

A HYBRID MODIFIED GROUP METHOD OF DATA HANDLING WITH THE
WAVELET DECOMPOSITION FOR OIL PALM PRICE FORECASTING

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I dedicate this dissertation to

My beloved family and my most supportive supervisor Prof. Dr. Azme Bin Khamis.

Thank you very much to my supervisor for being supportive, helpful and
understanding



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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

In the name of Allah, the most Beneficent and the most Merciful

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ABSTRACT

This thesis presents an exploratory study on hybrid modelling of palm oil price forecasting using modified group method of data handling (GMDH) network with the discrete wavelet transform (DWT) approach. Despite the fact that Malaysia is one of the largest producer and exporter of palm oil, the research on modelling of palm oil price forecasting is still in progress. This study comprises by exploring the appropriate models for forecasting the monthly palm oil price such as conventional GMDH, modified GMDH and hybrid wavelet modified GMDH models. To assess the effectiveness of these models, monthly crude palm oil (CPO) price of Malaysia from January 1983 until November 2019 and Pakistan from September 2001 until June 2019 were used as sample study. The study shows that modified GMDH model, which integrates four transfer functions such as radial basis, sigmoid, tangent and polynomial simultaneously into GMDH, has given the best fit for modelling of palm oil price forecasting as compared to conventional GMDH model. However, the individual model is not best every time to achieve the better results. In improving the model, this study explores a hybrid wavelet modified GMDH model. The architecture of the proposed hybrid model includes DWT, which is selected as a preprocessed clean and pure data enabling the modified GMDH network to present itself as a well-established alternative application to predict the future of CPO. The proposed hybrid model has been applied to different CPO data sets and verified using simulation of different splits of model input data series. Comparative studies among various models were carried out. The mean absolute percentage error (MAPE) of the proposed hybrid model for the monthly CPO price of Malaysia is less than 4 % and coefficient of correlation (R) is 0.99, which show an excellent fit as compared to the individual and other benchmark models. Similarly, the MAPE of hybrid model for Pakistan imports monthly CPO is less than 14 % and R is 0.94, which show good fit as compared to the individual and other benchmark models. The results have demonstrated that the proposed hybrid model is a better alternative model for crude palm oil price forecasting.

ABSTRAK

Tesis ini mengemukakan kajian mengenai pemodelan hibrid ramalan harga minyak sawit menggunakan kaedah pengumpulan data kumpulan yang diubah suai (GMDH) dengan pendekatan transformasi gelombang diskrit (DWT). Walaupun Malaysia merupakan salah satu pengeluar dan pengeksport minyak sawit terbesar, penyelidikan mengenai pemodelan ramalan harga minyak sawit masih mempunyai ruang untuk diteroka. Kajian ini merangkumi penerokaan model yang sesuai untuk meramal harga bulanan minyak sawit mentah (CPO) seperti kaedah GMDH konvensional, kaedah GMDH yang diubah suai dan model hibrid transformasi gelombang diskret dengan GMDH yang diubah suai. Untuk menilai keberkesanan model ini, harga bulanan minyak sawit mentah Malaysia dari Januari 1983 hingga November 2019 dan Pakistan dari September 2001 hingga Jun 2019 akan digunakan. Kajian menunjukkan bahawa model GMDH yang diubah suai, yang mengintegrasikan empat fungsi pemindahan seperti asas jejari, sigmoid, tangen dan polinomial secara serentak ke dalam GMDH. Pendekatan ini telah memberikan penyuaian terbaik untuk pemodelan peramalan harga minyak sawit berbanding dengan model GMDH konvensional. Bagi meningkatkan ketepatan model, kajian ini meneroka model gelombang hibrid GMDH yang diubah suai. Senibina model hibrid yang dicadangkan merangkumi DWT, yang dipilih sebagai data yang telah melalui proses pembersihan bagi membolehkan kaedah GMDH yang diubah suai menjadi lebih mapan dan sesuai untuk meramal harga minyak sawit. Model hibrid yang dicadangkan telah diterapkan pada kumpulan data harga minyak sawit yang berbeza dan disahkan keupayaannya menggunakan data simulasi siri yang berbeza. Kajian perbandingan antara pelbagai model telah dilakukan. Nilai purata peratusan sisihan mutlak (MAPE) model hibrid yang dicadangkan untuk harga bulanan CPO Malaysia adalah kurang dari 4% dan nilai pekali korelasi (R) adalah 0.99, yang menunjukkan kesesuaian yang sangat baik berbanding dengan model yang lain. Begitu juga, MAPE model hibrid untuk Pakistan adalah kurang dari 14% dan nilai R adalah 0.94, yang menunjukkan kesesuaian berbanding dengan model yang lain. Hasil kajian menunjukkan bahawa model hibrid yang dicadangkan adalah model alternatif yang terbaik untuk meramal harga minyak sawit mentah.

CONTENTS

	TITLE	i
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	CONTENTS	vii
	LIST OF TABLES	xi
	LIST OF FIGURES	xvi
	LIST OF SYMBOLS AND ABBREVIATIONS	xxiii
	LIST OF APPENDICES	xxv
CHAPTER 1	INTRODUCTION	1
	1.1 Background of the study	1
	1.2 Problem statement	6
	1.3 Objectives	8
	1.4 Scope of the study	8
	1.5 Significance of the study	9
	1.6 Thesis contribution	11
	1.7 Thesis structure and organization	11
CHAPTER 2	LITERATURE REVIEW	14
	2.1 Introduction	14
	2.2 Time series forecasting	15
	2.3 The fundamental of GMDH neural network	16
	2.4 Application of GMDH neural network	18
	2.5 Fundamental of wavelet	20
	2.6 Wavelet analysis and its applications	24
	2.7 Hybrid model and its applications	25

2.8	Summary	33
CHAPTER 3	RESEARCH METHODOLOGY	35
3.1	Introduction	35
3.2	Data source description	37
3.2	Group method of data handling	38
	3.3.1 Partial model construction	38
	3.3.2 External criteria of accuracy	39
	3.3.3 Sorting out procedure description	40
	3.3.4 GMDH algorithm	41
3.4	Modified GMDH	46
3.5	Discrete wavelet transform	50
3.6	ARIMA model	51
3.7	Hybrid wavelet-modified GMDH model	53
3.8	Hybrid wavelet modified GMDH algorithm	55
3.9	Summary of research methodology	57
3.10	Performance evaluation	59
3.11	Summary	60
CHAPTER 4	RESULTS AND DISCUSSION	61
4.1	Introduction	61
4.2	Results analysis of Malaysia palm oil data	62
	4.2.1 Non-stationary and non-linearity	65
	4.2.2 Augmented Dickey-Fuller test	66
4.3	Modeling configurations of Malaysia palm oil data	67
	4.3.1 GMDH modelling and its implementation	68
	4.3.2 Modified GMDH modelling and its implementation	73
	4.3.3 Discrete wavelet analysis	81
	4.3.4 Hybrid wavelet-modified GMDH modeling and its implementation	86
4.4	ARIMA modeling of Malaysia palm oil data	94
	4.4.1 Identification stationarity	95

4.4.2	Autoregressive and moving average components determination	96
4.4.3	Estimation and diagnostic checking	98
4.4.4	Model's use or application	103
4.5	Results analysis of Pakistan palm oil data	111
4.5.1	Non-stationary and non-linearity	114
4.6	Modeling configurations for Pakistan palm oil data	116
4.6.1	GMDH modelling	116
4.6.2	Modified GMDH modelling	122
4.6.3	Wavelet analysis of Pakistan palm oil data	129
4.6.4	Hybrid modelling (wavelet-modified GMDH) of Pakistan data	135
4.7	ARIMA modeling of Pakistan palm oil data	140
4.8	Simulation results of different model input data of the proposed hybrid model	154
4.9	Summary	158
CHAPTER 5 COMPARISON AND DISCUSSION		160
5.1	Introduction	160
5.2	Comparison	160
5.3	Discussions	165
5.3.1	Discussion on conventional GMDH	166
5.3.2	Discussion on modified GMDH	167
5.3.3	Discussion on hybrid wavelet modified GMDH	169
5.3.4	Discussion on ARIMA model	172
5.4	Comparison of model and forecasting accuracy measurements	173
5.5	Summary	177
CHAPTER 6 CONCLUSION AND FUTURE RECOMMENDATION		178
6.1	Introduction	178

6.2	Conclusion	178
6.3	Contributions	180
6.4	Limitation of the work	181
6.5	Suggestions for future research	182
	REFERENCES	183
	APPENDICES	195
	VITA	229



PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF TABLES

2.1	Summary of previous studies on crude palm oil price forecasting	27
2.2	Summary of previous studies on GMDH and modified GMDH	29
2.3	Summary of previous studies on the hybrid models	31
3.1	The suggested transfer functions	46
3.2	Difference between conventional GMDH and modified GMDH models	48
4.1	Descriptive statistics of monthly crude palm oil price for overall data set (Jan 1983 – Nov 2019)	63
4.2	Descriptive statistics of monthly crude palm oil price for training data set (Jan 1983 – June 2012)	64
4.3	Descriptive statistics of monthly crude palm oil price for testing data set (Jul 2012 – Nov 2019)	65
4.4	Unit root ADF test for overall data (Jan 1983- Nov 2019)	66
4.5	Unit root ADF test for training data (Jan 1983- 2012)	66
4.6	Unit root ADF test for testing data (Jul 2012-Nov 2019)	67
4.7	Forecast values of conventional GMDH model for overall, training and testing data of monthly CPO price of Malaysia	72
4.8	Forecasting accuracy (fit) of conventional GMDH model for overall, training and testing data set of monthly CPO price of Malaysia	73
4.9	Forecast values of modified GMDH model for overall,	

	training and testing data of monthly CPO price of Malaysia	79
4.10	Forecasting accuracy (fit) of modified GMDH model for overall, training and testing data of monthly CPO price of Malaysia	80
4.11	Accuracy (fit) of modified GMDH using individual and all transfer function for overall monthly CPO price data of Malaysia	81
4.12	The correlation coefficient (R) between discrete wavelet component and actual monthly CPO price for overall data	83
4.13	The correlation coefficient (R) between discrete wavelet component and actual CPO price of training data	83
4.14	The correlation coefficient (R) between discrete wavelet component and actual CPO price for testing data	86
4.15	Forecast values of hybrid wavelet modified GMDH model for overall, training and testing data of monthly CPO price of Malaysia	93
4.16	Forecasting accuracy (fit) of hybrid wavelet modified GMDH for overall, training and testing data of monthly CPO price of Malaysia	94
4.17	Coefficient, std. error and other parameters of ARIMA (7, 1, 7) for overall data of monthly CPO price of Malaysia	100
4.18	Coefficient, std. error and other parameters of ARIMA (6, 1, 6) for training data of monthly CPO price of Malaysia	101
4.19	Coefficient, std. error and other parameters of ARIMA (2, 1, 0) for testing data of monthly CPO price of Malaysia	102
4.20	Forecast values of ARIMA model for overall, training	

	and testing data of monthly CPO price of Malaysia	110
4.21	Forecasting accuracy (fit) of ARIMA model for overall, training and testing data of monthly CPO price of Malaysia	110
4.22	Descriptive statistics of Pakistan imports monthly palm oil price for overall data set	112
4.23	Descriptive statistics of Pakistan imports monthly palm oil price for training data set	113
4.24	Descriptive statistics of Pakistan imports monthly palm oil price for testing data set	114
4.25	Unit root ADF test for overall data of Pakistan imports monthly palm oil price	115
4.26	Unit root ADF test for training data of Pakistan imports monthly palm oil price	115
4.27	Unit root ADF test for testing data of Pakistan imports monthly palm oil price	115
4.28	Forecast values of conventional GMDH model for Pakistan imports monthly Palm oil price	121
4.29	Forecasting accuracy (fit) of conventional GMDH model for Pakistan imports monthly palm oil price for overall, training and testing data set	121
4.30	Forecast values of modified GMDH model for Pakistan imports monthly palm oil price	127
4.31	Forecasting accuracy (fit) of predicted modified GMDH model for Pakistan imports monthly palm oil price for overall, training and testing data	128
4.32	Accuracy (fit) of modified GMDH for individual and all transfer functions for training data of Pakistan imports monthly palm oil price	129
4.33	The correlation coefficient (R) between discrete wavelet components and Pakistan imports monthly palm oil price for overall data	131
4.34	The correlation coefficient (R) between discrete	

	wavelet component and Pakistan imports monthly palm oil price for training data set	131
4.35	The correlation coefficient (R) between discrete wavelet components and Pakistan imports monthly palm oil price for testing data	133
4.36	Forecast values of hybrid wavelet modified GMDH model for Pakistan imports monthly palm oil price	139
4.37	Forecasting accuracy (fit) of hybrid wavelet modified GMDH model for Pakistan imports monthly palm oil price for overall, training and testing data	139
4.38	Coefficient, std. error and other parameters of ARIMA (7, 1, 7) model for overall data set of Pakistan imports monthly palm oil price	143
4.39	Forecast values of ARIMA model for Pakistan imports monthly palm oil price data sets	145
4.40	Forecasting Accuracy (fit) of ARIMA modelling for overall, training and testing data sets of Pakistan imports monthly palm oil price	146
4.41	Coefficient, std. error and other parameters of ARIMA (6, 1, 6) model for training data set of Pakistan imports monthly palm oil price	147
4.42	Coefficient, std. error and other parameters of ARIMA (1, 1, 2) for testing data of Pakistan imports monthly palm oil price	152
4.43	The input structure of the models for monthly CPO price forecasting	155
4.44	Forecasted values after simulation results for different model input structures	156
4.45	Accuracy (fit) after simulation results for model input structures of modified GMDH model	156
4.46	Forecasted values after simulation results for different model input structures	157
4.47	Accuracy (fit) after simulation results for model input structures of hybrid wavelet modified GMDH model	157

5.1	Comparison of forecasting accuracy of monthly CPO price of Malaysia for overall data set	163
5.2	Comparison of forecasting accuracy of monthly CPO price of Malaysia for training data set	163
5.3	Comparison of forecasting accuracy of monthly CPO price of Malaysia for testing data set	163
5.4	Comparison of forecasting accuracy of Pakistan monthly imports palm oil price for overall data set	164
5.5	Comparison of forecasting accuracy of Pakistan monthly imports palm oil price for training data set	164
5.6	Comparison of forecasting accuracy of Pakistan monthly imports palm oil price for testing data set	164



LIST OF FIGURES

1.1	World major edible vegetables oils production	2
1.2	World palm oil supply by country	2
1.3	Monthly price of major vegetables oils including crude palm oil	3
2.1	Filter bank scheme for DWT	23
2.2	Wavelet decomposition tree	24
3.1	The study framework	36
3.2	GMDH neuron architecture	39
3.3	GMDH network with rejected neurons	41
3.4	Architecture network of GMDH	44
3.5	GMDH algorithms flow chart	45
3.6	Decomposition tree of DWT	50
3.7	Discrete wavelet analysis	51
3.8	The structure of ARIMA model	52
3.9	The structure of hybrid wavelet-modified GMDH	55
3.10	Flowchart of hybrid wavelet-modified GMDH algorithm	56
3.11	The structure of hybrid wavelet-modified GMDH	58
4.1	Crude palm oil price versus time plot for overall data	63
4.2	Crude palm oil price versus time plot for training data	64
4.3	Crude palm oil price versus time plot for testing data	65
4.4	Crude palm oil price versus time of conventional GMDH model for overall data	769
4.5	Scatter plot of fitted conventional GMDH model for	

	overall data of monthly CPO price of Malaysia	69
4.6	Crude palm oil price versus time of conventional GMDH model for training data	70
4.7	Scatter plot of fitted conventional GMDH model for training data of monthly CPO price of Malaysia	71
4.8	Crude palm oil price versus time of conventional GMDH model for testing data set	72
4.9	Crude palm oil price versus time of modified GMDH model for overall data set	75
4.10	Scatter plot of fitted modified GMDH model for overall data of monthly CPO price of Malaysia	75
4.11	Residuals plot of modified GMDH model for overall data of monthly CPO price of Malaysia	76
4.12	Crude palm oil price versus time of modified GMDH model for training data set	77
4.13	Scatter plot of fitted modified GMDH model for training data of monthly CPO price of Malaysia	77
4.14	Residuals plot of modified GMDH model for training data of monthly CPO price of Malaysia	78
4.15	Crude palm oil price versus time of modified GMDH model for testing data	79
4.16	Monthly CPO price of overall data and decomposed wavelet sub-series components (details (Ds) & approximate (As))	82
4.17	Monthly CPO price of training data and decomposed wavelet sub-series components (details (Ds) & approximate (As))	84
4.18	Monthly CPO price of testing data and decomposed wavelet sub-series components (details (Ds) & approximate (As))	85
4.19	Crude palm oil price versus time of hybrid wavelet-modified GMDH model for overall data set	88
4.20	Scatter plot of hybrid wavelet-modified GMDH	

	model for overall data of monthly CPO price of Malaysia	89
4.21	Residuals plot of hybrid wavelet-modified GMDH model for overall data of monthly CPO price of Malaysia	89
4.22	Crude palm oil price versus time of hybrid wavelet-modified GMDH model for training data set	91
4.23	Scatter plot of hybrid wavelet-modified GMDH model for training data of monthly CPO price of Malaysia	91
4.24	Residuals plot of hybrid wavelet-modified GMDH model for training data of monthly CPO price of Malaysia	92
4.25	Crude palm oil price versus time of wavelet-modified GMDH model for testing data	93
4.26	ACF and PACF of first differenced series by lag for overall data set of monthly CPO price of Malaysia	96
4.27	ACF and PACF of first differenced series by lag for training data set of monthly CPO price of Malaysia	97
4.28	ACF and PACF of first differenced series by lag for testing data set of monthly CPO price of Malaysia	98
4.29	Diagnostic test for the standard residuals of monthly CPO price for overall data set	99
4.30	Diagnostic test for the standard residuals of monthly CPO price for training data set	101
4.31	Diagnostic test for the standard residuals of monthly CPO price for testing data set	103
4.32	CPO Price versus time of ARIMA (7, 1, 7) model for overall data set	104
4.33	Scatter plot of ARIMA (7, 1, 7) model for overall data of monthly CPO price of Malaysia	105
4.34	Residuals plot of ARIMA (7, 1, 7) model for overall data of monthly CPO price of Malaysia	105

4.35	CPO price versus time of ARIMA (6, 1, 5) model For overall data set	106
4.36	Scatter plot of ARIMA (6, 1, 5) model for training data of monthly CPO price of Malaysia	107
4.37	Residuals plot of ARIMA (6, 1, 5) model for training data of monthly CPO price of Malaysia	107
4.38	CPO price versus time of ARIMA (2, 1, 0) model for testing data set	108
4.39	Scatter plot of ARIMA (2, 1, 0) model for testing data of monthly CPO price of Malaysia	109
4.40	Residuals plot of ARIMA (2, 1, 0) model for testing data of monthly CPO price of Malaysia	109
4.41	Pakistan imports monthly palm oil price versus time plot for overall data set	112
4.42	Pakistan imports monthly palm oil price versus time plot for training data set	113
4.43	Pakistan imports monthly palm oil price versus time plot for testing data set	114
4.44	Pakistan imports palm oil price versus time of conventional GMDH model for overall data set	117
4.45	Scatter plot of conventional GMDH model for overall data of Pakistan imports palm oil price	118
4.46	Residuals plot of conventional GMDH model for overall data of Pakistan imports monthly palm oil price	118
4.47	Pakistan imports palm oil price versus time of conventional GMDH for training data set	119
4.48	Residuals plot of conventional GMDH model for training data of Pakistan imports monthly palm oil price	119
4.49	Pakistan imports palm oil price versus time of conventional GMDH for testing data set	120
4.50	Residuals plot of conventional GMDH model for	

	testing data of Pakistan imports monthly palm oil price	120
4.51	Pakistan imports monthly palm oil price versus time of modified GMDH model for overall data set	123
4.52	Residuals plot of modified GMDH model for overall data set of Pakistan imports monthly palm oil price	124
4.53	Pakistan imports monthly palm oil price versus time of modified GMDH model for training data set	125
4.54	Residuals plot of modified GMDH model for training data set of Pakistan imports monthly palm oil price	125
4.55	Pakistan imports monthly palm oil price versus time of modified GMDH model for testing data set	126
4.56	Residuals plot of modified GMDH model for testing data set of Pakistan imports monthly palm oil price	127
4.57	Monthly Pakistan imports palm oil price of overall data and decomposed wavelet sub-series components (details (Ds) & approximate (As) of time series	130
4.58	Monthly Pakistan imports palm oil price of training data and decomposed wavelet sub-series components (details (Ds) & approximate (As)) of time series	132
4.59	Monthly Pakistan imports palm oil price of testing data and decomposed wavelet sub-series components (details (Ds) & approximate (As)) of time series	134
4.60	Pakistan imports monthly palm oil price versus time of the predicted hybrid wavelet-modified GMDH model for overall data set	136
4.61	Residuals plot of hybrid wavelet-modified GMDH model for overall data of Pakistan imports monthly palm oil price	136
4.62	Pakistan imports monthly palm oil price versus time of the predicted hybrid wavelet-modified GMDH model for training data set	137
4.63	Residuals plot of hybrid wavelet-modified GMDH	

	model for training data of Pakistan imports monthly palm oil price	137
4.64	Pakistan imports monthly palm oil price versus time of the predicted hybrid wavelet-modified GMDH model for testing data set	138
4.65	Residuals plot of hybrid wavelet-modified GMDH model for testing data of Pakistan imports monthly palm oil price	138
4.66	ACF and PACF of first differenced series by lag for overall data set of Pakistan imports monthly palm oil price	141
4.67	Diagnostic test for the standard residuals of Pakistan imports monthly palm oil prices for overall data set	142
4.68	Pakistan imports monthly palm oil price versus time of ARIMA (7, 1, 7) model for overall data set	144
4.69	Residuals plot of ARIMA (7, 1,7) model for overall data set of Pakistan imports monthly palm oil price	145
4.70	ACF and PACF of first differenced series by lag for training data set of Pakistan imports monthly palm oil price	146
4.71	Diagnostic test for the standard residuals of Pakistan. imports monthly palm oil price for training data set of Pakistan imports palm oil price	148
4.72	Pakistan imports monthly palm oil prices versus time of ARIMA (6, 1, 6) model for training data set	149
4.73	Residuals plot of ARIMA (6, 1,6) model for training data set of Pakistan imports monthly palm oil price	150
4.74	ACF and PACF of first differenced series by lag for testing data set of Pakistan imports monthly palm oil price	151
4.75	Diagnostic test for the standard residuals of Pakistan imports monthly palm oil price for overall data set	152
4.76	Pakistan imports monthly palm oil price versus time	

	of ARIMA (1, 1, 2) model for testing data set	153
4.77	Residuals plot of ARIMA (1, 1, 2) model for testing data of Pakistan imports monthly palm oil price	154
5.1	Comparison of the results of different modelling methods applied to monthly CPO price data of Malaysia	175
5.2	Comparison of the results of different modeling. methods applied to imports monthly palm oil data of Pakistan	176



LIST OF SYMBOLS AND ABBREVIATIONS

AI	Artificial Intelligence
As	Approximation Coefficients
ACF	Autocorrelation Function
ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criteria
AIM	Abductory induction mechanism
ANN	Artificial Neural Network
ANFIS	Adaptive neuro fuzzy inference system
AR	Auto Regressive
ARCH	Autoregressive Conditional Heteroskedasticity
ARFIMA	Autoregressive fractionally integrated moving average
ARIMA	Autoregressive Integrated Moving Average
ARMA	Autoregressive Moving Average
CPO	Crude Palm Oil
DE	Differential Evolution
Ds	Detail Coefficients
DWT	Discrete Wavelet Transform
EMD	Empirical Mode Decomposition
FA	Factor Analysis
FFNN	Feed-Forward Neural Network
FCM	Fuzzy c-means
FLR	fuzzy linear regression
GA	Genetic Algorithm
GARCH	Generalized Autoregressive Conditional

	Heteroskedasticity
GMDH	Group Method of Data Handling
GS	Generalized Structure
LSSVM	Least Squares Support Vector Machine
LSE	Least Square Error
MA	Moving Average
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
MGMDH	Modified Group Method of Data Handling
MPOB	Malaysian Palm Oil Board
MSE	Mean Square Errors
NN	Neural Network
PACF	Partial Autocorrelation Function
PBS	Pakistan Bureau of Statistics
PD	Partial description
PNN	Polynomial neural network
PSS	Prediction Sum of Squares
RBF	Radial Basis Function
RLSE	Regularized Least Square Error
RMSE	Root Mean Square Error
R	Correlation coefficient
R^2	Coefficient of determination
SARIMA	Seasonal Autoregressive Integrated Moving Average
SBO	Soybean Oil
SSA	Singular Spectral Analysis
SOPNN	Self-organizing polynomial neural network
TF	Transfer Function
WMGMDH	Wavelet-modified GMDH

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	List of publications	195
B	List of conference presentation	196
C	R codes for forecasting of modified GMDH algorithm	198
D	Three level discrete wavelet decomposition codes	205
E	Data processing in GMDH shell	206
F	ARIMA codes	207
G	Simulation data for (CPO) for modified GMDH model	211
H	Simulation data for (WCPO) for hybrid wavelet modified GMDH model	220

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APPENDIX A

LIST OF PUBLICATIONS

1. Modelling and Forecasting of Monthly Crude Palm Oil Price of Malaysia using Hybrid Wavelet-Modified GMDH Model, *ASM Science Journal* Sep 2021 (Accepted for publication, in-progress)
Huma Basheer, Azme Khamis,
2. Crude Palm Oil Price Forecasting: Comparative Study of Hybrid GMDH Neural Network and ARIMA Model,
Accepted for Publication in Malaysian Journal of Science (Aug 2021), in progress
Huma Basheer, Azme Khamis,
3. Forecasting of crude palm oil price using hybridizing wavelet and group method of data handling model. *Mal. J. Fund. Appl. Sci.*, 2017, 13, 642–648.
Huma Basheer, Azme Khamis,
4. A Hybrid Group Method of Data Handling (GMDH) with the Wavelet Decomposition for Time Series Forecasting. *ARNP Journal of Engineering and Applied Sciences*, 2016,11, 10792–10800.
5. Forecasting of crude palm oil price (CPO) and Soybean Oil (SBO) Prices using Group Method of Data Handling. *Proceedings of 4th International Science Postgraduate Conference 2016 (ISPC2016)*, Universiti Teknologi Malaysia ISBN 978-967-0194-54-7, Pp. 265–274.
6. Forecasting of crude palm oil price using hybrid model of Group Method of Data Handling with wavelet decomposition. **Proceedings of 6th International Graduate Conference on Engineering Science & Humanity (6th IGCESH 2016)**, UTM, Malaysia, ISBN:978-967-0194-67-7, Pp. 520–523.

APPENDIX B

LIST OF CONFERENCES PRESENTATION

1. "The International Seminar on Mathematics in Industry 2021 (ISMI2021)" organized by **UTM-Centre for Industrial and Applied Mathematics (UTM-CIAM)** and Department of Mathematical Sciences, Faculty of Science, UTM, 17-19 August 2021 "Modelling and Forecasting of Monthly Crude Palm Oil Price of Malaysia using Hybrid Wavelet-Modified GMDH Model"
Huma Basheer, Azme Khamis
2. "International Conference on the Application of Science and Mathematics (SCIEMATHIC)", organized by Faculty of Applied Sciences and Technology, UTHM, Oct 27-28, 2021
3. "FAST POSTGRADUATE SYMPOSIUM 2019" organized by Faculty of Sciences and Technology (FAST), **Universiti Tun Hussein Onn Malaysia (UTHM)**, Modeling and forecasting of monthly crude palm oil prices of Malaysia: A comparative study of GMDH, hybrid wavelet- modified GMDH and ARIMA models
Huma Basheer, Azme Khamis
4. International Graduate Conference on Engineering Science & Humanity 2016 (IGCESH 2016), organized by **Universiti Teknologi Malaysia**, Johor Bahru, Johor, Malaysia on 15 - 17 August 2016. Forecasting of crude palm oil price using hybrid model of group method of data handling with wavelet decomposition
Huma Basheer, Azme Khamis
5. 4th ISPC 2016 (UTM): (4th International Science Post Graduate Conference 2016), 22-24 February 2016, organized by **Universiti Teknologi Malaysia**, Johor Bahru, Johor, Malaysia Forecasting of crude palm oil price (CPO) and Soybean Oil (SBO) Prices using Group Method of Data Handling
Huma Basheer, Azme Khamis

6. MUCET2015: (Malaysian Technical Universities Conference on Engineering and Technology) 11-13, Oct, 2015 (UTHM): organized by **Universiti Tun Hussein Onn Malaysia**, Johor Bahru, Johor, Malaysia A Hybrid Group Method of Data Handling (GMDH) with the Wavelet Decomposition for Time Series Forecasting,
Huma Basheer, Azme Khamis

