Applying Neural Networks for Loan Decisions in the Jordanian Commercial Banking System

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Summary
Artificial Neural Networks play an increasingly important role in financial applications for such tasks as pattern recognition, classification, and time series forecasting. This study develops a proposed model that identifies artificial neural network as an enabling tool for evaluating credit applications to support loan decisions in the Jordanian commercial banks. A multi-layer feed-forward neural network with backpropagation learning algorithm was used to build up the proposed model. Different representative cases of loan applications were considered based on the guidelines of different banks in Jordan, to validate the neural network model. The results indicate that artificial neural networks are a successful technology that can be used in loan application evaluation in the Jordanian commercial banks.

Key words:
Business intelligence (BI) artificial intelligence (AI), artificial neural networks (ANN), backpropagation (BP) algorithm, credit scoring

1. Introduction

Artificial neural networks have been fruitfully used in a variety of business fields including marketing, accounting, management information systems, and production management (Cao and Parry, 2009). Most of the studies have used neural networks for predicting future stock behavior, financial crises, bankruptcy, exchange rate, and detecting credit card fraud.

The granting of loans by banks is one of the key areas concerning decision problems that need subtle care (Handzi et.al, 2003). Neural Networks have successfully provided effective credit evaluations for supporting granting loans.

Researchers are currently focusing on using neural network classification models and particularly backpropagation neural networks in classifying loan applications into good and bad ones. This research attempts to explore whether using neural networks will provide more accurate personal loan decisions in the Jordanian commercial banks. It will also propose a neural computing model as the basis for a decision support tool in granting or rejecting bank loans. The model will apply banking credit standards to determine the customer who will be eligible for credit approval.

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Despite the increase in consumer loans defaults and competition in the banking market, most of the Jordanian commercial banks are reluctant to use artificial intelligence software technologies in their decision-making routines. Generally, bank loan officers rely on traditional methods to guide them in evaluating the worthiness of loan applications. Generally, loan applications evaluations are based on a loan officers' subjective assessment. Such judgment is inefficient, inconsistent, and non-uniform (Limsombunchai et.al, 2005). Therefore, a knowledge discovery tool is needed to assist in decision making regarding the application. Furthermore, the complexity of loan decision tools and variation between applications is an opportunity for a neural-computing technology to provide learning capability that does not exist in other technologies.

Neural networks with their capability of capturing nonlinear and complex relationships are a powerful alternative to the conventional forecasting and classification methods. Neural networks are consistent paradigms of the nonparametric approach in financial modeling due to their ability to correctly classify and predict consumer loan defaults.

2. Literature Review:

Artificial Intelligence (AI) is generally defined as a discipline that concerns with designing and applying algorithms for analysis of learning from and interpretation of data. AI combines many techniques of machine learning, pattern recognition, logics and probability theory in addition to biologically inspired models, such as neural networks, evolutionary computing or fuzzy modeling, collectively described as computational intelligence (Duch et.al, 2007). AI is an attempt to develop computer-based technology that can act like humans, with the ability to learn languages, accomplish physical tasks, and emulate human expertise and decision making (Russell and Norvig, 2003). Intelligence is a skill that characterizes humans although humans do not behave intelligently all the time. Artificial intelligence is the ability of a machine to do activities that require human intelligence (Brachman, 2006). The integration of many application domains in the artificial intelligence and inspirations of the human intelligence have enabled researchers to make substantial progress towards achieving human-level artificial intelligence (Cassimatis, et.al, 2006).

3. Neural Networks:

Neural networks are an emerging artificial intelligence technology that imitates the human brain on the computer. These techniques are based on the parallel, distributed processing design. The parallel structure makes neural networks proficient at analyzing problems with many variables (Tafti, 1993; Zhang, 2004). Scientists have been inspired by the capabilities of the human brain for information processing and problem solving. Therefore, neural networks designers try to put intelligence into these systems in the form of generalized ability to learn and recognize patterns to exhibit similar intelligent functionality like humans (Shachurove, 2002).

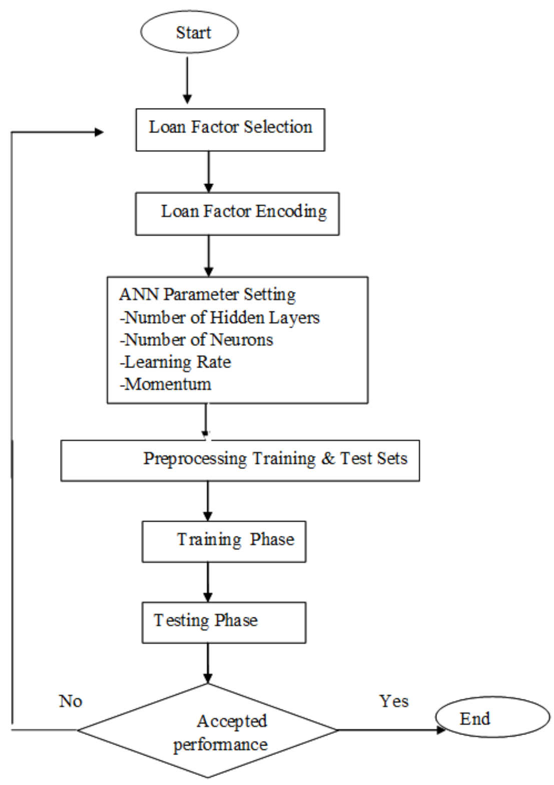
A neural network model is composed of a number of neurons that are organized in several layers: an input layer, a hidden layer(s), and an output layer (Malhotra and Malhotra, 2003; Cao and Parry, 2009). The input layer of neurons feeds the input variables into the network. The hidden layer is a bridge between the input layer and the output layer. The neurons in this layer are fundamentally hidden from view, and their number and arrangement can typically be treated as a black box to those who are carrying out the system.

The function of the hidden layer is to process the input variables. This is achieved by summing up all weighted inputs, checking whether the sum meets the threshold value and applying the transformation function. The weights between the input neuron and hidden neurons determine when each unit in the hidden layer may fire or not and by modifying these weights, the hidden layer may fire or not (Zhang, 2004; Shachmurove, 2002). In other words, the hidden layers learn the relationship between inputs and outputs in a way similar to that of the human brain by adjusting the weights during the training process (Peel and Wilson, 1996).

The function of the output layer is similar to that of the hidden layer. Each input for this layer is possessed as in the hidden layer (Muller et.al, 2009). A specific neural network model is determined by its topology, learning paradigm and learning algorithm (Handzic et.al, 2003).

4. A Proposed Neural Network Model for Loan Decisions:

Designing a neural network successfully relies on a clear understanding of the problem, and on deciding upon most influential input variables. The procedure of designing a neural network model is a logical process. This research followed the step designing methodology presented in figure (1). The process was not a single-pass one, but it required going back to previous steps several times:



Source: Prepared by researchers

Figure (1) Flow Diagram of the Proposed Model

4.1. Banking Data Sets:

The data set used in this research was divided into training and testing data sets. There were 94 cases used in the training and 46 in the testing. Both training and testing data sets contained half-good applications and half-bad applications. The training set cases approximately cover the input data space. All training cases were set by default taking into account the banks' guidelines for personal credit approval in the Jordanian banks. The network was trained on mixed types of good and bad applications.

4.2. Specifying Loan Variables:

In relation to loan applications evaluation, a set of decision variables that determine the credit worthiness of an application were used in this current research. These variables were taken from the guidelines that credit officers use in Jordanian commercial banks. The information that is considered as significant includes: the applicant's characteristics such as his age, account type, income, nationality, residency, companies' type, guarantor, job experience, and the DBR (i.e. debt balance ratio that measures the applicant's repaying ability). High DBR ratio indicates high credit risk. On the other hand, low DBR ratio indicates a good credit application. Therefore, there are 11 input neurons for the network; each represents an independent variable. They are referred to as respectively. On the other hand, the output in this research is 1 for good application or 0 for bad application; a single output neuron is needed to produce the output.

5. Defining the Network Parameters:

Deciding on the optimal parameters for the MLFN model is a critical issue. The best model is one that has the combination of parameters that minimizes the mean squared error. At the beginning, the researcher selected an initial configuration (one hidden layer with a number of hidden neurons, and one neuron in the hidden layer). After conducting a number of experiments with each model, the researcher retained the best network. In brief, a series of repeated trials were applied in order to reach the optimal set of parameters. The network was given a fixed number of training epochs 10000; the learning rate was set to 0.2, the momentum is 0.9, the log sigmoid is the transfer function, and the gradient descent is the learning algorithm. Furthermore, the new set of trials increased the number of hidden layers to two and three hidden layers with a different number of neuron combinations in order to decide on the best set of hidden layers and neurons. A multi-layer feed-forward neural network with two hidden layers with ten neurons in the first hidden and seven neurons in the second hidden had the best speed time at the fixed threshold level of 0.05. Table (1) illustrates the optimal set of the proposed Neural Network parameters.

6. Network Training:

First the networks' weights are initialized, consequently the network is prepared for training. The training cases are used to adjust the weights through minimizing the prediction made by the network. The back-propagation gradient descent-learning algorithm uses the performance function in order to trace the best set of weights that minimizes the average mean squared error. The algorithm allocates the error backward through the network's layers successively. Furthermore, the algorithm develops through a number of epochs and uses the error to adjust the weights in the direction in which the performance function decreases quickly. The training stopped when the error reached 0.0499948 performance level and about 4670 epochs see figure (2) below.

Table (1) The Optimal Set of Parameters

Parameter	Value
Number of Training Data	94
Number of Testing Data	46
Number of Hidden Layers	2
Number of Hidden Neurons	10, 7 respectively
Learning Rate	0.2
Momentum	0.9
Training Epochs	4862 (an average for 6 runs)
Threshold	0.05

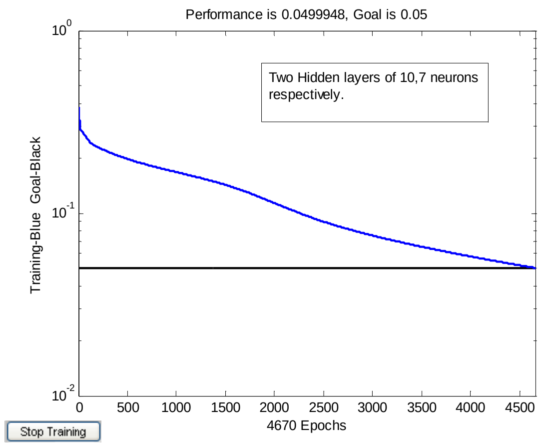


Figure (2)

7. Network Testing:

Testing the network is necessary in order to examine its ability to classify the testing data correctly. Testing starts after the training has been completed. The network was simulated on the testing set (i.e. cases the network has not seen before). The results were very good; the network was able to classify 95% of the cases in the testing set. The results are shown in the appendix. A pair wise t-test was used to compare between the actual neural network output and the target output of the testing set. The null hypothesis that assumes that there is no significant difference between the actual and the target output was accepted.

8. Findings and Conclusions:

This study proposed a decision support system that is able to adapt to the dynamic changes in the financial business environment. The proposed system will assist Jordanian banks in personal credit evaluation in order to reduce the risk of customers who default. The commercial banks in Jordan rely on loan officers to make credit decisions. Using neural networks in loan evaluation will reduce any bias or emotional intention that can distort the decision process. Hence, the cost of loan processing will be reduced; also it will reduce personal judgement which will enhance the quality of customer service. Moreover, the research findings correspond with research by Handzic Meliha et.al (2003); Molharta R., and Molharta D.K. (2003); and Mitchell D., and Pavur R., (2002) indicating that neural networks are a successful technology that can be used in loan application evaluations. The results also showed that the use of more training cases means better results.

Other researchers used a backpropagation neural network to classify loans, bond, and the problems of default prediction and bankruptcy prediction. The results of this study confirm researches of Singleton and Surkan (1990); Tam and Kiang (1992); Tay and Cao (2002).

REFERENCES:

[1] Askim Jostcin, (2004). Performance Management and Organizational Intelligence: Adapting the Balanced Scorecard in Larvik Municipality, International Public Management Journal Vol.7, No.3.

[2] Bagchi Kallol and Mukhopadhyay Somnath, (2006). Predicting Global Internet Growth Using Augmented Diffusion, Fuzzy Regression and Neural Network Models, International Journal of Information Technology & Decision Making, Vol. 5, and No. 1.

[3] Bensic Mirta, Sarlija Natasa and Zekic-Susac Marijana, (2005). Modeling Small-Business Credit Scoring by Using Logistic Regression, Neural Networks and Decision Trees, Intell. Sys. Acc. Fin. Mgmt. 13.

[4] Brachman, Ronald J, (2006). (AA)AI More Than the Sum of Its Parts, AI Magazine Volume 27 Number 4.

[5] Bratianu Constantin, Jianu Lonela and Vasilache Simona, (2007). Integrators for Organizational Intellectual Capital, IC-Congress, INHOLLAND University of Professional, Haarlem, the Netherlands.

[6] Brindley, C. and Ritchie, B. (2003). Reducing Risk in Information Search Activities, Manchester Metropolitan University, UK.

[7] Buchanan, Bruce G, (2005). A Very Brief History of Artificial Intelligence, American Association for Artificial Intelligence, 25th Anniversary Issue.

[8] Cao, Q. And Parry, M. (2009). Neural Network Earning Per Share Forecasting Models: A Comparison of Backward Propagation and Genetic Algorithm, Decision Support Systems 47.

[9] Casado, Edilberto, (2003). Expanding Business Intelligence Power with System Dynamics, Pero.

[10] Cassimatis, N. Mueller, E. And Winston P. (2006). Achieving Human-Level Intelligence through Integrated Systems and Research, AI Magazine Volume 27 Number 2 AAAI.

[11] Central Bank of Jordan, (2005-2008). Annual Reports, Amman - Jordan

[12] Chien-Ho Koand Min-Yuan Cheng .(2007). Dynamic Prediction of Project Success Using Artificial Intelligence, Journal of Construction Engineering and Management.

[13] Currry Bruce and Moutinho Luiz, (1993). Using Advanced Computing Techniques in Banking, International Journal of Bank Marketing, Vol.11.No.6.

[14] Duch W. Swaminathan K. And Meller J., (2007). Artificial Intelligence Approaches for Rational Drug Design and Discovery, Current Pharmaceutical Design, 2007, 13.

[15] El-Refae Ghaleb, Rashed Jamal, (2004). Optimal Investment under Standard Debt Contract: Knowledge Management Approach, Global Business and Economic Review Anthology, Business and Economics Society International, USA.

[16] Furness Peter. (1996). Neural Networks for Data-Driven Marketing, Intelligent Systems For Finance and Business, edited by Goonatilake and Treleaven, New York,Wiley Inc,.

[17] Gan C. Limsombunchai V. Clemes M. and Weng A. (2005). Consumer Choice Prediction: Artificial Neural Networks versus Logistic Models, American Journal of Applied Science 1 (4).

[18] Gan Christopher, Clemes Mike and Weng Amy. (2005). Consumer Choice Prediction: Artificial Neural Networks versus Logistic Models, Journal of Social Sciences, New Zealand.

[19] Giang H. (2005). Using Neural Network in Predicting Corporate Failure, Journal. of Social Sciences.

[20] Goodatilake S. and Treleaven P. (1995). Intelligent Systems for Finance and Business, Wiley, USA.

[21] Handzic Meliha, Tj and Rawibawa Felix and Yeo Julia. (2003). How Neural Networks Can Help Loan Officers to Make Better Informed Application Decisions, Informing Science Insite.

[22] Hariri B. and Sadati N., (2007). NN-RED: An AQM Mechanism Based on Neural Networks, Electronics Letters Vol. 43 No. 19.

[23] Hawley, D.D., Johnson, J.D. and Raina, D. (1990), Artificial Neural Systems: A New Tod for Financial Decision-Making, Financial Analysts Journal, (November-December) 63- 72.

[24] Huang Wei , Lai K. K. , Nakamori Y. and Wang Shouyang, (2004). Forecasting Foreign Exchange Rates with Artificial Neural Networks: A Review, International Journal of Information Technology & Decision Making Vol. 3, No. 1.

[25] Huanga Zan, Chena Hsinchun, Hsua Chia-Jung, Chenb Wun-Hwa and Wuc Soushan. (2004). Credit Rating Analysis with Support Vector Machines and Neural

Networks: A Market Comparative Study, Decision Support System 37.
[26] Huntley, D.G. (1991). Neural Nets: An Approach to the Forecasting of Time Series, Social Science Computing Review, 9 (1), 27-38.
[27] Hurbean Luminita., (2006). Business Intelligence: Applications, Trends, And Strategies, Analele Stiintifice Ale Universitatii, Alexandru Ioan Cuza" Din Iasi.
[28] Johnston, S.J. (1991), Neural Networks Are Making Inroads: Technology Has Found Many, Practical Applications, Inforworld, (July 8) 13-16.
[29] Kaastra .I, and Boyd .M. (1996). Designing a Neural Network for Forecasting Financial and Economic Time Series, Neurocomuting 10.
[30] Katsoulakos and Rutherford. (2006). An Introduction to Knowledge Oriented Strategy KOS and Strategic Knowledge Management Capabilities, Kbos Strategic Knowledge Management: SKM 1b.
[31] Khoshnevisan M., Bhattacharya S., and Smarandache F. (2003). Artificial Intelligence and Responsive Optimization, 2nd Edition, Xiquan & Authors 510 East Townley Av., Phoenix, USA. E-book.
[32] Lak Shmanan et.al. (2008). the 2008 Artificial Intelligence Competition.
[33] Lenk Margarita, Warzala Elaine and Silva Ana, (1997). High- Tech Valuation: Should Artificial Neural Networks Bypass the Human Valuer, Journal of property valuation &Investment. vol.15.no.1.
[34] Limsombunchai V. Gan C. and Lee M. (2005). An Analysis of Credit Scoring For Agricultural Loans in Thailand, American Journal of Applied Science 2 (8)-1205.
[35] Limsombunchai, Gan V. C. and Lee M (2005), Lending Decision Model for Agricultural Sector in Thailand, American Journal of Applied Science 2 (8)-1205.
[36] Malhorta R. And Malhorta D.K., (2003). Evaluating Consumer Loans Using Neural Networks, Elsevier Science Ltd.
[37] Marto Michel, (2008). Banks Report, Association of Banks of Jordan. Jordan.
[38] Mcgreal Stanley Et Al., (1998). Neural Networks: The Prediction of Residential Values, Journal of Property Valuation &Investment. Vol.16, No.1.
[39] Mitchell David and Pavur Robert, (2002) .Using Modular Neural Networks for Business Decisions, Management Decision 40/1.
[40] Mostafa Mohamed, El-Refae Ghaleb, (2003). Forecasting the Suez Canal Traffic: A Neural Network Analysis. Arab Journal of Administrative Sciences, Kuwait University, Kuwait.
[41] Muller G., Steyn-Bruwer and Hamman W. (2009). Predicting Financial Distress of Companies Listed on the JSE-A Comparison Techniques, S.Afr.J. Business Management 40(1).
[42] Nguyen Dat-Dao and Kira Dennis S., (2005). Building Knowledge Repositories with Neural Networks and Orthogonal Designed Bases of Expert Holistic Judgments, Journal of Information Science and Technology 2(2).
[43] Nikhil Ranja Pala, Animesh Sharmab and Somitra Kumar Sanadhyaa., (2008). Deriving Meaningful Rules From Gene Expression Data For Classification, Journal of Intelligent & Fuzzy Systems 19.
[44] Nilsson Nils J., (2006). Human- Level Artificial Intelligence? Be Serious! AI Magazine Volume 26(AAAI).
[45] Olszak and Ziemba, (2006). Business Intelligence Systems in the Holistic Infrastructure Development Supporting Decision-Making in Organizations, Interdisciplinary Journal of Information, Knowledge, and Management.
[46] Peel Michael and Wilson Nick, (1996). Neural Network Simulation: A New Approach To Risk Assessment and Business Forecasting, Management Research News, Vol.19.No.6.
[47] Pirttimaki. (2007). Business Intelligence as a Managerial Tool in Large Finish Companies, Tampereen University of Technology, Julkaisu.
[48] Pless Nicola and Maak Thomas, (2005). Relational Intelligence for Leading Responsibility in a Connected World, Annual Meeting of The Academy of Management, Honolulu, Hawaii, USA, Tripple - Blind Review.
[49] Pollard Austin. (2007). What are Neural Networks?, Artificial Intelligence.
[50] Russel S. and Norvig P. (2003). Artificial Intelligence, a Modern Approach, 2nd Edition.
[51] Sabarirajan A., (2008). Scope of Artificial Intelligence in Business, Articlebase.
[52] Saxby Lorie, (2007). The Brain-Performance Connection, Ahead Coaching And Consulting Inc., Waterloo, Ontario, Canada.
[53] Shaaf Mohamad, (1996). A Neural Network and Econometric Comparison of the Relative Importance of Fiscal and Monetary Actions, Emerald backfiles 2007.
[54] Shaaf Mohamad, (2000). Predicting Recession Using the Yield Curve: An Artificial Intelligence and Econometric Companies, Vol. 26, 2
[55] Shachmurove Yochanan, (2002). Applying Artificial Neural Networks to Business, Economics and Finance.
[56] Singleton J.C. & A.J. Surkan., (1990). Neural Networks for Bond Rating Improved by Multiple Hidden Layers, Proceedings of the IEEE International Conference on Neural Netorids.
[57] Smith, J.C. (1992). A Neural Network--Could It Work for You? Financial-Executive, (May-June), 26-30.
[58] Smith, Mark. (1992). Business Process Intelligence, Intelligent Enterprise.
[59] Smith, Mark. (2002). Business Process Intelligence, Intelligent Enterprise.
[60] Staskevicute Inga and Neverauskas Bronius, (2008). The Intelligent University's Conceptual Model, Engineering Economic, No.4 (59).
[61] Tafti Mohammed H.A. And Nikbakht Ehsan. (1993). Neural Networks and Expert Systems: New Horizons in Business Finance Applications, Information Management & Computer Security, and Vol.1no.1.
[62] Tam. K., and M. Kiang., (1992). Managerial Application of Neural Networks: The Case of Bank Failure Predictions, Management Science 38. (7)
[63] Tan NW. Clarence, (1998). An Artificial Neural Networks Primer with Financial Applications Examples in Financial Distress Predictions and Foreign Exchange Hybrid Trading

System, School of Information Technology, Bond University, Gold Coast, QLD 4229, Australia.
[64] Tay F.E.H., and L. J. Cao., (2002). Modified Support Vector Machines in Financial Time Series Forecasting, Neurocomputing 48.
[65] Thawornwong Suraphan, Enke David, and Dagli Cihan, (2003). Neural Networks as a Decision Maker Forstocktrading: Technical Analysis Approach, International Journal of Smart Engineering System Design, USA.
[66] Thawornwong, S., Enke, D., and Dagli, C. (2003) .Neural Networks As a Decision Maker for Stock Trading: A Technical Analysis Approach. International Journal of Smart Engineering System Design, USA.
[67] Trinkle Brad S., (2005). Forecasting Annual Excess Stock Returns via an Adaptive Network-Based Fuzzy Inference System, Intell. Sys. Acc. Fin. Mgmt. 13.
[68] Turban E., Aronson J., Liang T. and Sharda R. (2007). Decision Support and Business Intelligence Systems, Fifth Edition, Pearson.
[69] Watson Mark. (2008). Practical Artificial Intelligence Programming With JAVA, Third Edition.
[70] William Steve and William Nancy, (2003). The Business Value of Business Intelligence, Business Intelligence Journal.
[71] Zhang G.Peter. (2004). Neural Networks In Business Forecasting, Idea Group Inc.
[72] http:// www.cs.nott.ac.uk/neural-networks.htm
[73] http://images.google.com/images/hl=en&source=hp&q=neural+network&gbv=2&aq=0&oq=neural&aqi =g10
[74] http://www.articlebase.com/management-articles/scope-of-artificial-intelligence-in-business-328608.html.
[75] http://www.graph.com.
[76] http;//images.google.com/images/hl=en&source=hp&q=neural+network&gbv=2&aq=0&oq=neural&aqi=g10.

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