ENHANCED ARTIFICIAL BEE COLONY-LEAST SQUARES SUPPORT VECTOR MACHINES ALGORITHM FOR TIME SERIES PREDICTION

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Abstrak

Sejak beberapa dekad yang lalu, Mesin Sokongan Vektor Kuasa Dua Terkecil (LSSVM) telah digunakan secara meluas dalam masalah ramalan di pelbagai domain aplikasi. Walaubagaimanapun, literatur sedia ada menunjukkan keupayaan LSSVM bergantung kepada nilai parameter hiper, iaitu parameter regularisasi dan parameter kernel, di mana ianya akan mempengaruhi generalisasi LSSVM dalam tugasan ramalan. Kajian ini mencadangkan algoritma hibrid, berdasarkan Koloni Lebah Buatan (ABC) dan LSSVM yang terdiri dari tiga algoritma; ABC-LSSVM, *lv*ABC-LSSVM and *cm*ABC-LSSVM. Algoritma *lv*ABC diperkenalkan untuk mengatasi masalah minimum setempat dengan menambah baik proses carian menggunakan mutasi Levy. Dalam pada itu, algoritma *cm*ABC yang menggunakan mutasi konvensional dapat mengatasi masalah penyesuaian terlebih atau penyesuaian terkurang. Kombinasi algoritma *lv*ABC dan *cm*ABC, yang kemudiannya dikenali sebagai algoritma Koloni Lebah Buatan Dipertingkat-Mesin Sokongan Vektor Kuasa Dua Terkecil (*e*ABC-LSSVM) telah direalisasikan pada ramalan harga komoditi sumber asli yang tidak boleh diperbaharui. Setelah tugas pengumpulan data dan pra pemprosesan data siap dilakukan, algoritma *e*ABC-LSSVM direkabentuk dan dibangunkan. Keupayaan *e*ABC-LSSVM dinilai berdasarkan lima metrik statistik, iaitu Min Peratusan Ralat Mutlak (MAPE), ramalan ketepatan, simetri Min Peratusan Ralat Mutlak (sMAPE), Peratusan Ralat Punca Kuasa Min (RMSPE) dan Theil's U. Keputusan menunjukkan *e*ABC-LSSVM mempunyai kadar ralat ramalan yang lebih rendah berbanding dengan lapan model hibrid antara LSSVM dan algoritma Evolusi Pengkomputan (EC). Tambahan pula, algoritma yang dicadangkan juga telah dibandingkan dengan teknik ramalan tunggal iaitu Mesin Sokongan Vektor (SVM) dan Rangkaian Neural dengan Rambatan ke Belakang (BPNN). Secara umumnya, *e*ABC-LSSVM telah menghasilkan ramalan ketepatan melebihi 90%. Ini menunjukkan *e*ABC-LSSVM berkeupayaan dalam menyelesaikan masalah optimisasi terutamanya dalam bidang ramalan. Algoritma *e*ABC-LSSVM dijangka dapat memberi manfaat kepada para pelabur dan pedagang komoditi dalam perancangan pelaburan dan pengunjuran keuntungan.

Kata kunci: Koloni Lebah Buatan, Mesin Sokongan Vektor Kuasa Dua Terkecil, Ramalan Siri Masa

Abstract

Over the past decades, the Least Squares Support Vector Machines (LSSVM) has been widely utilized in prediction task of various application domains. Nevertheless, existing literature showed that the capability of LSSVM is highly dependent on the value of its hyper-parameters, namely regularization parameter and kernel parameter, where this would greatly affect the generalization of LSSVM in prediction task. This study proposed a hybrid algorithm, based on Artificial Bee Colony (ABC) and LSSVM, that consists of three algorithms; ABC-LSSVM, *lv*ABC-LSSVM and *cm*ABC-LSSVM. The *lv*ABC algorithm is introduced to overcome the local optima problem by enriching the searching behaviour using Levy mutation. On the other hand, the *cm*ABC algorithm that incorporates conventional mutation addresses the over-fitting or under-fitting problem. The combination of *lv*ABC and *cm*ABC algorithm, which is later introduced as Enhanced Artificial Bee Colony – Least Squares Support Vector Machine (*e*ABC-LSSVM), is realized in prediction of non renewable natural resources commodity price. Upon the completion of data collection and data pre processing, the *e*ABC-LSSVM algorithm is designed and developed. The predictability of *e*ABC-LSSVM is measured based on five statistical metrics which include Mean Absolute Percentage Error (MAPE), prediction accuracy, symmetric MAPE (sMAPE), Root Mean Square Percentage Error (RMSPE) and Theils' U. Results showed that the *e*ABC-LSSVM possess lower prediction error rate as compared to eight hybridization models of LSSVM and Evolutionary Computation (EC) algorithms. In addition, the proposed algorithm is compared to single prediction techniques, namely, Support Vector Machines (SVM) and Back Propagation Neural Network (BPNN). In general, the *e*ABC-LSSVM produced more than 90% prediction accuracy. This indicates that the proposed *e*ABC-LSSVM is capable of solving optimization problem, specifically in the prediction task. The *e*ABC-LSSVM is hoped to be useful to investors and commodities traders in planning their investment and projecting their profit.

Keywords: Artificial Bee Colony, Least Squares Support Vector Machines, Time series prediction

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To the other half…the love of my life, Mohd Herwan
&
my sweet honey bee, Zahra An Naurah

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List of Abbreviations

ABC	-	Artificial Bee Colony Algorithm
ACO	-	Ant Colony Optimization
AFSA	-	Artificial Fish Swarm Algorithm
AI	-	Artificial Intelligent
ANFIS	-	Adaptive Neuro Fuzzy Inference
ANN	-	Artificial Neural Network
ARIMA	-	Autoregressive Integrated Moving Average
ARE	-	Average Relative Error
BCC	-	Bacteria Colony Chemotaxis
BPNN	-	Back Propagation Neural Network
CI	-	Computational Intelligence
CV	-	Cross Validation
DE	-	Differential Evolution
EB	-	Employed Bee
EC	-	Evolutionary Computation
EMD	-	Empirical Mode Decomposition
EP	-	Evolutionary Programming
ERM	-	Empirical Risk Minimization
GA	-	Genetic Algorithm
GDP	-	Gross Domestic Product
GMSE	-	Generalization Mean Square Error
GSA	-	Gravitational Search Algorithm
IMF	-	Intrinsic Mode Function
LMSE	-	Learning Mean Square Error
LSSVM	-	Least Squares Support Vector Machines
MAE	-	Mean Absolute Error
MAPE	-	Mean Absoluter Percentage Error
MATLAB	-	Matrix Laboratory Software
MLP	-	Multilayer Perceptron

MRE	-	Mean Relative Error
MSE	-	Mean Square Error
NLL	-	Negative Log Likehood
OB	-	Onlooker Bee
OECD	-	Organization for Economic Co-operation and Development
PCA	-	Principal Component Analysis
PNN	-	Probabilistic Neural Network
PSO	-	Particle Swarm Optimization
QP	-	Quadratic Programming
RBF	-	Radial Basis Function
RE	-	Relative Error
RMSE	-	Root Mean Square Error
SB	-	Scout Bee
SOM	-	Self Organizing Maps
SRM	-	Structural Risk Minimization
SVM	-	Support Vector Machines
SVR	-	Support Vector Regression
WTI	-	West Texas Intermediate

CHAPTER ONE
INTRODUCTION

1.1 Background Study

Since its emergence in the past decades, Least Squares Support Vector Machines (LSSVM) (Suykens, Van Gestel, De Brabanter, De Moor, & Vandewalle, 2002)which is an extension of Support Vector Machines (SVM) (Vapnik,1995) has contributed significant impact in machine learning community. As a powerful algorithm, it has been recognized as one of the standard tools in solving various data mining tasks which include prediction, classification and many others (Cheng, Guo, & Wu, 2010, Li, 2009).Nonetheless, besides its diversity in application, it is worth noting that the capability of LSSVM is highly dependent on the value of its hyper-parameters, namely regularization parameter, γ and kernel parameter, σ^2 (Jiang & Zhao, 2013).

In this regard, this study proposes a hybridization of LSSVM with a relatively new optimization algorithm namely Artificial Bee Colony (ABC) (Karaboga, 2005). The ABC algorithm which has been introduced by Dervis Karaboga is enlightened from the intelligent foraging behavior of honey bees swarm (Karaboga, 2005). In 2008, an extensive review and comparative analysis regarding its performance efficiency was examined which concluded that the ABC algorithm is comparable to the other existing optimization algorithms including Differential Evolution (DE), Particle Swarm Optimization (PSO) and Genetic Algorithm (GA) (El-Abd, 2012; Karaboga & Basturk, 2008).

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REFERENCES

Abdullah, S. N., & Zeng, X. (2010, July 18-23). *Machine Learning Approach for Crude Oil Price Prediction with Artificial Neural Networks-Quantitative (ANN-Q) Model.* Proceedings of the International Joint Conference on Neural Networks (IJCNN), Barcelona, Spain.

Afshin, M. (2007). *Application of Least Squares Support Vector Machines in Medium-term Load Forecasting* (Master's Thesis). Retrieved from ProQuest Dissertations & Theses Database (UMI No. 304701942).

Afshin, M., Sadeghian, A., & Raahemifar, K. (2007, June 24-28). *On Efficient Tuning of LS-SVM Hyper-Parameters in Short-Term Load Forecasting: A Comparative Study.* Proceedings of the IEEE Power Engineering Society General Meeting (PES), Tampa, Florida, USA.

Ahmad, A. S., Hassan, M. Y., & Majid, M. S. (2012, December 2-5). *Application of Hybrid GMDH and Least Squares Support Vector Machines in Energy Consumption Forecasting.* Proceedings of the IEEE International Conference on Power and Energy (PECon), Kota Kinabalu, Sabah, Malaysia.

Ahmed Farid, J., & Salahudin, F. (2010). *Risk Frameworks and Applications* (2nd ed.). Karachi: Alchemy Technologies Pvt. Ltd.

Aiken, M. (1999). Using Neural Network to Forecast Inflation. *Industrial Management and Data System, 99*(7), 296-301.

Akram, Q. F. (2009). Commodity Prices, Interest Rates and the Dollar. *Energy Economics, 31*, 838-851.

Al-Shalabi, L., Shaaban, Z., & Kasasbeh, B. (2006). Data Mining: A Preprocessing Engine. *Journal of Computer Science, 2*(9), 735-739.

Alizadeh, A., Moghaddam, M., Khakzad, M., & Ebrahimipour, V. (2012). A Flexible Neural Network-Fuzzy Mathematical Programming Algorithm for Improvement of Oil Price Estimation and Forecasting. *Computers and Industrial Engineering, 62*, 421-430.

Armstrong, J. S. (2001). *A Handbook for Researchers and Practitioners*. New York: Springer.

Babayigit, B., & Ozdemir, R. (2012, July 1-4). *A Modified Artificial Bee Colony Algorithm for Numerical Function Optimization.* Proceedings of the IEEE Symposium on Computers and Communications (ISCC), Cappadocia, Turkey.

Bao, Y., Yang, Y., Xiong, T., & Zhang, J. (2011, April 15-19). *A Comparative Study of Multi-step-ahead Prediction for Crude Oil Price with Support Vector Regression.* Proceedings of the Fourth International Joint Conference on Computational Sciences and Optimization (CSO), Lijiang City, China.

Bao, Y., Zhang, X., Yu, L., Lai, K. K., & Wang, S. (2011). An Integrated Model Using Wavelet Decomposition and Least Squares Support Vector Machines for Monthly Crude Oil Prices Forecasting. *New Mathematics and Natural Computation, 7*(2), 299-311.

Barchart. (2011). *Historical Quote*. Retrieved December 25, 2011, from http://www.barchart.com/historicalquote.php?

Belaire, J., & Contreras, D. (2002). How to compute the BDS test: A Software Comparison. *Journal of Applied Econometrics, 17*(6), 691-699.

Bessedik, S. A., & Hadi, H. (2013). Prediction of Flashover Voltage of Insulators using Least Squares Support Vector Machine with Particle Swarm Optimization. *Electric Power Systems Research, 104*, 87-92.

Bhar, R., & Hammoudeh, S. (2011). Commodities and Financial Variables: Analyzing Relationships in a Changing Regime Environment. *International Review of Economics and Finance, 20*, 469-484.

Board of Governors of the Federal Reserve System. (2012). *Selected Interest Rates (Daily) - H.15.* Retrieved February 17, 2012, from http://www.federalreserve.gov/releases/h15/data.htm

Bolaji, A. L. A., Khader, A. T., Al-Betar, M. A., & A. Awadallah, M. A (2013). Artificial Bee Colony Algorithm, its Variants and Applications: A Survey. *Journal of Theoritical and Applied Information Technology, 47*(2), 434-459.

Bonabeau, E., & Meyer, C. (2001, May). Swarm Intelligence: A Whole New Way To Think About Business. *Harvard Business Review, 106-114.*

Brajevic, I., Tuba, M., & Subotic, M. (2010, August 20-22). *Improved Artificial Bee Colony Algorithm for Constrained Problems.* Proceedings of the 11th WSEAS International Conference on Neural Networks, Taipei, Taiwan.

Brock, W. A., Scheinkman, J. A., Dechert, W. D., & LeBaron, B. (1996). A Test for Independence on the Correlation Dimension. *Econometrics Reviews, 15*(3), 197-235.

Cao, D. Z., Pang, S. L., & Bai, Y. H. (2005, August 18-21). *Forecasting Exchange Rate Using Support Vector Machines.* Proceedings of the Fourth International Conference on Machine Learning and Cybernetics (ICMLC), Guangzhou, China.

Chen, Q., Wu, Y., & Chen, X. (2008, August 3-5). *Research on Customers Demand Forecasting for E-business Web Site Based on LS-SVM.* Proceedings of the International Symposium on Electronic Commerce and Security (ISECS), Guangzhou, China.

Chen, X., Wang, J., Sun, D., & Liang, J. (2008, October 18-20). *Time Series Forecasting Based on Novel Support Vector Machine Using Artificial Fish Swarm Algorithm.* Proceedings of the Fourth International Conference on Natural Computation (ICNC), Jinan, China.

Cheng, G., Guo, R., & Wu, W. (2010, January 22-24). *Petroleum Lithology Discrimination Based on PSO-LSSVM Classification Model.* Proceedings of the Second International Conference on Computer Modeling and Simulation (ICCMS), Sanya, China.

Cheng, J., Qian, J. S., & Guo, Y. N. (2006). Least Squares Support Vector Machines for Gas Concentration Forecasting in Coal Mine. *International Journal of Computer Science and Network Security, 6*(6), 125-129.

Colman, A. M., & Pulford, B. D. (2008). *A Crash Course in SPSS for Windows: Updated for Versions 14, 15 and 16* (4th ed.). West Sussex, United Kingdom: Wiley Blackwell.

Cristianini, N., & Shawe-Taylor, J. (2000). *An Introduction to Support Vector Machines and Other Kernel-based Learning Methods*. United Kingdom: Cambridge University Press.

Dooley, G., & Lenihan, H. (2005). An Assesment of Time Series Methods in Metal Price Forecasting. *Resources Policy, 30*, 208-217.

Dorigo, M., & Stutzle, T. (2004). *Ant Colony Optimization*. Cambridge: MIT Press

Dos Santos, G. S., Luvizotto, L. G. J., Mariani, V. C., & Dos Santos Coelho, L. (2012). Least Squares Support Vector Machines with Tuning based on Differential Evolution Approach Applied to the Identification of a Thermal Process. *Expert Systems with Applications, 39*, 4805-4812.

Dunsby, A., Eckstein, J., Gaspar, J., & Mulholland, S. (2008). *Commodity Investing: Maximizing Returns Through Fundamental Analysis*. New Jersey: John Wiley & Sons.

El-Abd, M. (2012). Performance Assessment of Foraging Algorithms vs. Evolutionary Algorithms. *Information Sciences, 182*, 243-263.

Elish, K. O., & Elish, M. O. (2008). Predicting defect-prone software modules using Support Vector Machines. *The Journal of Systems and Software, 81*, 649-660.

Fang, X. Y., & Bai, T. (2009). *Share Price Prediction using Wavelet Transform and Ant Colony Optimization for Parameters Optimization in SVM.* Proceedings of the Global Congress on Intelligent System (GCIS), Xiamen, China.

Feoktistov, V., & Janaqi, S. (2004, January 8-9). *Hybridization of Differential Evolution with Least-Square Support Vector Machines.* Proceedings of the Fifteenth Dutch-Belgian Conference on Machine Learning (BENELEARN), Brussels, Belgium.

Fontanills, G. A. (2007). *Getting Started in Commodities*. New Jersey: John Wiley & Sons.

Frush, S. (2008). *Commodities Demystified*. New York: McGraw-Hill.

Fu, H., Liu, S., & Sun, F. (2010, August 4-7). *Ship Motion Prediction Based on AGA-LSSVM.* Proceedings of the International Conference on Mechatronics and Automation (ICMA), Xi'an, China.

Fu, X., & Yu, J. (2009, August 14-16). *A Hybrid Algorithm Based on Extremal Optimization with Adaptive Levy Mutation and Differential Evolution and Application.* Proceedings of the Fifth International Conference on Natural Computation (ICNC), Tianjin, China.

Gao, W., & Liu, S. (2012). A Modified Artificial Bee Colony. *Computers & Operations Research, 39*, 687-697.

Gao, W., Liu, S., & Huang, L. (2012). A Global Best Artificial Bee Colony Algorithm for Global Optimization. *Journal of Computational and Applied Mathematics, 236*, 2741-2753.

Gao, W., Liu, S., & Huang, L. (2013). A novel artificial bee colony algorithm with Powell's method. *Applied Science Computing, 13*, 3763-3775.

Gao, X., Wang, P., Qi, Y., Yan, A., Zhang, H., & Gong, Y. (2009, August 14-16). *Comparison Studies of LS-SVM and SVM on Modelling for Fermentation Processes.* Proceedings of the Fifth International Conference on Natural Computation (ICNC), Tianjian, China.

Gencoglu, M. T., & Uyar, M. (2009). Prediction of Flashover Voltage of Insulators using Least Squares Support Vector Machines. *Expert Systems with Applications, 36*, 10789-10798.

Hadavandi, E., Ghanbari, A., & Abbasian-Naghneh, S. (2010, August 13-15). *Developing a Time Series Model Based on Particle Swarm Optimization for Gold Price Forecasting.* Proceedings of the Third International Conference on Business Intelligence and Financial Engineering (BIFE), Hong Kong, China.

Haidar, I., & Wolff, R. C. (2011, October 9-12). *Forecasting of Crude Oil Price (Revisited).* Proceedings of the 30th United States Association for Energy Economics (USAEE), Washington D.C.

Hall, M., Frank, E., Holmes, G., Pfahringer, B., Reutemann, P., & Witten, I. H. (2009). *The Weka Data Mining Software: An Update; SIGKDD Explorations*. Retrieved from http://www.cs.waikato.ac.nz/ml/weka/.

Hammoudeh, S., Sari, R., & Ewing, B. T. (2008). Relationships Among Commodities and with Financial Variables: A New Look. *Contemporary Economic Policy, 27*(2), 251-264.

Hammoudeh, S., & Yuan, Y. (2008). Metal Volatility in Presence of Oil and Interest Rate Shocks. *Energy Economics, 30*, 606-620.

Haupt, R. L., & Haupt, S. E. (2004). *Practical genetic algorithms* (2nd ed.). New York: A John Wiley & Sons, Inc., Publication.

He, R. J., & Yang, Z. Y. (2012). Differential Evolution with Adaptive Mutation and Parameter Control using Levy Probability Distribution. *Journal of Computer Science and Technology, 27*(5), 1035-1055.

Hegazy, O., Soliman, O. S., & Abdul Salam, M. (2013). A Machine Learning Model for Stock Market Prediction. *International Journal of Computer Science and Telecommunications, 4*(12), 17-23.

Hoorfar, A., Lakhani, S., & Jamnejad, V. (2007, September 17-21). *Application of Levy Mutation Operator in Evolutionary Programming Optimization of Antennas.* Proceedings of the International Conference on Electromagnetics in Advanced Applications (ICEAA), Torino, Italy.

Hsieh, T. J., Hsiao, H. F., & Yeh, W. C. (2011). Forecasting Stock Markets Using Wavelet Transforms and Recurrent Neural Networks: An Integrated System Based on Artificial Bee Colony Algorithm *Applied Soft Computing, 11*, 2510-2525.

Hsieh, T. J., Hsiao, H. F., & Yeh, W. C. (2012). Mining Financial Distress Trend Data using Penalty Guided Support Vector Machines based on Hybrid Particle Swarm Optimization and Artificial Bee Colony Algorithm. *Neurocomputing, 82*, 196-206.

Huang, G. B., Zhou, H., Ding, X., & Zhang, R. (2012). Extreme Learning Machine for Regression and Multiclass Classification. *IEEE Transactions on Systems, Man, and Cybernetics - Part B: Cybernetics, 42* (2), 513-529.

Hussein, S. F.M, Shah, M. B.N, Jalal, M. R.A, & Abdullah, S. S. (2011, April 19-21). *Gold Price Prediction Using Radial Basis Function Neural Network.* Proceedings of the 4th International Conference on Modeling, Simulation and Applied Optimization (ICMSAO), Kuala Lumpur, Malaysia.

Hyndman, R. J., & Athanasopoulos, G. (2013). *Forecasting: principles and practice*. Retrieved from https://www.otexts.org/fpp.

Hyndman, R. J., & Koehler, A. B. (2006). Another Look at Measures of Forecast Accuracy.*International Journal of Forecasting, 22*, 679-688.

Irani, R., & Nasimi, R. (2011). Application of Artificial Bee Colony-Based Neural Network in Bottom Hole Pressure Prediction in Underbalanced Drilling. *Journal of Petroleum Science and Engineering, 78*, 6-12.

Ismail, S., Shabri, A., & Samsudin, R. (2011). A Hybrid Model of Self-Organizing Maps (SOM) and Least Squares Support Vector Machines (LSSVM) for Time Series Forecasting. *Expert Systems with Applications, 38,* 10574-10578.

Jahjouh, M. M. (2012). *Design Optimization of Reinforced Concrete Frames using Artificial Bee Colony Algorithm.* (Master's Thesis, The Islamic University of Gaza, Palestine). Retrieved from library.iugaza.edu.ps/thesis/103769.pdf

Jain, R. K., Smith, K. M., Culligan, P. J., & Taylor, J. E. (2014). Forecasting Energy Consumption of Multi-family Residential Buildings using Support Vector Regression: Investigating the Impact of Temporal and Spatial Monitoring Granularity on Performance Accuracy. *Applied Energy, 123*, 168-178.

Jammazi, R., & Aloui, C. (2012). Crude oil price forecasting: Experimental evidence from wavelet decomposition and neural network modeling. *Energy Economics, 34*, 828-841.

Jiang, B. T., & Zhao, F. Y. (2013). Particle Swarm Optimization-based Least Squares Support Vector Regression for Critical Heat Flux Prediction. *Annals of Nuclear Energy, 53*, 69-81.

Kao, L. J., Chiu, C.-C., Lu, C. J., & Ya\ng, J. L. (2013). Integration of Nonlinear Independent Component Analysis and Support Vector Regression for Stock Price Forecasting. *Neurocomputing, 99*, 534-542.

Karaboga, D. (2005). *An Idea Base on Honey Bee Swarm for Numerical Optimization* (Technical Report-TR06). Retrieved from http://mf.erciyes.edu.tr/abc/pub/tr06_2005.pdf.

Karaboga, D., & Akay, B. (2009). A Comparative Study of Artificial Bee Colony. *Applied Mathematics and Computation, 214*, 108-132.

Karaboga, D., & Basturk, B. (2008). On the Performance of Artificial Bee Colony (ABC) Algorithm. *Applied Soft Computing, 8*, 687-697.

Karaboga, D., Gorkemli, B., Ozturk, C., & Karaboga, N. (2012). A Comprehensive Survey: Artificial Bee Colony (ABC) Algorithm and Applications. *Artificial Intelligence Review*, 1-37. doi: 10.1007/s10462-012-9328-0

Kemp, D. D. (2004). *Exploring Environmental Issues: An Integrated Approach.* London: Routledge.

Kennedy, & Eberhart, R. (1995). *Particle Swarm Optimization.* Proceedings of the IEEE International Conference on Neural Networks (ICNN), Perth, Australia.

Khalifa, A. A. A., Hong, M., & Ramchander, S. (2010). Return Distributions and Volatility Forecasting in Metal Futures Markets: Evidence from Gold, Silver and Copper. *The Journal of Futures Markets, 31*(1), 55-80.

Khashman, A., & Nwulu, N. I. (2011, January 27-29). *Intelligent Prediction of Crude Oil Price Using Support Vector Machines.* Proceedings of the 9th

IEEE International Symposium on Applied Machine Intelligence and Informatics (SAMI), Smolenice, Slovakia.

Khazem, H. A. (2008). *Using Artificial Neural Networks to Forecast the Futures Prices of Crude Oil.* (D.B.A. dissertation). Retrieved from ProQuest Dissertations & Theses database (UMI No. 3295968).

Khemchandani, R., Jayadeva, & Chandra, S. (2009). Regularized Least Squares Fuzzy Support Vector Regression for Financial Time Series Forecasting. *Expert Systems with Applications, 36*, 132-138.

Kohzadi, N. (1994). *Neural Networks versus Time Series Models for Forecasting Commodity Prices.* (Ph.D dissertation). Retrieved from ProQuest Dissertations & Theses database (UMI No. 250231218).

Kotsiantis, S. B., Kanellopoulos, D., & Pintelas, P. E. (2006). Data Preprocessing for Supervised Learning. *International Journal of Computer Science, 1*(2), 1306-4428.

Krebs, R. E. (2003). *The Basics of Earth Science*. Connecticut: Greenwood Publishing Group, Inc.

Kulkarni, S., & Haidar, I. (2009). Forecasting Model for Crude Oil Price Using Artificial Neural Networks and Commodity Futures Prices. *International Journal of Computer Science and Information Security, 2*(1), 1-8.

Kumar, M., & Thenmozhi, M. (2007). Support Vector Machines Approach to Predict the S&P CNX NIFTY Index Returns. *Journal of Academy of Business and Economics, 7*(1), 1-19**.**

Labys, W. C. (2006). *Modelling and Forecasting Primary Commodity Prices*. Hampshire: Ashgate Publishing Limited.

Lai, L. K. C., & Liu, J. N. K. (2010, July 11-14). *Stock Forecasting Using Support Vector Machines.* Proceedings of the Ninth International Conference on Machine Learning and Cybernetics (ICMLC), Qingdao, China.

Lee, C. Y., & Yao, X. (2001, May 27-30). *Evolutionary algorithms with adaptive Levy mutations.* Proceedings of the Congress on Evolutionary Computation (ICEC), Seoul, South Korea.

Lee, C. Y., & Yao, X. (2004). Evolutionary programming using mutations based on the Levy probability distribution. *IEEE Transactions on Evolutionary Computation, 8*(1), 1-13.

Lee, W. P., & Cai, W. T. (2011, July 26-28). *A Novel Artificial Bee Colony Algorithm with Diversity Strategy.* Proceedings of the Seventh International Conference on Natural Computation (ICNC), Shanghai, China.

Lendasse, A., Ji, Y., Reyhani, N., & Verleysen, M. (2005, September 11-15). *LS-SVM Hyperparameter Selection with a Nonparametric Noise Estimator.* Proceedings of the 15th International Conference on Artificial Neural Networks: Formal Models and Their Applications (ICANN), Warsaw, Poland.

Levy, P. (1937). *Theorie de l'Addition des Veriables Aleatoires*. Paris, France: Gauthier-Villars.

Li, G. D., Masuda, S., & Nagai, M. (2013). An Optimal Prediction Model for Time Series Prediction in Manufcaturing Systems. *International Journal of Advance Manufacturing Technology, 67*, 2343-2349.

Li, H., Guo, S., Zhao, H., Su, C., & Wang, B. (2012). Annual Electric Load Forecasting by a Least Squares Support Vector Machines with a Fruit Fly Optimization Algorithm. *Energies, 5,* 4430-4445.

Li, X., Shao, Z., & Qian, J. (2002). An Optimizing Method base on Autonomous Animates: Fish Swarm Algorithm. *Systems Engineering Theory and Practice, 22*, 32-38.

Li, Y. (2009, November 8-12). *Short-Term Load Forecasting Based on LS-SVM Optimized by BCC Algorithm.* Proceedings of the 15th International Conference on Intelligent System Applications to Power Systems (ISAP), Curitiba, Brazil.

Liao, R., Zheng, H., Grzybowski, S., & Yang, L. (2011). Particle Swarm Optimization-Least Squares Support Vector Regression based Forecasting model on Dissolved Gases in Oil-Filled Power Transformers *Electric Power Systems Research, 81*, 2074-2080.

Liao, W., & Balzen, Z. (2013). LSSVM Network Flow Prediction Based on the Self-adaptive Genetic Algorithm Optimization. *Journal of Networks, 8*(2), 507-512.

Lin, C. S., Chiu, S. H., & Lin, T. Y. (2012). Empirical Mode Decomposition-based Least Squares Support Vector Regression for Foreign Exchange Rate Forecasting. *Economic Modelling, 29*, 2583-2590.

Liu, C. (2009, September 20-22). *Price Forecast for Gold Futures Based on GA-BP Neural Network.* Proceedings of the International Conference on Management and Service Science (MASS), Wuhan, China.

Liu, H. X., Yao, X. J., Zhang, R. S., Liu, M. C., Hu, Z. D., & Fan, B. T. (2005). Prediction of Tissue/Blood Partition Coefficients of Organic Compounds based on the Molecular Structure using Least Squares Support Vector Machines. *Journal of Computer-Aided Molecular Design, 19*, 499-508

Liu, L., & Wang, W. (2008, December 12-14). *Exchange Rates Forecasting with Least Squares Support Vector Machine.* Proceedings of the International Conference on Computer Science and Software Engineering (JCSSE), Kanchanaburi, Thailand.

Liu, P., & Yao, J. (2009, November 20-22). *Application of Least Square Support Vector Machine based on Particle Swarm Optimization to Chaotic Time Series Prediction.* Proceedings of the IEEE International Conference on Intelligent Computing and Intelligent Systems (ICIS), Shanghai, China.

Lomax, R. G. (2007). *An Introduction to Statistical Concepts*. New Jersey: Lawrence Erlbaum Associates, Inc. Publisher.

Lu, S., Cai, Z. J., & Zhang, X. B. (2009, August 8-11). *Application of GA-SVM time series prediction in tax forecasting.* Proceedings of the 2nd IEEE International Conference on Computer Science and Information Technology (ICCSIT), Beijing, China.

Makridakis, S., & Hibon, M. (2000). The M3-Competition: Results, Conclusions and Implications. *International Journal of Forecasting, 16*, 451-476.

Malliaris, M. E., & Malliaris, S. G. (2008). Forecasting Inter-Related Energy Product Prices. *The European Journal of Finance, 14*(6), 453-468.

Marsland, S. (2009). *Machine Learning An Algorithm Perspective*. Boca Raton, Florida: A Chapman & Hall Book.

McCulloch, J. H. (1996). *J. Huston McCulloch*. Retrieved March 15, 2012, from http://www.econ.ohio-state.edu/jhm/jhm.html

Mellit, A., Massi Pavan, A., & Benghanem, M. (2013). Least Squares Support Vector Machine for Short-Term Prediction of Meteorological Time Series. *Theor Appl Climatol, 111*, 297-307.

Montgomery, D. C., Jennings, C. L., & Kulahci, M. (2008). *Introduction to Time Series Analysis and Forecasting*. New Jersey: John, Wiley & Sons.

Mustafa, M. W., Sulaiman, M. H., Shareef, H., & Abd. Khalid, S. N. (2011). Transmission Loss Allocation in Deregulated Power System Using the Hybrid Genetic Algorithm-Support Vector Machine Technique. *Cyber Journals: Multidiscplinary Journals in Science and Technology, Journal of Selected Areas in Renewable and Sustainable Energy (JRSE)*, 10-18.

Mustafa, M. W., Sulaiman, M. H., Shareef, H., & Abd. Khalid, S. N. (2012). Reactive Power Tracing in Pool-Based Power System utilising the Hybrid Genetic Algorithm and Least Squares Support Vector Machine. *IET, Generation, Transmission & Distribution, 6*(2), 133-141.

Nieto, P. J. G., Fernandez, J. R. A., Juez, F. J. d. C., Lasheras, F. S., & Muniz, C. D. (2013). Hybrid modelling based on support vector regression with genetic algorithms in forecasting the cyanotoxins presence in the Trasona reservoir (Northern Spain). *Environmental Research, 122*, 1-10.

Nourani, E., Rahmani, A. M., & Navin, A. H. (2012, May 21-22). *Forecasting Stock Prices using a Hybrid Artificial Bee Colony base Neural Networks.* Proceedings of the International Conference on Innovation, Management and Technology Research (ICIMTR), Malacca, Malaysia.

OANDA (2012). *Currency Converter.* Retrieved January 30, 2012, from http://www.oanda.com/currency/converter/

Ou, P., & Wang, H. (2009). Prediction of Stock Market Index Movement by Ten Data Mining Techniques. *Modern Applied Science, 3*(12), 28-42.

Pahasa, J., & Ngamroo, I. (2011). A heuristic training-based least squares support vector machines for power system stabilization by SMES. *Expert Systems with Applications, 38*, 13987-13993.

Pan, W. T. (2012). A New Fruit Fly Optimization Algorithm: Taking the Financial Distress Model as an Example. *Knowledge Based System, 26*, 69-74.

Papadimitriou, T., Gogas, P., & Stathakis, E. (2014). Forecasting Energy Markets using Suppoer Vector Machines. *Energy Economics, 44*, 135-142.

Parisi, A., Parisi, F., & Diaz, D. (2008). Forecasting Gold Price Changes: Rolling and Recursive Neural Network Models. *Journal of Multi. Finance Management, 18*, 477-487.

Park, J. B., Jeong, Y.W., Shin, J. R., & Lee, K. Y. (2010). An Improved Particle Swarm Optimization for Nonconvex Economic Dispatch Problems. *IEEE Transactions on Power Systems, 25*(1), 156-165.

Pelkmans, K., Suykens, J. A. K., Gestel, T. V., Brabanter, J. D., Lukas, L., Hamer, B., Vandewalle, J. (2002). *LS-SVMlab: A Matlab/C Toolbox for Least*

Squares Support Vector Machines. Retrieved 22 January, 2010, from http://www.esat.kuleuven.be/sista/lssvmlab/

Peng, Y. (2011). An Improved Artificial Fish Swarm Algorithm for Optimal Operation of Cascade Reservoirs. *Journal of Computers, 6*(4), 740-746.

Qi, J., Hu, J., Peng, Y. H., & Ren, Q. (2011). Electrical evoked potentials prediction model in visual prostheses based on support vector regression with multiple weights. *Applied Soft Computing, 11*, 5230-5242.

Radetzki, M. (2008). *A Handbook of Primary Commodities in the Global Economy*. United Kingdom: Cambridge University Press.

Rajasekhar, A., Abraham, A., & Pant, M. (2011, October 9-12). *Levy Mutated Artificial Bee Colony Algorithm for Global Optimization.* Proceedings of the IEEE International Conference on Systems, Man, and Cybernetics (SMC), Anchorage, Alaska.

Rao, Y., Xu, S., & Xiong, L. (2011, March 26-28). *Time Series Prediction of Heavy Metal Contamination in Mining Areas Based on Exponential Smoothing Mode.* Proceedings of the International Conference on Information Science and Technology, Nanjing, Jiangsu, China.

Rashedi, E., Nezahabadi-pour, H., & Saryazdi, S. (2009). GSA: A Gravitational Search Algorithm. *Information Sciences, 179*, 2232-2248.

Richer, T. J., & Blackwell, T. M. (2006, July 16-21). *The Levy Particle Swarm.* Proceedings of the IEEE Congress on Evolutionary Computation (CEC), Vancouver, Canada.

Roy, R., & Jadhav, H. T. (2015). Optimal Power Flow Solution of Power System Incorporating Stochastic Wind power using Gbest Guided Artificial Bee Colony Algorithm. *Electrical Power and Energy Systems, 64*, 562-578.

Selvi, V., & Umarani, R. (2010). Comparative Analysisi of Ant Colony and Particle Swarm Optimization Techniques. *International Journal of Computer Applications, 5*(4), 1-5.

Shadbolt, J., & Taylor, J. G. (2002). *Neural Networks and the Financial Markets*. London: Springer-Verlag.

Sharma, T. K., Pant, M., & Bansal, J. C. (2012, June 10-15). *Some Modifications to Enhance the Performance of Artificial Bee Colony.* Proceedings of the IEEE World Congress on Computational Intelligence (WCCI), Brisbane, Australia.

Sharma, T. K., Pant, M., & Bhardwaj, T. (2011, December 4-7). *PSO Ingrained Artificial Bee Colony Algorithms for Solving Continuous Optimization Problems.* Proceedings of the International Conference on Computer Applications and Industrial Electronics (ICCAIE), Penang, Malaysia.

Shen, W., Zhang, Y., & Ma, X. (2009, July 24-26). *Stock Return Forecast with LS-SVM and Particle Swarm Optimization.* Proceedings of the International Conference on Business Intelligence and Financial Engineering (BIFE), Beijing, China.

Shi, J. Y., Zou, X. B., Huang, X. W., Zhao, J. W., Li, Y., Hao, L., & Zhang, J. (2013). Rapid Detecting Total Acid Content and Classifying Different Types of Vinegear based on Near Infrared Spectroscopy and Least Squares Support Vector Machines. *Food Chemistry, 138*, 192-199.

Shin, K. S., Lee, T. S., & Kim, H. J. (2005). An Application of Support Vector Machines in Bankruptcy Prediction Model. *Expert Systems with Applications, 28*, 128-135.

Shrivastava, N. A., Ch, S., & Panigrahi, B. K. (2011, December 28-30). *Price Forecasting using Computational Intelligence Techniques: A Comparative Analysis.* Proceedings of the International Conference on Energy, Automation, and Signal (ICEAS), Bhubaneswar, Odisha, India.

Storn, R., & Price, K. (1997). Differential Evolution- ASimple and Efficient Heuristic for Global Optimization Over Continuous Spaces. *Journal of Global Optimization, 11*, 341-359.

Subotic, M. (2011, April 28-30). *Artificial Bee Colony Algorithm with Multiple Onlookers for Constrained Optimization Problems.* Proceedings of the European Computing Conference (ECC), Paris, France.

Sulaiman, M. H., Mustafa, M. W., Shareef, H., & Abd. Khalid, S. N. (2012). An Application of Artificial Bee Colony Algorithm with Least Squares Support Vector Machine for Real and Reactive Power Tracing in Deregulated Power System. *Electrical Power and Energy Systems, 37*(1), 67-77.

Sun, W., & Zhang, J. (2008, January 28-29). *Forecasting Day Ahead Spot Electricity Prices Based on GASVM.* Proceedings of the International Conference on Internet Computing in Science and Engineering (ICICSE), Harbin, China.

Suykens, J. A. K., Van Gestel, T., De Brabanter, J., De Moor, B., & Vandewalle, J. (2002). *Least Squares Support Vector Machines*. Leuven, Belgium: World Scientific Publishing Co. Pte. Ltd.

Tan, S. T. (2010). *Applied Mathematics for the Managerial, Life, and Social Sciences* (6th ed.). Belmont, USA: Richard Stratton.

Tang, L., & Hammoudeh, S. (2002). An Empirical Exploration of the World Oil Price Under the Target Zone Model. *Energy Economics, 24*, 577-596.

Tarhouni, M., Laabidi, K., Zidi, S., & Ksouri-Lahmari, M. (2011, March 22-25). *A Nonlinear MIMO Systems Identification Based on Improved Multi-Kernel Least Squares Support Vector Machines (Improved Multi-Kernel LSSVM).* Proceedings of the 8th International Multi-Conference on Systems, Signals and Devices (SSD), Sousse, Tunisia.

Taylor, J. B., & Weerapana, A. (2012). *Principles of Economics* (7th ed.). Mason, USA: South Western, Cengage Learning.

Tehrani, R., & Khodayar, F. (2011). A hybrid optimized Artificial Intelligent Model to Forecast Crude Oil using Genetic Algorithm. *African Journal of Bussiness Management, 5*(34), 13130-13135.

Tsai, P. W., Pan, J. S., Liao, B. Y., & Chu, S. C. (2009). Enhanced Artificial Bee Colony Optimization. *International Journal of Innovative Computing, Information and Control, 5*(12), 1-12.

U.S. Energy Information Administration. (2013). *Energy and Financial Merkets: What Drives Crude Oil Prices?* Retrieved February 22, 2013, from http://www.eia.gov/finance/markets/

Van Gestel, T., A. K. Suykens, J., Baestaens, D. E., Lambrechts, A., Lanckriet, G., Vandaele, B., Vandewalle, J. (2001). Finance Time Series Prediction Using

Least Squares Support Vector Machines Within the Evidence Framework. *IEEE Transactions on Neural Networks, 12*(4), 809-821.

Vapnik, V. N. (1995). *The Nature of Statistical Learning Theory* (2nd ed.). New York: Springer-Verlag.

Varahrami, V. (2011). Recognition of Good Prediction of Gold Price Between MLFF and GMDH Neural Network. *Journal of Economics and International Finance, 3*(4), 204-210.

Vlad, S. (2010). Investigation of Chaotic Behavior in Euro-Leu Exchange Rate. *Journal of Applied Computer Science and Mathematics, 8*(4), 67-71.

Wang, D. C., Wang, C. X., Xie, Y. H., & Zhu, T. Y. (2010, December 13-15). *Air Temperature Prediction Based on EMD and LSSVM.* Proceedings of the Fourth International Conference on Genetic and Evolutionary Computing (ICGEC), Shenzhen, China.

Wang, J., Kou, L., Hou, X., & Zhou, Z. (2010, June 25-27). *Empirical Analysis on Co-movement of Stock Price of Gold Mine Enterprises and the International Gold Price.* Proceedings of the International Conference on Electrical and Control Engineering (ICECE), Wuhan, China.

Wang, K. M., & Lee, Y. M. (2010). Could Gold Serve as an Exchange Rate Hedge in Japan. *Inzinerine Ekonomika-Engineering Economics, 21*(2), 160-170.

Wang, S., Yu, L., & Lai, K. K. (2005). Crude Oil Price Forecasting with TEI@I Methodology. *Journal of Systems Science and Complexity, 18*(2), 145-166.

Wang, X., & Li, H. (2009, October 16-18). *One-Month Ahead Prediction of Wind Speed and Output Power Based on EMD and LSSVM.* Proceedings of the International Conference on Energy and Environment Technology (ICEET), Guilin, China.

Wang, X., Zhang, H., Zhang, C., Cai, X., Wang, J., & Wang, J. (2005, December 5-8). *Prediction of Chaotic Time Series using LS-SVM with Automatic Parameter Selection.* Proceedings of the Sixth International Conference on Parallel and Distributed Computing, Applications and Technologies (PDCAT), Dalian, China.

Wang, Y., & Li, B. (2008, June 1-6). *A Restart Univariate Estimation of Distribution Algorithm: Sampling Under Mixed Gaussian and levy Probability Distribution.* Proceedings of the Proceedings of the IEEE World Congress on Computational Intelligence, Hong Kong, China.

Wang, Y., & Li, Y. (2010, November 7-9). *Applying LS-SVM to Predict Primary Energy Consumption.* Proceedings of the International Conference on E-Product E-Service and E-Entertainment (ICEEE), Henan, China.

Wang, Y. S., & Chueh, Y. L. (2013). Dynamic Transmission Effects between the Interest Rate, the US Dollar, and Gold and Crude Oil Prices. *Economic Modelling, 30*, 792-798.

Williams, G. (2011). *Data Mining with Rattle and R The Art of Excavating Data for Knowledge Discovery*. New York: Springer.

Wu, D., Feng, S., & He, Y. (2007). Infrared Spectroscopy Technique for the Nondestructive measurement of Fat Content in Milk Powder. *Journal Dairy Science, 90*, 3613-3619.

Wu, J., & Niu, D. (2009, October 28-30). *Short-Term Power Load Forecasting Using Least Squares Support Vector Machines(LS-SVM).* Proceedings of the Second International Workshop on Computer Science and Engineering (WCSE), Qingdao, China.

Xiang, Y., & Jiang, L. (2009, January 23-25). *Water Quality Prediction Using LS-SVM and Particle Swarm Optimization.* Proceedings of the Second International Workshop on Knowledge Discovery and Data Mining (WKDD), Moscow, Russia.

Xiao, J., He, C., & Wang, S. (2012, August 18-21). *Crude Oil Price Forecasting: A Transfer Learning based Analog Complexing Model.* Proceedings of the Fifth International Conference on Bussiness Intelligence and Financial Engineering (BIFE), Lanzhou, Gansu, China.

Xie, C., Shao, C., & Zhao, D. (2011). Parameters Optimization of Least Squares Support Vector Machines and Its Application. *Journal of Computers, 6*(9), 1935-1941.

Xie, H. L., Li, N., Lu, F. C., & Xie, Q. (2009, March 28-30). *Application of LS-SVM by GA for Dissolved Gas Concentration Forecasting in Power Transformer Oil.* Proceedings of the Asia-Pacific Power and Energy Engineering Conference (APPEEC), Wuhan, China.

Yang, J. H., & Dou, W. (2012, November 17-18). *Prediction of Gold Price based on WT-SVR and EMD-SVR model.* Proceedings of the Eighth International Conference on Computational Intelligence and Security, Guangzhou, China.

Yang, X. S. (2010). *Nature-Inspired Metaheuristic Algorithms* (2nd ed.). United Kingdom: Luniver Press.

Yang, Z., Gu, X. S., Liang, X. Y., & Ling, L. C. (2010). Genetic Algorithm-Least Squares Support Vector Regression based Predicting and Optimizing Model on Carbon Fiber Composite Integrated Conductivity. *Materials and Design, 31*, 1042-1049.

Yeh, C. C., Chi, D. J., & Hsu, M. F. (2010). A hybrid approach of DEA, rough set and support vector machines for business failure prediction. *Expert Systems with Applications, 37*, 1535-1541.

Yorucu, V. (2003). The Analysis of Forecasting Performance by Using Time Series Data for Two Mediterranean Islands. *Review of Social, Economic & Business Studies, 2*, 175-196.

Yu, L., Chen, H., Wang, S., & Lai, K. K. (2009). Evolving Least Squares Support Vector Machines for Stock Market Trend Mining. *IEEE Transactions on Evolutionary Computation, 13*(1), 87-102.

Yu, L., Wang, S., & Lai, K. K. (2007). An Online Learning Algorithm with Adaptive Forgetting Factors for Feedforward Neural Networks in Financial Time Series Forecasting. *Nonlinear Dynamics and Systems Theory, 7*(1), 51-66.

Yu, L., Wang, S., & Lai, K. K. (2008). Forecasting Crude Oil Price with an EMD-based Neural Network Ensemble Learning Paradigm. *Energy Economics, 30*, 2623-2635.

Yu, L., Wang, S., Wen, B., & Lai, K. K. (2008, June 18-20). *An AI-Agent-Based Trapezoidal Fuzzy Ensemble Forecasting Model for Crude Oil Price*

Prediction. Proceedings of the Third International Conference on Innovative Computing Information and Control (ICICIC), Dalian, China.

Yuan, Y., Zhuang, X. T., Liu, Z. Y., & Huang, W.Q. (2014). Analysis of the temporal properties of price shock sequences in crude oil markets. *Physica A, 394*, 235-246.

Yusof, N., A. Rashid, R., & Mohamed, Z. (2010, December 5-7). *Malaysia Crude Oil Production Estimation: an Application of ARIMA Model.* Proceedings of the International Conference on Science and Social Research (CSSR), Kuala Lumpur, Malaysia.

Zhai, J., & Huang, L. (2013). Marketing Prediction Based on Time Series Prediction Algorithm of Least Squares Support Vector Machines. *Journal of Convergence Information Technology, 8*(3), 245-250.

Zhang, D., Guan, X., Tang, Y., & Tang, Y. (2011, May 28-29). *Modified Artificial Bee Colony for Numerical Optimization.* Proceedings of the 3rd International Workshop on Intelligent Systems and Applications (ISA), Wuhan, China.

Zhang, G., Patuwo, B. E., & Hu, M. Y. (1998). Forecasting with Artificial Neural Network: The State of Art. *International Journal of Forecasting, 14*, 35-62.

Zhang, S., Wang, F., & He, D. (2012). Real-time product quality control for batch processes based on stacked least-squares support vector regression models. *Computers and Chemical Engineering, 36*, 217-226.

Zhang, T., & Fukushige, A. (2002, May 12-17). *Forecasting Time Series by Bayesian Neural Networks.* Proceedings of the International Joint Conference on Neural Networks (IJCNN), Honolulu, Hawaii.

Zhang, W., Niu, P., Li, G., & Li, P. (2013). Forecasting of Turbine Heat Rate with Online Least Squares Support Vector Machine based on Gravitational Search Algorithm *Knowledge-Based Systems, 39*, 34-44

Zhang, X., Wu, Q., & Zhang, J. (2010, October 20-21). *Crude Oil Price Forecasting Using Fuzzy Time Series.* Proceedings of the 3rd International Symposium on Knowledge Acquisition and Modeling (KAM), Wuhan, China.

Zhang, Y. J., & Wei, Y. M. (2010). The Crude Oil Market and the Gold Market: Evidence for Cointegration, Causality and Price Discovery. *Resources Policy, 35*(3), 168-177.

Zhou, B., & Shi, A. (2010, August 13-15). *LSSVM and Hybrid Particle Swarm Optimization for Ship Motion Prediction.* Proceedings of the International Conference on Intelligent Control and Information Processing (ICICIP), Dalian, China.

Zhou, S., & Lai, K. K. (2011). An Improved EMD Online Learning-Based Model for Gold Market Forecasting. In J. Watada et. al (Eds.), *Intelligent Decision Technologies Smart Innovation, Systems and Technologies* (pp. 75-84). Berlin Heidelberg: Springer-Verlag

Zhou, S., Lai, K. K., & Yen, J. (2012). A Dynamic Meta-Learning Rate-Based Model for Gold Market Forecasting. *Expert Systems with Applications, 39*, 6168-6173.

Zhu, B., & Wei, Y. (2013). Carbon Price Forecasting with a Novel Hybrid ARIMA and Least Squares Support Vector Machines Methodology. *Omega, 41*, 517-524.

Zhu, G., & Kwong, S. (2010). Gbest-guided artificial bee colony algorithm for numerical function optimization. *Applied Mathematics and Computation, 217*, 3166-3173.

Zou, M. (2009, July 12-15). *Condition Prediction of Hydroturbine Generating Units using Least Squares Support Vector Regression with Genetic Algorithm.* Proceedings of the Eighth International Conference on Machine Learning and Cybernetics (ICMLC), Baoding, China.