

INFORMATION ON DOCTORAL THESIS

1. Full name : Dong Thi Ngoc Lan 2. Sex: Female
3. Date of birth: January 1, 1982..... 4. Place of birth: Ninh Bình
5. Admission decision number: 1200/QĐ-CTSV Dated December 29, 2020, issued by the Rector of the VNU University of Engineering and Technology, Vietnam National University, Hanoi.
6. Changes in academic process:
7. Official thesis title: Development of Forecasting Models for GDP and Selected Macroeconomic Indicators Based on Multi-Source Data.
8. Major: Information Systems 9. Code: 9480104
10. Supervisors: Assoc. Prof. Dr. Nguyễn Hà Nam
Dr. Nguyễn Thị Hậu
11. Summary of the new findings of the thesis:

Objectives and Research Subjects:

The thesis aims to establish a scientific and empirical foundation for developing a forecasting model for GDP and other key macroeconomic indicators based on multi-source data integration. The main research subjects include forecasting models, GDP, and selected macroeconomic indicators.

Research Methods:

1. Literature review: Synthesizing theoretical and empirical studies related to macroeconomic forecasting and machine-learning applications.
2. Analysis and synthesis: Used to evaluate the characteristics and structure of macroeconomic data, and to compare traditional and modern models for identifying suitable model-selection criteria.
3. Data processing and extraction: Including data collection, integration, cleaning, normalization, and feature construction to create training and testing datasets from

reputable sources such as the World Bank (WB), General Statistics Office (GSO), and Penn World Table (PWT).

4. Modeling and machine-learning training: Building, training, and evaluating models such as Random Forest, XGBoost, LSTM, Bi-LSTM, Transformer, and DQN; including network-architecture design and hyperparameter optimization.
5. Experimental evaluation: Assessing model forecasting performance using real data and standard metrics such as RMSE, MAE, MAPE, and R^2 ; comparing results with traditional econometric models to verify improvements.
6. Cross-country validation: Applying the proposed model to data from multiple countries to test scalability, generalization, and robustness over time and across economies.

Main Results and Conclusions:

1. The thesis constructs a multi-source macroeconomic database integrating data from reputable organizations such as the World Bank, PWT, and GSO. The data were processed to ensure quality and suitability for time-series forecasting models.
2. The research implements and evaluates a comprehensive system of forecasting models—from traditional econometric to modern deep-learning approaches. Experimental results show that deep-learning models outperform others in capturing nonlinear relationships and long-term dependencies.
3. The thesis proposes a novel deep-learning model named Phase-Adaptive Attention LSTM (PAA-LSTM), which combines multi-layer LSTM with a phase-adaptive attention mechanism aligned with economic cycles. The model learns phase-specific attention weights (recession, recovery, expansion, boom) to better represent dynamic economic behavior. Validation using GDP data from diverse institutional groups confirms the model's effectiveness and scalability.

Conclusion:

The thesis “Research on Building a Multi-Source Data-Based Model for Forecasting GDP and Selected Macroeconomic Indicators” addresses the challenges of forecasting in complex, nonlinear, and dynamic macroeconomic environments. By combining economic theory with modern machine- and deep-learning techniques, the research establishes a solid theoretical framework, constructs an integrated data foundation, and proposes an

empirically validated forecasting model that enhances accuracy and adaptability across varied economic contexts.

12. Practical applicability, if any:

- The proposed forecasting model can assist policy-making agencies such as the Ministry of Finance, the State Bank of Vietnam, and the General Statistics Office in analyzing, forecasting, and making timely economic and financial decisions under macroeconomic fluctuations.
- Additionally, businesses and financial institutions can apply the model's results to identify trends in growth, inflation, and macro-risk, thereby improving strategic planning, investment, and policy adjustment.

13. Further research directions, if any:

- Extending the model to other indicators such as inflation, trade balance, and unemployment rate to test the flexibility and generalization capability of the PAA-LSTM model.
- Integrating real-time and non-traditional data sources (Google Trends, social media, satellite imagery) to enhance the model's adaptability to rapid market changes.
- Incorporating explainable-AI techniques (e.g., SHAP) to improve model transparency and support policy-making decisions.

14. Thesis-related publications:

[CT1] Lan Dong Thi Ngoc, Khai Phan Van, Ngo-Thi-Thu-Trang, Gyoo Seok Choi, Ha-Nam Nguyen, "A Multiple Variable Regression-based Approaches to Long-term Electricity Demand Forecasting", *International Journal of Advanced Smart Convergence*, Vol.10 No.4, page 59-65, 2021

[CT2] Lan Dong Thi Ngoc, Ha-Nam Nguyen, Khai Phan Van, Nam Nguyen Hoai, Hoa Tran Xuan, Dung Hoang Van, GyooSeokChoi, "Research and application of multi-regression analysis method to forecast the electricity consumption demand for Vietnam's residential sector", *9th International Symposium, ISAAC 2021 in Conjunction with ICACT*, page 99-102, 2021

[CT3] Lan Dong Thi Ngoc, Duy-Linh Bui, Sang Van Ha, Huong Tran Thi, Viet Pham Minh, Ha-Nam Nguyen, "Using Machine Learning to Improve Forecasting

Efficiency for the Stock Market”, *International Conference on Research in Management & Technovation*, page 439-447, Springer Nature Singapore, 2023.

- [CT4] Lan Dong Thi Ngoc, Ngo-Thi-Thu-Trang, Kyoung-Mok Kim, Vung Pham and Ha-Nam Nguyen, "Study of Machine Learning Models for Forecasting Macroeconomic Indicators," *25th International Conference on Advanced Communication Technology (ICACT)*, page 22-233, IEEE, 2025 (Hội nghị trong danh mục scopus)
- [CT5] Lan Dong Thi Ngoc, N. D. Hoan, and Ha-Nam Nguyen, “Gross Domestic Product Forecasting Using Deep Learning Models with a Phase-Adaptive Attention Mechanism, “Gross Domestic Product Forecasting Using Deep Learning Models with a Phase-Adaptive Attention Mechanism,” *Electronics*, vol. 14, no. 11, Art. no. 2132, May 2025. (Tạp chí thuộc danh mục trong Scopus, SCIE (WoS) Q2)

Date:

Signature:

Full name:

Date:

Signature:

Full name: