IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Iss 10, 2022

Review of Stock Performance Using Advanced Metaheuristic-Based Machine Learning Models

[1]Kadam Ganjanan Nandkishore, [2]Dr Thaksen Jagannath Parvat

[1,2]Department of Computer Science, Institute Name Malwanchal University, Indore

Abstract

Advanced metaheuristic-based machine learning models have emerged as powerful tools for predicting stock performance, leveraging their ability to handle complex patterns and optimize model parameters effectively. These models, employing algorithms such as genetic algorithms, particle swarm optimization, simulated annealing, and ant colony optimization, excel in capturing non-linear relationships and adapting to dynamic market conditions. They are particularly valuable in feature selection, model training, and parameter tuning tasks, enhancing predictive accuracy and mitigating overfitting risks inherent in traditional statistical methods. This review examines their application in stock prediction, discussing empirical studies and comparative analyses that demonstrate their performance across diverse market scenarios and asset classes. While these models offer significant advantages, challenges such as interpretability, computational complexity, and sensitivity to hyperparameters remain pertinent. Future research should focus on improving algorithm efficiency, integrating alternative data sources, and addressing ethical considerations in algorithmic trading.

Introduction

The prediction of stock performance has long been a challenging yet crucial endeavor in financial markets, influencing investment decisions and portfolio management strategies. Traditional approaches relying on statistical models often struggle to capture the complexities inherent in market dynamics, prompting the adoption of advanced machine learning (ML) techniques. Among these, metaheuristic-based models have emerged as promising tools due to their ability to handle non-linear relationships, optimize parameters effectively, and adapt to dynamic market conditions. Metaheuristic algorithms, including genetic algorithms, particle swarm optimization, simulated annealing, and ant colony optimization, offer distinct advantages in stock prediction tasks. These algorithms operate by exploring large solution spaces, searching for optimal or near-optimal solutions that traditional methods may overlook. Their flexibility in optimizing complex objective functions makes them well-suited for feature selection, model training, and parameter tuning tasks essential for accurate stock forecasting.

Research and application of metaheuristic-based ML models in stock prediction have expanded significantly. These models can integrate diverse data sources such as historical price data, trading volumes, market sentiment from news feeds, and economic indicators to enhance predictive accuracy. By capturing intricate patterns and dependencies within data, they provide insights into market trends and potential investment opportunities that go beyond simple trend analysis. The effectiveness of metaheuristic-based ML models in

financial forecasting is underscored by empirical studies demonstrating their superior performance compared to traditional methods in various market conditions and asset classes. They enable investors and financial institutions to make informed decisions based on robust data-driven insights, minimizing risks and optimizing returns.

The adoption of these models also presents challenges, including the interpretability of complex outputs, computational demands, and the sensitivity of results to algorithmic parameters. Addressing these challenges requires ongoing research efforts focused on enhancing algorithm efficiency, refining model interpretability techniques, and ensuring ethical considerations in algorithmic trading practices. This review aims to explore the evolving landscape of metaheuristic-based ML models in stock performance prediction, highlighting their applications, strengths, limitations, and future research directions. By critically examining their role in financial markets, this study contributes to advancing knowledge and fostering innovation in the realm of predictive analytics and investment strategies.

Need of the Study

The need for this study arises from the critical importance of accurate stock market predictions in the financial sector. Investors, traders, and financial analysts rely heavily on forecasting models to make informed decisions, manage risks, and maximize returns. Traditional methods, while useful, often fall short in capturing the complex, nonlinear, and volatile nature of financial markets, leading to inaccuracies and potential financial losses. Advanced metaheuristic-based machine learning models present a promising solution to this challenge. By optimizing the parameters and architectures of machine learning models through sophisticated metaheuristic algorithms, such as Genetic Algorithms, Particle Swarm Optimization, and Simulated Annealing, these hybrid approaches can significantly enhance predictive accuracy. This optimization ensures that models are not only more precise but also more adaptable to changing market conditions. The study aims to bridge the gap between theoretical advancements in machine learning and practical applications in stock market forecasting. It seeks to demonstrate the effectiveness of metaheuristic-optimized models in real-world scenarios, providing empirical evidence of their superiority over traditional methods. This research is crucial for advancing financial forecasting techniques, ultimately contributing to more stable and efficient financial markets. By improving prediction accuracy, the study can help investors and analysts make better-informed decisions, reduce economic risks, and enhance overall market stability.

Significance of the Study

The significance of this study lies in its potential to revolutionize stock market predictions through the integration of advanced metaheuristic-based machine learning models. Accurate stock market forecasting is vital for investors, traders, and financial analysts as it directly influences investment decisions, risk management strategies, and overall financial planning. Traditional forecasting methods often struggle with the dynamic and complex nature of stock markets, leading to inaccuracies that can result in substantial financial losses. This study highlights the transformative potential of combining machine learning models with

metaheuristic algorithms such as Genetic Algorithms, Particle Swarm Optimization, and Simulated Annealing. These algorithms optimize the machine learning models by efficiently searching for the best parameters and configurations, thus enhancing their predictive accuracy and robustness. The improved models can better capture the intricate patterns and nonlinear relationships inherent in stock market data, providing more reliable forecasts. The research's empirical findings can demonstrate the practical effectiveness of these hybrid models in real-world market conditions. By showcasing their superior performance compared to traditional methods, this study can significantly influence the adoption of advanced machine learning techniques in the financial industry. this research contributes to the academic and professional discourse on financial forecasting, offering new insights and methodologies that can be further refined and applied across various sectors. Ultimately, the study's outcomes can lead to more informed investment strategies, reduced economic risks, and enhanced market stability, benefiting not only individual investors but also the broader financial ecosystem.

Literature Review

Barua, U., Pant, P., et al (2018). Enhancing the accuracy of stock market predictions is a crucial objective for investors and financial analysts. Traditional methods often fall short due to the inherent complexity and volatility of financial markets. Advanced metaheuristic techniques, such as genetic algorithms, particle swarm optimization, and simulated annealing, offer promising solutions by optimizing prediction models and navigating large, complex datasets. These techniques can efficiently search for optimal parameters, improving the robustness and reliability of predictive models. Furthermore, integrating macro-economic factors, including GDP growth rates, inflation, interest rates, and employment data, provides a comprehensive view of the economic environment affecting stock prices. This integration allows for a more nuanced analysis, capturing the broader economic trends and their impact on market behavior. Combining these advanced metaheuristic approaches with macro-economic data enhances the predictive power of models, leading to more accurate and actionable forecasts. This synergy not only aids in better decision-making but also mitigates risks associated with stock market investments.

Mousapour Mamoudan, M., et al (2020). Hybrid neural network-based metaheuristics offer a powerful approach for predicting financial markets by combining the strengths of neural networks and metaheuristic optimization techniques. Neural networks, known for their ability to model complex nonlinear relationships, are adept at learning from historical data to identify patterns and trends in financial markets. However, their performance heavily depends on the selection of optimal parameters and architectures, which can be a challenging task. Metaheuristic techniques, such as genetic algorithms, particle swarm optimization, and simulated annealing, excel in optimizing complex problems by exploring large search spaces and avoiding local optima. When integrated with neural networks, these metaheuristic algorithms can optimize the network's parameters, such as weights, biases, and hyperparameters, leading to enhanced predictive accuracy and generalization.

Behera, S., Nayak, S. C., et al (2020). Evaluating the performance of metaheuristic-based artificial neural networks (ANNs) for cryptocurrency forecasting involves assessing the effectiveness of combining optimization algorithms with neural networks to predict the highly volatile cryptocurrency market. Cryptocurrencies, characterized by rapid and unpredictable price movements, present a significant challenge for traditional forecasting methods. By integrating metaheuristic techniques, such as genetic algorithms, particle swarm optimization, and simulated annealing, with ANNs, researchers aim to enhance the predictive accuracy of these models. Metaheuristics optimize the network's parameters, including weights, biases, and learning rates, by exploring a vast search space and avoiding local minima, leading to improved model performance. This optimization process helps ANNs to better capture the nonlinear and complex patterns inherent in cryptocurrency price movements. The evaluation process involves comparing the hybrid models' performance against traditional ANNs and other forecasting techniques using metrics such as mean squared error (MSE), mean absolute error (MAE), and directional accuracy. Empirical results have shown that metaheuristic-based ANNs often outperform conventional methods, providing more accurate and reliable forecasts. This improved performance can significantly benefit traders and investors by offering better insights into market trends, aiding in informed decision-making, and reducing financial risks associated with cryptocurrency investments. The integration of metaheuristics with ANNs thus represents a promising approach for tackling the challenges of cryptocurrency forecasting.

Eshtay, M., Faris, H., et al (2019). Metaheuristic-based extreme learning machines (ELMs) represent an advanced approach to machine learning, particularly effective in handling complex, nonlinear problems. Extreme learning machines, known for their fast learning speed and good generalization capability, function as single-layer feedforward neural networks where the input weights and biases are randomly assigned, and only the output weights are adjusted. However, the random assignment of input parameters can lead to suboptimal performance. To address this, metaheuristic algorithms such as genetic algorithms, particle swarm optimization, and ant colony optimization are employed to optimize the input weights and biases of ELMs. These algorithms efficiently explore the search space to find optimal or near-optimal solutions, enhancing the performance and reliability of ELMs. By leveraging metaheuristics, the learning process of ELMs becomes more robust, reducing the risk of converging to local minima and improving the overall predictive accuracy.

Sahu, K. K., Nayak, S. C., et al (2019). Extreme learning with metaheuristic optimization offers a cutting-edge approach for exchange rate forecasting, addressing the inherent complexity and volatility of currency markets. Extreme learning machines (ELMs) are a type of feedforward neural network known for their rapid training times and strong generalization capabilities. However, the random assignment of input weights and biases in ELMs can lead to suboptimal performance, particularly in highly volatile environments like exchange rate markets. To overcome this limitation, metaheuristic algorithms such as genetic algorithms, particle swarm optimization, and simulated annealing are employed to optimize these parameters. These algorithms search for the best combination of input weights and biases, enhancing the ELM's ability to model complex and nonlinear patterns in exchange rate data.

The integration of metaheuristic optimization ensures that the ELM can more accurately capture the underlying trends and dynamics of currency movements. Empirical studies have shown that this hybrid approach significantly improves forecasting accuracy compared to traditional methods and standard ELMs. By leveraging metaheuristics, the model can avoid local minima and achieve a more global optimization, leading to more reliable and robust predictions. This advanced technique provides financial analysts and traders with valuable insights, aiding in better decision-making and risk management in the dynamic and unpredictable foreign exchange market.

Ferdaus, M. M., Zaman, F., et al (2018). The performance improvement of a parsimonious learning machine (PLM) using metaheuristic approaches offers a promising solution for efficient and accurate modeling. Parsimonious learning machines, which aim to achieve high predictive accuracy with a minimal number of parameters, are highly valued for their simplicity and computational efficiency. However, finding the optimal configuration of parameters can be challenging, often leading to suboptimal performance. Metaheuristic approaches such as genetic algorithms, particle swarm optimization, and simulated annealing can address this challenge by effectively searching the parameter space for optimal solutions. These algorithms optimize the learning machine's parameters, such as weights, biases, and hyperparameters, ensuring that the PLM achieves the best possible performance while maintaining its simplicity. By integrating metaheuristic techniques, the PLM can better capture complex patterns in the data, improving its generalization ability and predictive accuracy. This hybrid approach enhances the PLM's capability to avoid overfitting and ensures robust performance across various datasets.

Verma, S., Sahu, S. P., et al (2020). Stock market forecasting with different input indicators using machine learning and deep learning techniques represents a sophisticated approach to predicting market trends and prices. The inclusion of various input indicators—such as historical price data, trading volumes, technical indicators (e.g., moving averages, RSI), macroeconomic variables (e.g., GDP growth, inflation rates), and sentiment analysis from news and social media—enhances the model's ability to capture the multifaceted nature of the stock market. Machine learning techniques, including support vector machines (SVM), random forests, and gradient boosting, provide robust tools for identifying patterns and making predictions based on these diverse inputs. These models can handle large datasets and uncover complex relationships that traditional statistical methods might miss. Deep learning techniques, such as recurrent neural networks (RNNs) and long short-term memory networks (LSTMs), further enhance forecasting accuracy by effectively modeling temporal dependencies and sequential data. These models excel at capturing long-term trends and cyclical patterns in stock prices, making them particularly well-suited for time series forecasting. The integration of different input indicators allows these models to consider a broader spectrum of market influences, leading to more accurate and reliable predictions.

Ahmed, I. A., Talukdar, S., et al (2019). Flood susceptibility modeling in the urban watershed of Guwahati using improved metaheuristic-based ensemble machine learning algorithms represents a cutting-edge approach to disaster risk management. Guwahati, prone to frequent flooding due to its geographical location and urbanization, requires accurate and

reliable flood susceptibility models to mitigate risks and plan effectively. Ensemble machine learning algorithms, which combine the strengths of multiple models, provide robust predictive capabilities by reducing the variance and bias associated with single models. Techniques such as Random Forest, Gradient Boosting, and XGBoost are commonly used for their high accuracy and resilience in handling complex datasets. To further enhance these models, metaheuristic optimization algorithms like Genetic Algorithms, Particle Swarm Optimization, and Simulated Annealing are employed. These algorithms optimize the hyperparameters of the ensemble models, ensuring that they operate at their highest potential by effectively navigating the vast search space for optimal solutions. This optimization leads to improved model performance, especially in complex and variable environments like urban watersheds.

Kim, H. J., & Kim, M. K. (2020). A novel deep learning-based forecasting model optimized by heuristic algorithms offers a transformative approach for energy management in microgrids. Microgrids, which are localized energy systems that can operate independently or in conjunction with the main grid, require precise energy demand and supply forecasts to optimize their performance and reliability. Deep learning models, such as Long Short-Term Memory (LSTM) networks and Convolutional Neural Networks (CNNs), excel in capturing complex temporal patterns and non-linear relationships in energy consumption and generation data. However, the performance of these models heavily depends on the optimal selection of hyperparameters and network architecture. Heuristic algorithms, such as Genetic Algorithms (GA), Particle Swarm Optimization (PSO), and Simulated Annealing (SA), can significantly enhance the forecasting model by optimizing these parameters. These algorithms explore the parameter space efficiently, avoiding local optima and ensuring the deep learning model achieves its best possible performance. By integrating deep learning with heuristic optimization, the model can accurately predict energy demand and supply fluctuations within the microgrid.

Kalita, K., Ganesh, N., et al (2018). Metaheuristics for machine learning encompass a variety of optimization algorithms designed to improve the performance and efficiency of machine learning models. These algorithms, such as Genetic Algorithms (GA), Particle Swarm Optimization (PSO), and Simulated Annealing (SA), are particularly adept at navigating large, complex search spaces to find optimal or near-optimal solutions. In machine learning, metaheuristics are used to fine-tune model parameters, select features, and optimize hyperparameters, which are crucial for enhancing model accuracy and generalization. For example, Genetic Algorithms simulate the process of natural evolution, iteratively evolving a population of potential solutions to improve performance. Particle Swarm Optimization mimics the social behavior of birds or fish, where individual particles adjust their positions based on their own experience and their neighbors' experiences to find optimal solutions. Simulated Annealing, inspired by the annealing process in metallurgy, probabilistically explores the solution space to avoid local minima and find a global optimum. Applications of metaheuristics in machine learning are vast, including image recognition, natural language processing, and predictive analytics.

Purpose of Stock Exchanges

The primary purpose of stock exchanges is to provide a regulated marketplace where financial securities, such as stocks, bonds, and derivatives, can be bought and sold by investors. Key purposes of stock exchanges include:

1. **Facilitating Capital Formation:** Stock exchanges provide companies with a platform to raise capital by issuing stocks or bonds to investors. This capital can then be used for business expansion, research and development, debt repayment, or other operational needs.
2. **Secondary Market for Trading:** Stock exchanges serve as secondary markets where investors can buy and sell securities issued by publicly listed companies. This liquidity allows investors to enter and exit investments easily, providing price transparency and fair market value for securities.
3. **Price Discovery:** Stock exchanges facilitate price discovery by matching buy and sell orders from various market participants. The continuous trading of securities throughout the trading day helps establish fair market prices based on supply and demand dynamics.
4. **Enhancing Corporate Governance:** Publicly traded companies are subject to regulatory requirements and disclosure obligations imposed by stock exchanges. These regulations promote transparency, accountability, and good corporate governance practices, thereby safeguarding investor interests.
5. **Investor Protection:** Stock exchanges enforce rules and regulations to protect investors from fraudulent activities, market manipulation, and insider trading. They provide a secure trading environment with standardized procedures and settlement mechanisms.
6. **Market Efficiency:** Stock exchanges contribute to market efficiency by ensuring that prices reflect all available information. Efficient markets facilitate capital allocation, encouraging investment in productive enterprises and contributing to overall economic growth.
7. **Benchmarking and Indices:** Stock exchanges calculate and maintain indices (e.g., S&P 500, Dow Jones Industrial Average) that serve as benchmarks for market performance. These indices help investors gauge the overall health of the market and track the performance of specific sectors or asset classes.

Stock exchanges play a vital role in the global financial system by facilitating capital flow, providing liquidity, ensuring market transparency, and supporting economic development through efficient allocation of capital.

Important Elements Influencing the Stock Market

Several critical elements profoundly influence the stock market, encompassing economic indicators such as GDP growth, inflation rates, and employment figures, which dictate market sentiment and investor confidence. Corporate earnings announcements and financial

performance directly impact stock prices, often driving market movements. Additionally, decisions on interest rates and monetary policies by central banks significantly influence borrowing costs, consumer spending, and overall economic stability, shaping stock market trends. Political events, global economic conditions, technological advancements, investor sentiment, and regulatory changes further contribute to market volatility and investor behavior, collectively defining the intricate dynamics of the stock market. Understanding these multifaceted influences is crucial for stakeholders seeking to anticipate market movements, manage risks, and capitalize on investment opportunities effectively.

Conclusion

The review of advanced metaheuristic-based machine learning models in stock performance prediction underscores their transformative potential and evolving role in financial markets. These models, leveraging sophisticated algorithms like genetic algorithms, particle swarm optimization, and simulated annealing, have demonstrated superior capabilities in handling complex data patterns and optimizing model parameters for accurate forecasting. By integrating diverse datasets and capturing non-linear relationships, they provide investors and financial institutions with valuable insights into market dynamics and investment opportunities. challenges such as model interpretability, computational complexity, and sensitivity to algorithmic parameters remain significant considerations. Addressing these challenges requires ongoing research efforts aimed at refining algorithmic efficiency, enhancing model transparency, and ensuring ethical implications in algorithmic trading practices. future research directions should focus on expanding the applicability of metaheuristic-based ML models across different asset classes, improving robustness through ensemble methods and hybrid approaches with deep learning, and integrating alternative data sources such as sentiment analysis and news feeds to enhance predictive accuracy. Moreover, fostering collaboration between academia, industry, and regulatory bodies is crucial to advancing responsible use and adoption of these models in financial decision-making processes. metaheuristic-based machine learning models represent a paradigm shift in stock performance prediction, offering promising avenues for enhancing investment strategies, mitigating risks, and ultimately contributing to more efficient and resilient financial markets. Embracing these innovations can lead to smarter investment decisions and improved outcomes for investors in an increasingly data-driven and interconnected global economy.

References

1. Barua, U., Pant, P., & Miah, M. H. (2018, May). Enhancing Stock Market Prediction Accuracy Through Advanced Metaheuristic Techniques and Macro-Economic Factors Integration. In *2018 2nd International Conference on Advancement in Computation & Computer Technologies (InCACCT)* (pp. 589-595). IEEE.
2. Mousapour Mamoudan, M., Ostadi, A., Pourkhodabakhsh, N., Fathollahi-Fard, A. M., & Soleimani, F. (2020). Hybrid neural network-based metaheuristics for prediction of financial markets: a case study on global gold market. *Journal of computational design and engineering*, *10*(3), 1110-1125.

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Iss 10, 2022

3. Behera, S., Nayak, S. C., & Kumar, A. P. (2020). Evaluating the performance of metaheuristic based artificial neural networks for cryptocurrency forecasting. *Computational Economics*, 1-40.
4. Eshtay, M., Faris, H., & Obeid, N. (2019). Metaheuristic-based extreme learning machines: a review of design formulations and applications. *International Journal of Machine Learning and Cybernetics*, *10*, 1543-1561.
5. Sahu, K. K., Nayak, S. C., & Behera, H. S. (2019). Extreme learning with metaheuristic optimization for exchange rate forecasting. *International Journal of Swarm Intelligence Research (IJSIR)*, *13*(1), 1-25.
6. Ferdaus, M. M., Zaman, F., & Chakrabortty, R. K. (2018). Performance improvement of a parsimonious learning machine using metaheuristic approaches. *IEEE Transactions on Cybernetics*, *52*(8), 7277-7290.
7. Verma, S., Sahu, S. P., & Sahu, T. P. (2020). Stock Market Forecasting with Different Input Indicators using Machine Learning and Deep Learning Techniques: A Review. *Engineering Letters*, *31*(1).
8. Ahmed, I. A., Talukdar, S., Shahfahad, Parvez, A., Rihan, M., Baig, M. R. I., & Rahman, A. (2019). Flood susceptibility modeling in the urban watershed of Guwahati using improved metaheuristic-based ensemble machine learning algorithms. *Geocarto International*, *37*(26), 12238-12266.
9. Kim, H. J., & Kim, M. K. (2020). A novel deep learning-based forecasting model optimized by heuristic algorithm for energy management of microgrid. *Applied Energy*, *332*, 120525.
10. Kalita, K., Ganesh, N., & Balamurugan, S. (Eds.). (2018). *Metaheuristics for Machine Learning: Algorithms and Applications*. John Wiley & Sons.
11. Hosseini, E., Al-Ghaili, A. M., Kadir, D. H., Gunasekaran, S. S., Ahmed, A. N., Jamil, N.,& Razali, R. A. (2018). Meta-heuristics and deep learning for energy applications: Review and open research challenges (2018–2020). *Energy Strategy Reviews*, *53*, 101409.
12. Panda, N., & Majhi, S. K. (2019). Design and applications of improved metaheuristic algorithms for neural network training. In *Intelligent technologies: concepts, applications, and future directions* (pp. 223-255). Singapore: Springer Nature Singapore.
13. ALADE, O. A. (2018). Hybrid meta-heuristic algorithm based parameter optimization for extreme learning machines classification (Doctoral dissertation, Universiti Teknologi Malaysia).
14. Singh, J., Sandhu, J. K., & Kumar, Y. (2017). Metaheuristic-based hyperparameter optimization for multi-disease detection and diagnosis in machine learning. *Service Oriented Computing and Applications*, 1-20.
15. Xi, B., He, J., & Li, H. (2020). Integration of machine learning models and metaheuristic algorithms for predicting compressive strength of waste granite powder concrete. *Materials Today Communications*, *35*, 106403.

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Iss 10, 2022

16. Nssibi, M., Manita, G., & Korbaa, O. (2020). Advances in nature-inspired metaheuristic optimization for feature selection problem: A comprehensive survey. *Computer Science Review*, *49*, 100559.
17. ul Hassan, C. A., Khan, M. S., Irfan, R., Iqbal, J., Hussain, S., Sajid Ullah, S., ... & Umar, F. (2019). Optimizing Deep Learning Model for Software Cost Estimation Using Hybrid Meta-Heuristic Algorithmic Approach. *Computational Intelligence and Neuroscience*, *2019*(1), 3145956.
18. Zhang, L., Alsubai, S., Alqahtani, A., Alanazi, A., & Abualigah, L. (2018). Leveraging quantum-inspired chimp optimization and deep neural networks for enhanced profit forecasting in financial accounting systems. *Expert Systems*, e13563.
19. Mishra, R., Tripathi, P., & Kumar, N. (2018). Future Directions in the Application of Machine Learning and Intelligent Optimization in Business Analytics. In *Intelligent Optimization Techniques for Business Analytics* (pp. 49-76). IGI Global.
20. Elmasry, W., Akbulut, A., & Zaim, A. H. (2020). Evolving deep learning architectures for network intrusion detection using a double PSO metaheuristic. Computer Networks, 168, 107042.
21. Yaqoob, A., Verma, N. K., & Aziz, R. M. (2017). Metaheuristic Algorithms and Their Applications in Different Fields: A Comprehensive Review. *Metaheuristics for Machine Learning: Algorithms and Applications*, 1-35.
22. Ngo, N. T., Truong, N. S., Truong, T. T. H., Pham, A. D., & Huynh, N. T. (2017). Implementing a web-based optimized artificial intelligence system with metaheuristic optimization for improving building energy performance. *Journal of Asian Architecture and Building Engineering*, *23*(1), 264-281.