successfully fulfilled by artificial neural networks. Since the error rate computed as a result of the prediction was within an acceptable range, it was determined that the predictions were consistent. Based on this;

- Artificial neural networks can make consistent predictions in the food industry,
- As a result of ANN prediction, production can be made more planned,
- As a result of ANN prediction, production and consumption can be managed more easily,
- Investments can be made according to the demand resulting from ANN prediction,
- More accurate analysis can be made as a result of ANN prediction,
- According to the results of ANN estimation, stock quantities and raw material needs can be kept more easily and consistently,
- According to the ANN prediction results, it can increase competitiveness,
- According to the results of ANN prediction, it can be said that efficiency can be increased.

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