PREDICTING MACROECONOMIC TIME SERIES IN MALAYSIA: USING NEURAL NETWORKS APPROACHES

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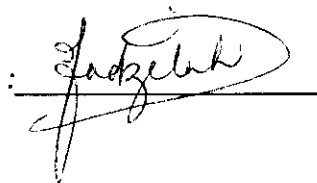*(that the project paper acceptable in form and content, and that a satisfactory knowledge of the field is covered by the project paper).*

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ABSTRACT (BAHASA MALAYSIA)

Sejak kebelakangan ini, neural buatan telah banyak mendapat sambutan dan perhatian yang sungguh menggalakkan daripada kalangan peramal makroekonomi. Hal ini adalah disebabkan oleh potensi yang ada pada neural buatan dalam mengesan dan menyelesaikan masalah hubungan linear dan tidak linear terhadap set pemboleh ubah. Kajian ini menyediakan satu pengenalan terhadap neural buatan dan memperkenalkannya sebagai pendekatan baru kepada teknik-teknik ekonometrik yang standard. Keputusan emperik dalam meramal pemboleh ubah siri masa model makroekonomi terhadap Keluaran Dalam Negara Kasar (KDNK) di Malaysia mengesahkan bahawa kedua-dua tempoh 'in-sample' dan 'out-of-sample' menunjukkan ramalan menggunakan model neural buatan adalah lebih baik berbanding model regrasi dengan pengurangan ralat di antara *8 peratus* hingga *57 peratus*.

Kajian-kajian yang lepas mencadangkan bahawa neural buatan secara umumnya lebih baik berbanding dengan model linear untuk ramalan 'out-of-sample' output ekonomi dan pelbagai pemboleh ubah kewangan seperti harga stok. Walau bagaimanapun, tinjauan karya yang dipaparkan tidak harus dianggap sebagai kesimpulan yang mutlak kerana sekarang ini kedapatan masih kurang lagi kajian-kajian yang berkaitan dengan bidang ini. Potensi neural buatan boleh diekploitasi sepenuhnya bersama-sama dengan model linear regrasi. Oleh kerana itu, neural buatan seharusnya dilihat sebagai satu 'new tool' yang patut digunakan bersama-sama dengan 'toolbox' yang lain khususnya bagi peramal makroekonomi.

ABSTRACT (ENGLISH)

In recent years, neural networks have received an increasing amount of intention among macroeconomic forecasters because of their potential to detect and reproduce linear and nonlinear relationship among a set of variables. This study provides an introduction to neural networks and its establishment to standard econometric techniques. An empirical results in forecasting macroeconomic variables to GDP growth in Malaysia was initially introduced. For both the in-sample and the out-of-sample periods, the forecasting accuracy of the neural network is found to be superior to a well established linear regression model, with the error reduction ranging 8 per cent to 57 per cent.

A throughout review of the literature suggests that neural networks are generally more accurate than linear models for out-of-sample forecasting of economic output and various financial variables such as stock prices. However, the literature should still be considered inconclusive due to the relatively small number of reliable studies on the macroeconomic forecasting. The full potential of neural networks can probably be exploited by using them in conjunction with linear regression models. Hence, neural networks should be viewed as an additional tool to be included in the toolbox of macroeconomic forecasters.

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CHAPTER 1

INTRODUCTION

1.1 Overview

Macroeconomic forecasting is a very difficult task due to the lack of an accurate, convincing model of the economy. The most accurate models for economic forecasting, "black box" time series models assume little about the structure of the economic (Moody, 1995). Recent research suggests that neural networks may prove useful to forecast volatility financial variables that are difficult to forecast with conventional statistical methods, such as exchange rates (Verkooijen, 1996) and stock performance (Refenes, Zappranis and Francis, 1994). Neural networks have also been successfully applied to macroeconomic variables such as economic growth (Tkacz, 1999), industrial production (Moody, Levin and Rehfuss, 1993) and aggregate electricity consumption (McMenamin, 1997).

Most of these applications would benefit from the inclusions of nonlinearity in the forecasting function. However, nonlinear time series forecasting is not straightforward and theory does not guide the model building process by suggesting a functional relationship between relevant lags and the response variable. Within sample fit criteria are less effective in choosing a nonlinear rather than a linear model, and the best fitting nonlinear model may not produce the most accurate out-of-sample forecast.

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BIBLIOGRAPHY

Ash, T. (1989). 'Dynamic node creation in backpropagation neural networks', *Connection Science* 1(4), 365–375.

Aiken, Milam (1999). 'Using a Neural Network to Forecast Inflation', *Industrial Management and Data Systems*.

Aiken, Milam and Bsat, Mohammad (1999). 'Forecasting with Neural Networks', *Information Systems Management*.

Altman, E.L. (1968). 'Financial ratios, discriminate analysis and the prediction of corporate bankruptcy'. *Journal of Finance 23*, 589-609.

Anders, U. and O. Korn (1997). 'Model selection in neural networks'. *Technical Report 96-21, ZEW*. http://www.zew.de/pub_dp/2196.html.

Andersson, Tomas and Falksund, Victoria (1994). 'Using neural nets to analyse global markets', *AI in Finance*, Fall 1994, p.7-17.

Arthur, W.B. (1993). 'On designing economic agents that act like human agents'. *Journal of Evolutionary Economics 3*, 1-22.

Beltratti, N., Margarita S., and Terna P. (1996). 'Neural networks for economic and financial modelling'. *Intl. Thomson Computer Press*.

Bosarge, W. E. (1993). 'Adaptive processes to exploit the nonlinear structure of financial market'. In R. R. Trippi and Turban (eds.), neural networks in finance and investing, pp.371-402. *Probus Publishing*.

Bramson, M.J. and Hoptroff, R.G. (1990): 'Forecasting the Economic Cycle: A Neural Network Approach', paper presented at the Workshop on Neural Networks for Statistical and Economic Data, *Dublin*, 10-11 December, 1990.

Bigus, J. P. (1996). 'Data mining with neural networks'. *McGraw-Hill*

Brockett, P.W., Cooper W.W., Golden L. L., and Pitaktong U. (1994). 'A neural network method for obtaining an early warning of insurer insolvency'. *The Journal of Risk and Insurance 6*, 402-424.

Chatfield, C. (1993). 'Neural networks: forecasting breakthrough of passing fad?'. *International Journal of Forecasting 9*, 1-3.

Cho, I. K. (1994). 'Bounded rationality, neural network and folk theorem in repeated games with discounting'. *Economic Theory 4*,935-957.

Cox, E. (1992). 'Fuzzy fundamentals.' *IEEE Spectrum* 29 (10): 58–61.

Cho, I. K. and Sargent T.J. (1996). 'Neural networks for encoding and adapting in dynamic economies'. In H.M. Amman, D. A. Kendrick, and J. Rust (Eds.), *Handbook of Computational Economics, Vol. 1*. Pp. 441-470. Elsvier.

Church, K. B. and Curram S.P. (1996). 'Forecasting consumer's expenditure: A comparison between econometric and neural network models'. *International Journal of Forecasting 12*, 255-267.

Clemen, R.T. (1989).'Combining forecasts: A review and annotated bibliography'.*International Journal of Forecasting* (5), 559–583.

Coleman, K.G., Graettinger T.J., and Lawrence W. F. (1991). 'Neural network for bankruptcy prediction: The power to solve financial problems'. *AI Review July/August*, 48-50.

Donaldson, Glen R. and Kamstra, M. (1996). 'Forecast Combining with Neural Networks', *Journal of Forecasting*, Vol. 15, p.49-61.

Delurgio, S.A. (1998). 'Forecasting Principles and Applications', *MaGraw Hill, International Edition*

Eight Malaysian Plan Report (2001-2010). Various Issues

Fama, E. (1970). 'Efficient capital markets: A review of theory and empirical work'. *Journal of Finance 25*, 383-417.

Fauset, L. (1994). ' Fundamentals of neural networks: architecture, algorithms, and applications.' *Prentice-Hall Inc.*

Fu, Jiarong (1998). 'A Neural Network Forecast of Economic Growth and Recession,' *The Journal of Economics*, XXIV, No. 1, p.51-66.

Geman, S., Bienenstock E. and Doursat, R. (1992). 'Neural networks and the bias/variance dilemma', *Neural Computation* 4(1), 1–58.

Granger, C. W. J. and Newbold, P. (1986). 'Forecasting Economic Time Series, 2nd eds, *Academic Press*, San Diego, California.

Granger, C. W. J. and Terasvirta, T. (1993). 'Modelling nonlinear economic relationships', Oxford University Press.

Grudnitzki, G. (1997). 'Valuations of residential properties using a neural network.' *Handbook of neural computation 1*, G6.4:1-G6.4:5.

Goldberg, D.E. (1989). 'Genetic algorithms in search, optimization and machine learning'. Reading,MA: *Addison-Wesley Publishing Co.*

Haefke, C. and Helmenstein C. (1996). 'Neural networks in the capital markets: An application to index forecasting'. *Computational Economics 9*, 37-50.

Hamilton, J. D. (1994), 'Time Series Analysis', *Princeton University Press.*

Hiemstra, Y. (1996). 'Linear regression versus backpropagation networks to predict quarterly stock market excess returns'. *Computational Economics 9*, 67-76.

Hill, T., L. Marquez, O'Connor M. and Remus W. (1994). 'Artificial neural network models for forecasting and decision making'. *International Journal of Forecasting 10*, 5-15

Hill, T.; Marquez, L., O'Connor, M. and Remus, W. (1994). 'Artificial neural network models for forecasting and decision making", *International Journal of Forecasting*, 10, p.5-15.

Hoerl, A. and Kennard, R. (1970a). 'Ridge regression: applications to non orthogonal problems', *Technometrics* 12, 69–82.

Hoerl, A. and Kennard, R. (1970b). 'Ridge regression: biased estimation for nonorthogonal problems', *Technometrics* 12, 55–67.

Jagielska, I. and Jaworski J, (1996). 'Neural network for predicting the performance of credict cards accounts'. *Computational Economics 9*, 77-82.

Kaastra, I.B. Kermanshasi S., and Goodmann D. (1992). 'Neural networks for forecasting: an introduction'. *Canadian Journal of Agriculture Economics 43*, 463-474.

Kuan, C. M. and Liu T. (1995). 'Forecasting exchange rates using feedforward and recurrent neural networks'. *Journal of Applied Econometrics 10*, 347-364.

LeCun, Y., Denker, J. S. and Solla, S. A. (1990), 'Optimal brain damage', *in* D. S. Touretzky, ed., 'Advances in Neural Information Processing Systems 2', *Morgan Kaufmann Publishers.*

Lee, T.H., White H. and C.W.J. Granger (1993). 'Testing for neglected linearity in time series models'. *Journal of Econometrics 56*, 269-290.

Levin, A. U., Leen, T. K. and Moody, J. E. (1994). 'Fast pruning using principal components', *in* J. Cowan, G. Tesauro and J. Alspector, eds,'Advances in Neural Information Processing Systems 6', *Morgan Kaufmann Publishers*, San Francisco, CA.

Litterman, R. B. (1986), 'Forecasting with bayesian vector autoregressions – five years of experience', *Journal of Business and Economic Statistics* 4(1), 25–38.

Luna, F. (1996). 'Computable Learning, neural networks and institutions'. University of Venice (IT), http://helios.unive.it/~fluna/english/luna.html.

Malkiel, B. (1992). 'Efficient markets hypothesis'. In Eatwell J. (ed.), *New Palgrave Dictionary of Money and Finance*. Macmillan.

Marose, R.A. (1990). 'A financial neural network application'. *AI Expert may*, 50-53.

Meese, R. A. and Rogoff A.K. (1983). 'Empirical exchange rate models of the seventies: Do they fit out of sample?'. *Journal of International Economics*, 13, 3-24.

Moody, J. (1992). 'The effective number of parameters: an analysis of generalization and regularization in nonlinear learning systems', *in* J. E.Moody, S. J. Hanson and R. P. Lippmann, eds, 'Advances in Neural Information Processing Systems 4', *Morgan Kaufmann Publishers*, San Mateo, CA, pp. 847–854.

Moody, J. (1994a). 'Challenges of economic forecasting: noise, nonstationarity, and nonlinearity', invited talk presented at Machines that Learn, Snowbird Utah, April 1994.

Moody, J. (1994b). 'Prediction risk and neural network architecture selection', *in* V. Cherkassky, J. Friedman and H. Wechsler, eds, 'From Statisticsto Neural Networks: Theory and Pattern Recognition Applications', Springer-Verlag.

Moody, J. and Ognvaldsson R. T. (1995). 'Smoothing regularizers for feed-forward neural networks', Manuscript in preparation.

Moody, J. and Utans, J. (1994). 'Architecture selection strategies for neural networks: Application to corporate bond rating prediction, *in* A. N.Refenes, ed., 'Neural Networks in the Captial Markets', *John Wiley & Sons*.

Moody, J., Rehfuss, S. and Saffell, M. (1996), 'Macroeconomic forecasting with neural networks', Manuscript in preparation.

Moody, John; Levin, Uzi and Rehfuss, S. (1993). 'Predicting the U.S. index of industrial production", *Neural Network World*, 3(6), p.791-794 in special issue: *Proceedings of Parallel Applications in Statistics and Economics '93*, Mirko Novak (ed.).

Mozer, M. C. and Smolensky, P. (1990). Skeletonization: A technique for trimming the fat from a network via relevance assessment, *in* D. S. Touretzky, ed., 'Advances in Neural Information Processing Systems 1', Morgan Kaufmann Publishers, San Mateo, CA.

Natter, M., Haefke, C., Soni, T. and Otruba, H. (1994). 'Macroeconomic forecasting using neural networks, *in* 'Neural Networks in the Capital Markets 1994'.Network Approach", paper presented at the Workshop on Neural Networks for Networks", *Journal of Forecasting*, Vol. 15, p.49-61.

Odom, M. D. and Sharda (1990). 'A neural network model for bankruptcy prediction'. *Proceeding of the IEEE International Conference on Neural Networks, San Diego II*,163-168.

Orsini, R. (1996). 'Esternalita locali, aspettative, comportamenti erratici: Un modello di consumo con razionalita and limitata'. *Rivista Internazionale di Scienze Economiche e Commerciali 43*, 981-1012.p.540-550.

Packalen, M. (1998). 'Adaptive learning of rational expectations: A neural network approach'. Paper presented at the 3rd SIEC workshop, Ancoma. http://www.econ.unian.it/dipartimento/ siec/HIA98/papers/Packa.zip.

Pi, H. and Peterson, C. (1994). 'Finding the embedding dimension and variable dependencies in time series', *Neural Computation* pp. 509-520.

Plaut, D., Nowlan, S. and Hinton, G. (1986). 'Experiments on learning by back propagation, Technical Report CMU-CS-86-126, Dept. of Computer Science, Carnegie-Mellon University, Pittsburgh, Pennsylvania. *Proceedings of Parallel Applications in Statistics and Economics '93*, Mirko

Raghupati, W., L.L. Schkade and B.S. Raju (1993).'A neural network approach to bankruptcy prediction. In R. R. Trippi and E Turban (Eds.), Neural Networks in Finance and Investing, pp. 141-158. *Probus Publishing.*

Rahimian, E., S. Singh, T. Thammachote, and R. Virmani (1993). 'Bankruptcy prediction by neural network'. In R. R. Trippi and E Turban (Eds.), Neural Networks in Finance and Investing, pp. 159-171. *Probus Publishing.*

Refenes, A. P. (1995). Neural Networks in the capital markets. *Wiley.*

Refenes, A. P., A. D. Zapranis and G. Francis (1995). 'Modeling stock returns in the framework of APT: A Comparative study with regression models'. In A. P Refenes, (Ed.) Neural Networks in the capital markets. *Wiley.*

Rehfuss, S. (1994), 'Macroeconomic forecasting with neural networks', *Unpublished simulations.*

Ripley, B. D. (1994). 'Neural networks and related methods for classification'. *Journal of the Royal Statistical Society 56,* 409-456.

Rumelhart, D.E., G.E. Hinton, and R.J Williams (1986). 'Learning representations by backpropagating errors'. *Nature 323,* 533-536.

Salchenberger, L., E. Cinar and N. Lash (1992). 'Neural networks: A new tool for predicting bank failures'. *Decision Sciences 23,* 899-916.

Sargent, T. S. (1993). 'Bounded Rationality in Macroeconomics'. *Clarendon Press.* Statistical and Economic Data, Dublin, 10-11 December, 1990.

Shaaf, M. and Ahmadi, A., (1999). 'An Artificial Intelligence Approach to the Role of Exports in Economic Development of Malaysia', *Atlantic Economic Journal,* December, 363-75.

Shaaf, M., (2000). 'Predicting Recession Using The Yield Curve: An Artificial Intelligence and Econometric Comparison', *Eastern Economic Journal,* 26(2), Spring.

Swanson, N. R. and White, H. (1995). 'A Model-Selection Approach to Assessing the Information in the Term Structure Using Linear Models and Artificial Neural Networks', *Journal of Business and Economic Statistics,* July 1995, Vol. 13, No. 3, p.265-275.

Swanson, N. R. and White, H. (1997). 'A Model Selection Approach to Real-Time Macroeconomic Forecasting Using Linear Models and Artificial Neural Networks', *Review of Economics and Statistics,* 79, November 1997, p.540-550.

Tam, K. Y (1991). 'Neural networks and the prediction of bank bankruptcy'. *OMEGA 19*, 429-445. *The Journal of Economics,* XXIV, No. 1, p.51-66.

Tam, K.Y. and Kiang Y.M. (1992). 'Managerial application of neural networks: The case of bank failure predictions'. *Management Science 38*, 926-947.

Tkacz, Greg (1999): 'Neural network forecasts of canadian GDP growth using financial variables,' Bank of Canada, mimeo, April 1999.

Trippi, R. R. and Turban E. (1990). 'Auto learning approaches for building expert systems'. *Computers and Operations Research 17*, 553-560.

Turbant, E. (1992). 'Expert systems and applied Artificial Intelligence'. *New York: MacMillan Publication Co.*

Weigend, A. S., Huberman B. A, and Rumelhart D.E (1992). 'Predicting sunspots and exchange rates with connectionist networks'. In M Casdagli and Eubank (Eds.), Nonlinear Modeling and Forecasting, pp. 395-432. *SFI Studies in the Science of Complexity, Proc. Vol. XII.*

White, H. (1988). 'Economic prediction using neural networks: The case of IBM daily stock returns'. *Proceeding of the IEEE International Conference on Neural Networks II*,451-458.

Watkins, P. and Eliot. L.B. (1993). 'Expert systems in business & finance: Issues & Applications'. Chichester: *John Wiley & Sons Canada, Limited.*