Robust and Generalized Functional Data Approach for Yield Curve Modelling of the Asian Frontier Government Bond Market for Steady State and Non-Steady State

K P N S Dayarathne

228029G

Doctor of Philosophy

Computer Science and Engineering

Faculty of Engineering

University of Moratuwa

Sri Lanka

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DECLARATION

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

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The above candidate has carried out research for the PhD thesis under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Dr. Uthayasanker Thayasivam

Dr. V.K.B. Welagadara

Prof. Umashanger Thayasivam

Signature of the Supervisor: Date: 4th Jan 2026

4th Jan 2026

DEDICATION

To the courageous people of Sri Lanka who sacrificed their lives in the pursuit of a better nation, and to the students who continue to defend the right to free education, your strength, resilience, and unwavering commitment inspire this work. You remind us that education is not only a privilege but a responsibility.

May this research, in its humble capacity, serve the betterment of our society and honour the legacy of those who paved the path before us.

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A special note of gratitude goes to my parents, whose sacrifices and unwavering faith in the value of education laid the foundation for all my accomplishments. This achievement stands as a reflection of your love, dedication, and lifelong commitment to my growth.

ABSTRACT

Studies in Yield curve modelling have a long history in the financial capital market. Its ability to produce substantial insights about the future behaviour of interest rates and economic performance has encouraged many scholars to refine further the model's suite for complex, dynamic global capital markets. The state-of-the-art yield curve model structure developed by Nelson-Siegel is still being used by many monetary authorities. However, the accuracy of the model has been questioned theoretically as well as its applicability, especially to frontier markets, due to the inherent limitations of the model. Despite many studies having been done to improve the Nelson-Siegel model to capture the dynamic nature in the developed capital market, while addressing the weaknesses, limited studies have focused on the frontier markets. Due to the lack of sequential data availability and not enough depth of the tenor vis data, three-dimensional yield curve predictions are left in a dilemma for countries like Sri Lanka. The study examined the yield curve data of Sri Lanka, Bangladesh and Pakistan while deriving the zero-coupon bond yield from the discounted yields. Non-traditional smoothing tools such as super-smoothing and spline smoothing have been found to improve the accuracy of the Nelson-Siegel model. The functional principal component analysis suggested the existence of a strong functional structure. However, the study examined the multiple univariate approach of the yield curve prediction using deep learning architectures such as LSTM, RNN, CNN and TCN. Mean Square Error indicated that the multivariate approach exhibits higher accuracy as the yields of each tenor collectively influence the next step of the yield matrix. Utility of the Gompertz function supersedes the Nelson-Siegel model in the Sri Lankan and Bangaldesh context, while the multivariate LSTM architecture outperforms the rest in the Pakistan yield curve modelling after hyperparameter tuning.

Keywords: Deep Learning, Frontier Market, Interest Rate, Yield Curve

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LIST OF ABBREVIATIONS

Abbreviation	Description
ACF	Autocorrelation Function
ADNS	Adaptive Dynamic Nelson-Siegel Model
AE	Auto Encoder
AFDNS	Arbitrage-Free Dynamic Nelson-Siegel Model
AFNS	Arbitrage-Free Nelson-Siegel
ANN	Artificial Neural Networks
AR	Auto Regression
BiLSTM	Bidirectional LSTM
CD	Certificates of Deposit
CIR	Cox-Ingersoll-Ross model
CNN	Convolutional Neural Networks
CSE	Colombo Stock Exchange
DCF	Discounted Cash Flow
DGNS	Dynamic Generalized Nelson-Siegel Model
DNN	Deep Neural Networks
DNS	Dynamic Nelson- Siegel Model
DRF	Dynamic De Rezende-Ferreira five-factor model
EA	Evolutionary Algorithms
FDA	Functional Data Analysis
FFNN	Feed-Forward Neural Network
FPCA	Functional Principal Component Analysis
GDP	Gross Domestic Product
IMF	International Monetary Fund
kNN	k-Nearest Neighbors
LAR	Local AutoRegressive Model
LARX	Local AutoRegressive model with eXogenous
LN-MV-SBM	Logarithmic Modified Super-Bell Model
LSTM	Long Short-Term Memory
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error

Max	Maximum
Min	Minimum
ML	Machine Learning
MLE	Maximum Likelihood Estimation
MLP	Multilayer Perceptron
MSCI	Morgan Stanley Capital International
MSE	Mean Square Error
MV-SBM	Modified Super-Bell Model
NN	Neural Networks
NS	Nelson-Siegel
NS Model	Nelson-Siegel Model
NSS	Nelson-Siegel-Svensson
OLS	Ordinary Least Squares
PCA	Principal Component Analysis
RMSE	Root Mean Square Error
RMSFE	Root Mean Squared Forecast Error
RNN	Recurrent Neural Networks
RW	Random Walk
Std. Div	Standard Deviation
SVR	Support Vector Regression
SWAP	Simultaneous With Agreement of Payment
T-Bond	Treasury Bond
T-Bill	Treasury Bill
TCN	Temporal Convolutional Network
UK	United Kingdom
USD	United States Dollar
VAR	Vector Auto Regression
YTM	Yield-To-Maturity

LIST OF APPENDICES