Predicting Bank Return on Equity (ROE) Using Neural Networks

Tolgay BALCI

Faculty of Computer Engineering, Başkent University, TURKEY

E-mail: tolgay.balci@hotmail.com

Hasan OĞUL

Faculty of Computer Sciences, Østfold University College, NORWAY

E-mail: hasan.ogul@hiof.no

INCLUDING

- INTRODUCTION
- METHODS
- RESULTS
- FINDINGS
- DISCUSSION
- CONCLUSION
- REFERENCES

INTRODUCTION

- Banks are one of the most important factors for a country's financial and economic development. Therefore, the banking sector needs to be able to maintain its existence in a strong manner in order for the economy to progress with health and to maintain stability.

- Starting with the liberalization policy after 1980, it happened a major change in the banking sector. The banking sector extended in Turkey and in that period it was allowed foreign banks to operate in Turkey. The banks have targeted to make high profits so they engaged in not only tradional banking activities (deposit and loan) but also repos, securitization, off-shore activities and etc.

- After 1994 crisis, they suffered a huge loss and after 2000 – 2001 crisis, the banking system in Turkey damaged dramatically[1].

- In particular, profitability came into prominence in the 2000s the local and the global financial crisis of Turkey. During the global crisis worldwide in 2008, banks in Turkey by showing high rates of profitability, has attracted the attention of domestic and foreign investors[2]. The existence of this situation caused researchers to carry out various studies related to profitability.

- Today, studies on profitability are based on asset profitability (EC), equity profitability (SP) and net interest margin (NFM), but especially in the literature, equity profitability and asset profitability are generally more used in studies. In particular, the fact that central banks and audit authorities refocus profitability on asset profitability and return on equity led researchers to these two criteria.

- In calculating bank profitability, many experts generally use statistical models such as Logistic Regression Analysis, Full Logistics Rectification, Multiple Separation Analysis, Multiple Regression Analysis.

- In recent years, it has been observed that newer techniques have been used especially in calculating bank profitability. Especially, thanks to developments in artificial intelligence such as making decisions logically, artificial intelligence has started to use in different areas like calculating bank profitability using artificial neural networks (ANNs)[3] or genetic algorithms (GA)[4].

- In the study, three state-owned commercial banks profitability of artificial neural networks in Turkey have tried to estimate using optimization algorithms.

METHODS

ARTIFICIAL NEURAL NETWORKS

- Artificial Neural Networks are computer systems that perform the learning function, which is the most basic feature of the human brain. They perform the learning process with the help of examples.

- Artificial neural networks can be considered among the most powerful techniques especially in classification, pattern recognition, signal filtering, data compression and optimization studies.

- It is possible to come across successful examples that we will see in our daily lives in many fields such as data mining [5], optical character recognation [6], predicting the magnitude of the largest earthquake in a pre-defined future time period [7], fingerprint recognition [8], palm recognation [9], iris recognation [10], material science analysis [11], medical image analysis [12].

OPTIMIZATION ALGORITHMS

- Artificial neural network optimization algorithms used in the study are Stochastic Gradient Descent, Adam and RMSprop. In the following section, these algorithms will be briefly mentioned.

Stochastic Gradient Descent

- Stochastic Gradient Descent (SGD) has taken its place in the literature as one of the most important features of modern machine learning. In particular, it is the preferred optimization method for training highly complex and non-convex models such as artificial neural networks[13]. It is observed that they suffer from less damage than problems caused by overfitting. Given that SGD has the best of finding a local minimum of non-convex objective function, it is suggested that all such minimums can be equally good. However, at the same time, in the majority of empirical studies, and trade tricks, such as early stopping, show that in practice a person may not reach the minimum level, but still observes excellent performance.

RMSProp

- Rmsprop was developed as a solution to the problem of excessive reduction of the learning coefficient in Adagrad algorithm. Instead of using all the values obtained from the squares of all past slopes in Adagrad, it restricted the amount of value to a certain frame size [14][15].

ADAM

- Calculation with this method is just like calculating with RMSprop method. The squares of slope use momentum changes as well as using exponentially weighted averages. Thus RMSprop and momentum combine. The default values are 0.9 for β1; It is stated as 0.999 for β2 and 10^{-8} for ϵ [16][17].

Implementation Details Paramethers of Networks

Definitions	Explanations
Type of Network	Forward Feeding Multilayer Perceptron
Learning Algorithm	Back Propogation
Type of Learning	Supervised Learning
Rule of Learning	Adam, RMSProp, Stochastic Gradient Descent(Momentum)
Number of Input Layer	15(neurons)
Number of Hidden Layer	5
Number of Hidden Layer1	32(neurons)
Number of Hidden Layer2	64(neurons)
Number of Hidden Layer3	32(neurons)
Number of Hidden Layer4	32(neurons)
Number of Hidden Layer5	64(neurons)
Number of Output Layer	1(neuron)
Learning Rate	0.01
Epoch Number	1000
Transfer Function	**Relu**

RESULTS

DATA

Banks Information: Deposit money banks comprise commercial banks and other financial instutions that accept transferable deposits, such as demand deposits. In Turkey, deposit money banks are divided into 3 groups. These are public deposit banks, domestic private deposit banks and foreign private deposit banks. In this study, we use data of the state deposit money banks which are Ziraat Bankası, Halk Bankası and Vakıflar Bankası.

Dependent Variable	Independent Variables
	Endogenous Variables
Average Return on Equity	Shareholders' Equity / Total Assets
	Total Deposits / Total Assets
	Total Loans and Receivables / Total Assets
	Loans Under Follow-up (gross) / Total Loans and Receivables
	Liquid Assets / Total Assets
	Net Interest Income After Specific Provisions / Total Assets
	Non-interest Income (net) / Total Assets
	Personnel Expenses / Other Operating Expenses
	Exogenous Variables
	Exchange Rate (USD/TL)
	Required Reserve Ratio (ZKTL)
	Inflation Rate (TUFE)
	Crisis (dummy)
	GDP growth rate
	Industrial Production Index (SUE)
	Interest Rate (overnight borrowing rate)

Experimental Setup

- Our study was carried out to find return of equity in artificial neural network optimization algorithms. As can be seen from the parameters in Table 1, our model is forward feeding multilayer perceptron. Our learning algorithm is back propagation. Our learning type is Supervised Learning. In the experiments, we used Adam, RMSprop and Stochastic Gradient Descent optimization algorithms.

- We have 15 input layer, 5 hidden layer (32, 64, 32, 32, 64 neurons) and 1 output layer. In the figure below, all neurons are interconnected.

```python
def build_model():
  model = keras.Sequential([
    layers.Dense(64, activation='relu', input_shape=[len(train_dataset.keys())]),
    layers.Dense(32, activation='relu'),
    layers.Dense(64, activation='relu'),
    layers.Dense(32, activation='relu'),
    layers.Dense(32, activation='relu'),
    layers.Dense(64, activation='relu'),
    layers.Dense(1)
  ])
```
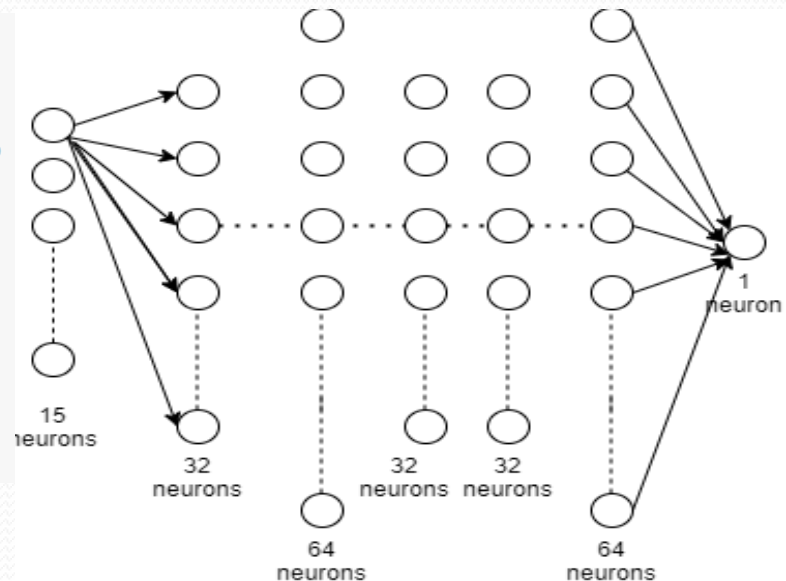
- We accepted 0.01 as the learning rate in the models. Our best performance was realized at 1000 epoch with trial and error. Our transfer function is Relu.

- In the experiments, we first checked for corrupt data. If there is any corrupt data, system determine corrupt data and start to delete them until there is no corrupt data in our data set as much as possible. On the other hand, only the values and bank names showing the periods were extracted from our data set during the pre-transaction. This procedure shows how many input layers to use exactly. Thus, the accuracy value will increase by excluding unnecessary input values.

```
dataset = dataset.dropna()
```

- In the study, the first factor that increases the accuracy value is to augment both total numbers of layers and total numbers of neurons in the layers. At this point, random values are used with grid search method when determining the number of nodes within layers. So that we achieved the best results in 5 layers.

- After all these processes, we divided our data set into 80 percent education and 20 percent test data with cross validation method. While machine learning datasets are expected to consist of thousands of lines, the our data set is considered small. Therefore, our accuracy value may be larger. The solution of this problem is to run the model over and over again using the cross validation technique. When we assign the random state value as "0", "1", "2", "3" and "4" in the cross validation method, our data set will be mixed up as much as these numbers. If we assign the random state value as "5", our accuracy value is equal to accuracy value of random state value of "0". So that, we decided to assign our random state values between [0 - 4].

- Therefore, model training becomes much more reliable as 20% test and 80% model training part of the dataset changes every time in cross validation procedure. In the study, we increased the number of layers.

```
train_dataset = dataset.sample(frac=0.8, random_state=0)
test_dataset = dataset.drop(train_dataset.index)
```

- After dividing our data, we put the separated data into normalization. Especially by keeping numerical values between 0 and 1 in normalization, we increased our performance as a result of experiments.

```python
def norm(x):
    print(x)
    return (x - train_stats['mean']) / train_stats['std']
normed_train_data = norm(train_dataset)
normed_test_data = norm(test_dataset)
```

- Since the values that were not normalized in the first place yielded very distant results in the figures, the forecast values were quite low. After normalization process, we made the estimated values closer to the real values.

```
train_stats = train_dataset.describe()
train_stats.pop("return_on_equity")
train_stats = train_stats.transpose()
train_stats
```

- Learning ratios are given as 0.01 in all optimization algorithms, but only momentum is defined in Stochastic Gradient Descent algorithm. As mentioned before; system has performed 1000 times epoch at every turn. Thus, the training of the data set was completed after the network performed 1000 times back propagation.
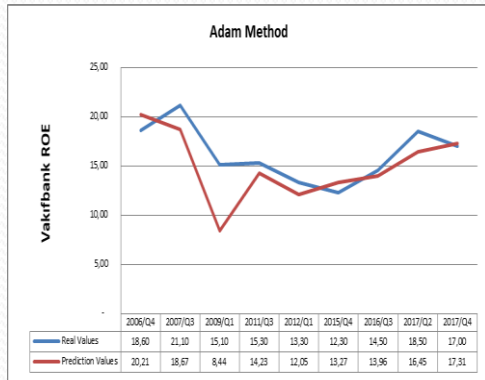
```
EPOCHS = 1000

history = model.fit(
  normed_train_data, train_labels,
  epochs= EPOCHS, validation_split = 0.2, verbose=0,
  callbacks=[tfdocs.modeling.EpochDots()])
```
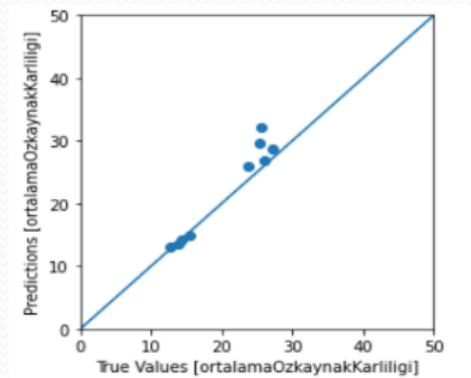
FINDINGS

Adam Method of ROE(s)
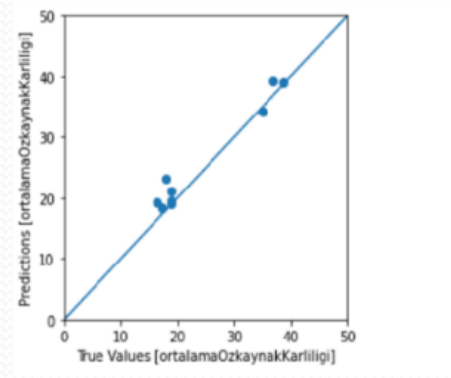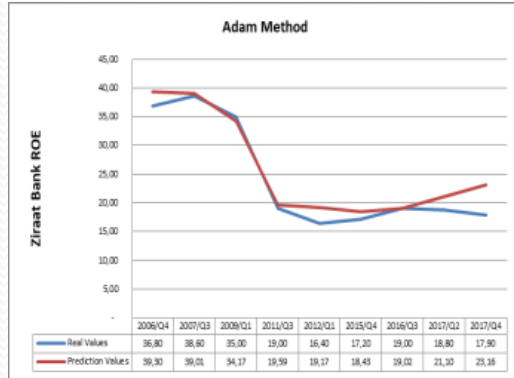
Vakıfbank ROE with Adam Method
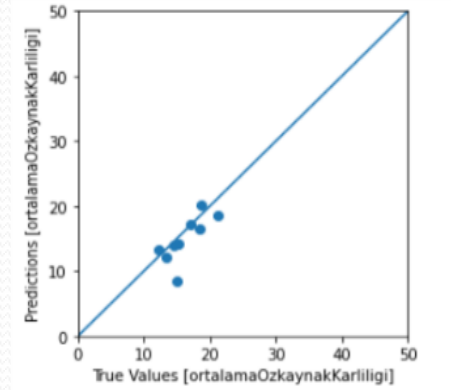
- The calculated ROE values and the real ROE values of the bank are very close to each other between the 3rd quarter of 2011 and the 4th quarter of 2017. The accuracy value for Vakıfbank is 88.31%.

Halkbank ROE with Adam Method

The calculated ROE values and the real ROE values of the bank are very close to each other between the 1st quarter of 2012 and 4th quarter of 2017. The accuracy value for Halkbank is 92.06%.
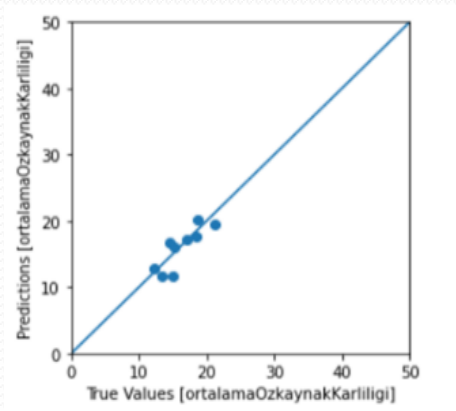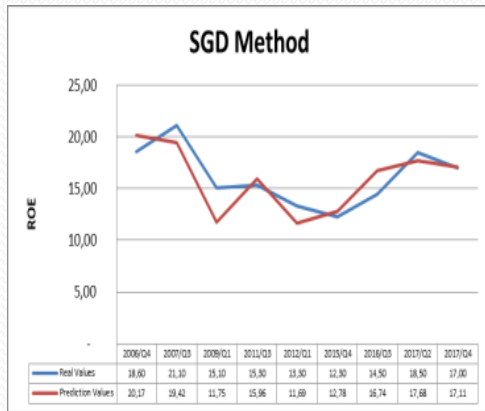
Ziraat Bank ROE with Adam Method

	2006/Q4	2007/Q3	2009/Q1	2011/Q3	2012/Q1	2015/Q4	2016/Q3	2017/Q2	2017/Q4
Real Values	36,80	38,60	35,00	19,00	16,40	17,20	19,00	18,80	17,90
Prediction Values	39,30	39,01	34,17	19,59	19,17	18,43	19,02	21,10	23,16

- The calculated ROE values and the real ROE values of the bank are very close to each other between the 4th quarter of 2006 and 4th quarter of 2017. The accuracy value for Ziraat Bank is 91.22%.
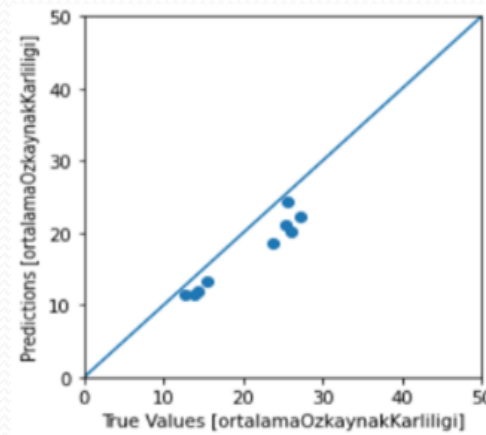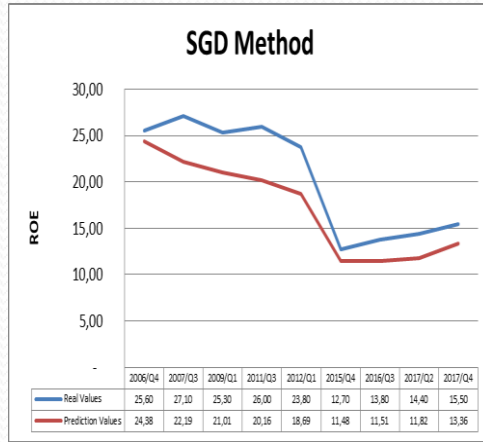
Stochastic Gradient Descent Method of ROE(s)

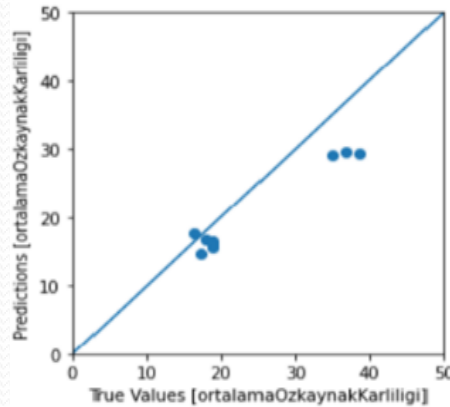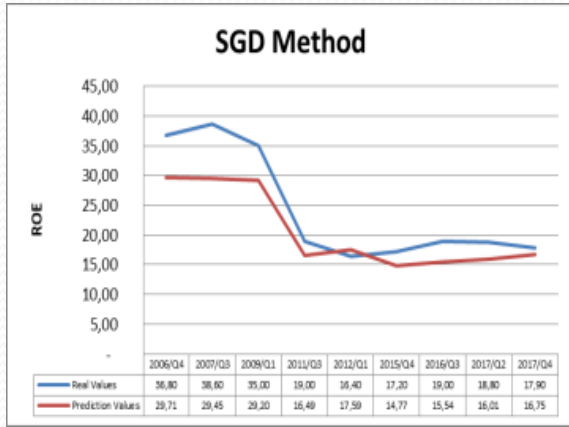**Vakıfbank ROE with SGD Method**

- The calculated ROE values and the real ROE values of the bank are very close to each other between the 3rd quarter of 2011 and 4th quarter of 2017. The accuracy value for Vakifbank is 91.17%.

Halkbank ROE with SGD Method

- The calculated ROE values and the real ROE values of the bank aren't very close to each other in all periods. The accuracy value for Halkbank is 84.25%.
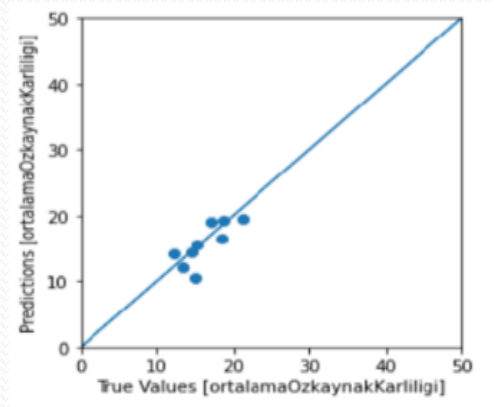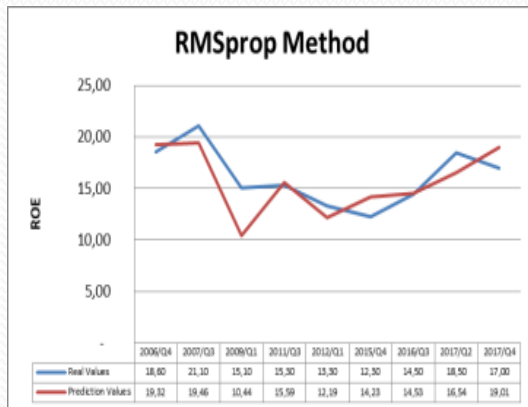
Ziraat Bank ROE with SGD Method

- The calculated ROE values and the real ROE values of the bank aren't very close to each other in all periods. The accuracy value for Ziraat Bank is 85.25%.

RMSprop of ROE(s)

Vakıfbank ROE with RMSProp Method

The table within the left chart:

	2006/Q4	2007/Q3	2009/Q1	2011/Q3	2012/Q1	2015/Q4	2016/Q3	2017/Q2	2017/Q4
Real Values	18,60	21,10	15,10	15,30	13,30	12,50	14,50	18,50	17,00
Prediction Values	19,32	19,46	10,44	15,59	12,19	14,23	14,53	16,54	19,01

- The calculated ROE values and the real ROE values of the bank are very close to each other. The accuracy value for Vakifbank is 89.88%.

Halkbank ROE with RMSProp Method
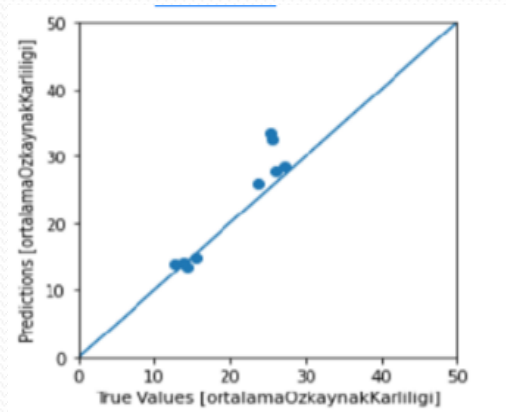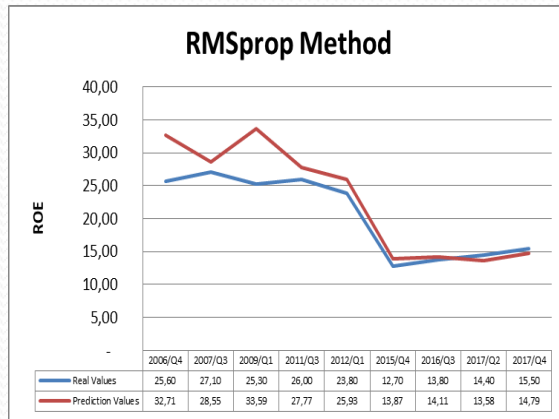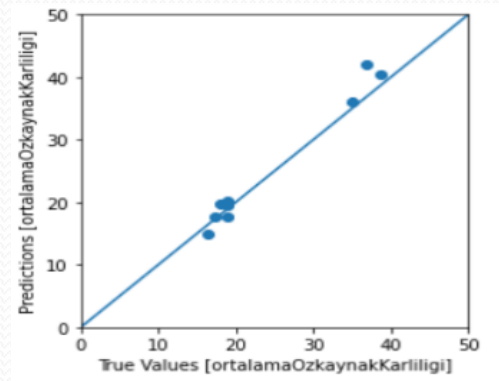

	2006/Q4	2007/Q3	2009/Q1	2011/Q3	2012/Q1	2015/Q4	2016/Q3	2017/Q2	2017/Q4
Real Values	25,60	27,10	25,30	26,00	23,80	12,70	13,80	14,40	15,50
Prediction Values	32,71	28,55	33,59	27,77	25,93	13,87	14,11	13,58	14,79

- The calculated ROE values and the real ROE values of the bank are very close to each other between the 3rd quarter of 2011 and 4th quarter of 2017. The accuracy value for Halkbank is 88.52.

Ziraat Bank ROE with RMSprop Method
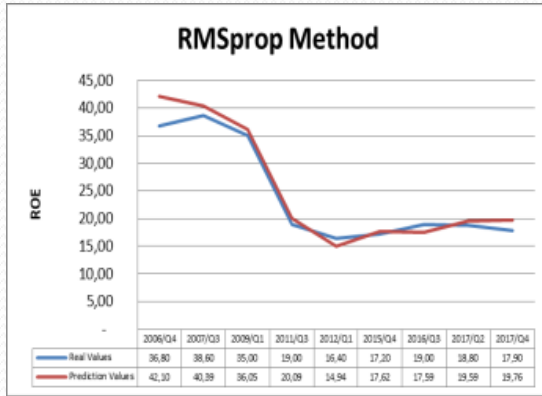
	2006/Q4	2007/Q3	2009/Q1	2011/Q3	2012/Q1	2015/Q4	2016/Q3	2017/Q2	2017/Q4
Real Values	36,80	38,60	35,00	19,00	16,40	17,20	19,00	18,80	17,90
Prediction Values	42,10	40,39	36,05	20,09	14,94	17,62	17,59	19,59	19,76

- The calculated ROE values and the real ROE values of the bank are very close to each other between the 3rd quarter of 2007 and 4th quarter of 2017. The accuracy value for Ziraatbank is 93.21%.

- All optimization methods accuracy results are given. We manage to achieve a very high percentage in general. As it can be seen from the below table, our accuracy rates are between 84.25% and 93.21%. The most successful result for our dataset is realized for Ziraat Bank which is 93.21%. If it elaborates, the Stochastic Gradient Descent method (91.17%) for Vakifbank, the Adam method for Halkbank (92.06%) and RMSprop (93.21%) for Ziraat Bank give the most successful results.

Accuracy Value of Banks with Optimization Methods

Bank	Adam	SGD	RMSprop
Vakıf Bank	88,31	91,17	89,88
Halk Bank	92,06	84,25	88,52
Ziraat Bank	91,22	85,15	93,21

DISCUSSION

- In the model we created, real ROE values were compared with calculated ROE values by various optimization methods. Thus, the proximity of the real ROE values and the calculated ROE values is shown on the basis of accuracy value. It is thought that different studies can be conducted to accurately predict future ROE and other important ratios of banks in various countries by various finance experts using different variables and developed optimization methods. In this context, our study is thought to make an important contribution to the literature.

CONCLUSION

- The study focused on public deposit banks on behalf of the banking sector in Turkey. In this context by using artificial neural network optimization algorithm methods, we calculate ROE values for public deposit banks between December 2006 and December 2017. As a result, for the banking sector in Turkey, all three methods can be thought as appropriately. According to Table 4, the most effective method is Adam method and it is preferred initially. Then, it was concluded that the RMSprop and Stochastic Gradient Descent optimization algorithms should be used, respectively. As a result, to estimate future unknown value of any variables by using the advanced versions of these three models in Turkish banking sector, we assume that the priority order should be taken into account of this study results.

REFERENCES

[1] Saritas, H., Kangalli Uyar, S. G., & Gokce, A. (2016). The Analysis of Banks' Profitability with Financial Ratios and Macroeconomic Variables Based on System Dynamic Panel Data Model: Research on Turkey. Eskişehir Osmangazi Üniversitesi IIBF Dergisi-Eskişehir Osmangazi University Journal of Economics and Administrative Sciences, 11(1), 87-108.

[2] Sönmez, F., Zontul, M., & Bülbül, Ş. (2015). Mevduat bankalarının karlılığının yapay sinir ağları ile tahmini: Bir yazılım modeli tasarımı. BDDK Bankacılık ve Finansal Piyasalar, 9(1), 9-45.

[3] Ömürbek, V., Akçakanat, Ö., Aksoy, E. "Aktif Büyüklüklerine Göre Değerlendirilen Büyük Ölçekli Bankaların Yapay Sinir Ağları ile Karlılık Tahmini". Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi 33 (2019): 451-466

[4] Noura Metawa, M. Kabir Hassan, Mohammed Elhoseny(2017). Genetic algorithm based model for optimizing bank lending decisions, Expert System With Applications, 75-82

[5] Buscema, M., Ferilli, G., & Sacco, P. L. (2017). What kind of 'world order'? An artificial neural networks approach to intensive data mining. Technological Forecasting and Social Change, 117, 46-56.

[6] Desai, A. A. (2010). Gujarati handwritten numeral optical character reorganization through neural network. Pattern recognition, 43(7), 2582-2589.

[7] Adeli, H., & Panakkat, A. (2009). A probabilistic neural network for earthquake magnitude prediction. Neural networks, 22(7), 1018-1024.

[8] Baldi, Pierre & Chauvin, Yves. (1993). Neural Networks for Fingerprint Recognition. Neural Computation. 5. 10.1162/neco.1993.5.3.402.

[9] Gong, Weiyong & Zhang, Xinman & Deng, Bohua & Xu, Xuebin. (2019). Palmprint Recognition Based on Convolutional Neural Network-Alexnet. 313-316. 10.15439/2019F248.

[10] Abiyev, Rahib & Altunkaya, Koray. (2008). Personal Iris Recognition Using Neural Network. International Journal of Security and its Applications. 2.

[11] Singh, Mohan & Kaur, Harminder. (2016). Artificial neural networks in material science research. Current Reports on Science and Technology. 2. 145-159.

[12] Jiang, J., Trundle, P., & Ren, J. (2010). Medical image analysis with artificial neural networks. Computerized Medical Imaging and Graphics, 34(8), 617-631.

[13] Kuzborskij, I. and Lampert, C. Data-dependent stability of stochastic gradient descent. In Dy, J. and Krause, A. (eds.), Proceedings of the 35th International Conference on Machine Learning, volume 80 of Proceedings of Machine Learning Research, pp. 2815–2824, Stockholmsmssan, Stockholm Sweden, 10–15 Jul 2018. PMLR.

[14] Ruder, S. (2016). An overview of gradient descent optimization algorithms. arXiv preprint arXiv:1609.04747.

[15] Kurt, F. (2018). Evrişimli Sinir Ağlarında Hiper Parametrelerin Etkisinin İncelenmesi (Yüksek Lisans Tezi). Hacettepe Üniversitesi, Fen Bilimleri Enstitüsü. Ankara, Türkiye.

[16] Li, P. (2017). Optimization algorithms for deep learning. department of systems engineering and engineering management. http://lipiji.com/docs/li2017optdl.pdf. Erişim Tarihi: 01.09.2020

[17] Çarkacı, N. (2018). Derin öğrenme uygulamalarında en sık kullanılan hiper parameteler. https://medium.com/deep-learning-turkiye/derin-ogrenme-uygulamalarinda-en-sik-kullanilanhiper-parametreler-ece8e9125c4. Erişim tarihi: 06.06.2020

THANK YOU