



TABLE OF CONTENTS

APPROVAL PAGE	iii
CONTENTS	vii
LIST OF TABLES	x
LIST OF FIGURES	xii
LIST OF EQUATIONS	xv
ABSTRACT	xvi
I. INTRODUCTION	1
1.1 Research Background	1
1.2 Research Problem	3
1.3 Research Boundary/Scope	4
1.4 Research Objective	5
1.5 Research Advantage	5
II. LITERATURE REVIEW	6
III. BASIC THEORY	13
3.1 Autoregressive	13
3.2 Long Short-Term Memory	13
3.3 Convolutional Neural Network	15
3.4 Autoregressive Integrated Moving Average	17
3.5 Hybrid Model	18
3.6 Mean Absolute Percentage Error	19
3.7 Root Mean Squared Error	20
3.8 Root Mean Absolute Error	21
IV. RESEARCH METHODOLOGY	22
4.1 Research Description	22
4.2 Research Plan	23



4.2.1	Research Activities Plan/Layout	23
4.2.2	Research Dataset	25
4.2.3	Research Model Layout	29
4.2.4	Overall Research Evaluation Example	33
V.	IMPLEMENTATIONS	35
5.1	Importing Libraries	35
5.2	Dataset Importing and Loading	36
5.3	Data Cleaning and Modifying	39
5.4	Data Visualization	40
5.5	Data Division	41
5.6	Model Building	41
5.6.1	Autoregressive Model	42
5.6.2	Convolutional Neural Network Model	43
5.6.3	Long-Short Term Memory Model	45
5.6.4	Autoregressive Integrated Moving Average Model	47
5.6.5	Convolutional Neural Network – Long-Short Term Memory Hybrid Model	48
5.7	Model Execution and Obtaining Results	49
5.8	Facilities	50
VI.	RESULT ANALYSIS AND DISCUSSION	51
6.1	Dataset	51
6.2	Model Training Results	54
6.2.1	Autoregressive Model Training Result	55
6.2.2	Autoregressive Integrated Moving Average Model Training Result	56
6.2.3	Convolutional Neural Network Model Training Result	57



6.2.4	Long-Short Term Memory Model Training Result	63
6.2.5	Convolutional Neural Network – Long-Short Term Memory Hybrid Model Training Result	68
6.3	Overall Evaluation Results	74
6.4	Prediction Results	80
6.5	Validation Model Results	83
6.6	Comparison Between Original and Validation Dataset	87
6.7	Comparison with a Previous Research	88
6.8	Overall Discussion	91
VII. CONCLUSION AND RECOMMENDATION		93
7.1	Conclusion	93
7.2	Recommendation	93
REFERENCES		94
APPENDIX		98



LIST OF TABLES

Table 2.1 Literature Review Content	10
Table 4.1 Gold Price Dataset	26
Table 4.2 Dataset Cleaning	26
Table 4.3 Prediction Dataset	27
Table 4.4 Brent Oil Dataset	27
Table 4.5 Antam Dataset	28
Table 4.6 Condensed Comparison Data	28
Table 6.1 Overall AR Model Evaluation Comparison	55
Table 6.2 Overall ARIMA Model Evaluation Comparison	56
Table 6.3 USD CNN 80% Training Result	58
Table 6.4 IDR CNN 80% Training Result	59
Table 6.5 USD CNN 70% Training Result	60
Table 6.6 IDR CNN 70% Training Result	60
Table 6.7 USD CNN 60% Training Result	61
Table 6.8 IDR CNN 60% Training Result	62
Table 6.9 Overall CNN Model Evaluation Comparison	62
Table 6.10 USD LSTM 80% Training Result	63
Table 6.11 IDR LSTM 80% Training Result	64
Table 6.12 USD LSTM 70% Training Result	65
Table 6.13 IDR LSTM 70% Training Result	66
Table 6.14 USD LSTM 60% Training Result	66
Table 6.15 IDR LSTM 60% Training Result	67
Table 6.16 Overall LSTM Model Evaluation Comparison	67
Table 6.17 USD CNN-LSTM Model 80% Training Result	69
Table 6.18 IDR CNN-LSTM Model 80% Training Result	70
Table 6.19 USD CNN-LSTM Model 70% Training Result	70
Table 6.20 IDR CNN-LSTM Model 70% Training Result	71
Table 6.21 USD CNN-LSTM Model 60% Training Result	72
Table 6.22 IDR CNN-LSTM Model 60% Training Result	73
Table 6.23 Overall CNN-LSTM Model Evaluation Comparison	73
Table 6.24 USD Overall Model Evaluation Comparison	75
Table 6.25 IDR Overall Model Evaluation Comparison	76
Table 6.26 Comparison Table He et al. (2019) Research	



Table 6.27 CNN Model USD Prediction Accuracy Result	77
Table 6.28 CNN Model IDR Prediction Accuracy Result	81
Table 6.29 LSTM Model USD Prediction Accuracy Result	81
Table 6.30 LSTM Model IDR Prediction Accuracy Result	81
Table 6.31 CNN-LSTM Model USD Prediction Accuracy Result	82
Table 6.32 CNN-LSTM Model IDR Prediction Accuracy Result	82
Table 6.33 Prediction Accuracy Results Combined	82
Table 6.34 CNN Model Validation Accuracy Result	82
Table 6.35 LSTM Model Validation Accuracy Result	85
Table 6.36 CNN-LSTM Model Validation Accuracy Result	85
Table 6.37 Combined Overall Model Validation Accuracy Result	86
Table 6.38 Overall Comparisons Result	87
Table 6.39 Comparison Dataset Result	91



LIST OF FIGURES

Figure 3.1 Architecture of an LSTM Block	14
Figure 3.2 1-D CNN Architecture	16
Figure 3.3 Classification Class of Hybrid Model	19
Figure 4.1 Research Plan Flow Chart	24
Figure 4.2 Model Implementation Plan for World Gold Council Dataset	30
Figure 4.3 Model Prediction and Validation Plan using Prediction and Validation Dataset	31
Figure 4.4 Model Comparison Plan using Antam Dataset	32
Figure 5.1 Imported Libraries	35
Figure 5.2 Google Drive Connection	36
Figure 5.3 Loading in Datasets	37
Figure 5.4 World Gold Council Dataset Preview	37
Figure 5.5 Prediction Dataset Preview	38
Figure 5.6 Brent Oil Dataset Preview	38
Figure 5.7 Antam Dataset Preview	39
Figure 5.8 Cleaning up Data	39
Figure 5.9 Date Conversion for Neater Plotting	40
Figure 5.10 Plotting Dataset for Content Display	40
Figure 5.11 Data Division for Training and Testing	41
Figure 5.12 Autoregressive Model Implementation	42
Figure 5.13 Sequence Format Conversion	43
Figure 5.14 Data Reshaping to Fit Model	44
Figure 5.15 Convolutional Neural Network Model	44
Figure 5.16 Long-Short Term Memory	45
Figure 5.17 Autoregressive Integrated Moving Average Initialization	45
Figure 5.18 Moving Average Implementation	46
Figure 5.19 ARIMA New Dataset	46
Figure 5.20 Assigning Variables	46
Figure 5.21 Differencing Values	47
Figure 5.22 ARIMA Model	47
Figure 5.23 Creating Subsequence	48
Figure 5.24 CNN-LSTM Hybrid Model	48
Figure 5.25 Executing Model	48



Figure 5.26 Getting Prediction Values	49
Figure 5.27 Getting Evaluation Results	49
Figure 5.28 Recording Results	49
Figure 6.1 World Gold Council USD Dataset Values	51
Figure 6.2 World Gold Council IDR Dataset Values	52
Figure 6.3 Brent Oil Dataset Values	52
Figure 6.4 Antam Dataset Values	53
Figure 6.5 Dataset Values Comparison	53
Figure 6.6 Prediction Dataset Values	54
Figure 6.7 USD CNN 80% Training Result	58
Figure 6.8 IDR CNN 80% Training Result	58
Figure 6.9 USD CNN 70% Training Result	59
Figure 6.10 IDR CNN 70% Training Result	60
Figure 6.11 USD CNN 60% Training Result	61
Figure 6.12 IDR CNN 60% Training Result	61
Figure 6.13 USD LSTM 80% Training Result	63
Figure 6.14 IDR LSTM 80% Training Result	64
Figure 6.15 USD LSTM 70% Training Result	64
Figure 6.16 IDR LSTM 70% Training Result	65
Figure 6.17 USD LSTM 60% Training Result	66
Figure 6.18 IDR LSTM 60% Training Result	67
Figure 6.19 USD CNN-LSTM Hybrid 80% Training Result	69
Figure 6.20 IDR CNN-LSTM Hybrid 80% Training Result	69
Figure 6.21 USD CNN-LSTM Hybrid 70% Training Result	70
Figure 6.22 IDR CNN-LSTM Hybrid 70% Training Result	71
Figure 6.23 USD CNN-LSTM Hybrid 60% Training Result	71
Figure 6.24 IDR CNN-LSTM Hybrid 60% Training Result	72
Figure 6.25 CNN Model Validation Result	84
Figure 6.26 LSTM Model Validation Result	85
Figure 6.27 CNN-LSTM Hybrid Validation Result	85
Figure 6.28 Double Exponential Smoothing Result	89
Figure 6.29 CNN-LSTM Hybrid Result	90
Figure 6.30 Graphed Values of Hybrid Result	90



LIST OF EQUATIONS

3.1 Autoregressive Equation	13
3.2 Forget Gate Equation	14
3.3 Input Gate Equation 1	14
3.4 Input Gate Equation 2	14
3.5 Cell State Equation	15
3.6 Output Gate Equation 1	15
3.7 Output Gate Equation 2	15
3.8 Autoregressive Integrated Moving Average Equation	17
3.9 Mean Absolute Percentage Error Equation	19
3.10 Root Mean Squared Error Equation	20
3.11 Root Mean Absolute Error Equation	21