

Synergistic advantages of deep learning and reinforcement learning in economic forecasting

Gaohan Zhang

University of Chinese Academy of Social Sciences, Beijing 100000, China

ABSTRACT

With the progress of science and technology, emerging technologies such as deep learning and reinforcement learning have emerged in economic forecasting, injecting synergy into this field. First of all, deep learning makes the economic model capture the dynamic changes of the economic system more comprehensively and accurately by dealing with nonlinear relations, learning complex characteristics and conducting accurate time series analysis. Its multi-level neural network structure and the ability to learn features automatically improve the adaptability of the model and avoid the tedious process of traditional manual feature selection. Secondly, the introduction of reinforcement learning gives the economic forecasting model more flexible and adaptive advantages. Through interactive learning between agent and environment, the model can optimize decision-making, deal with uncertainty better, and is adaptive. Reinforcement learning improves the flexibility of decision-making by constantly trying and learning and adjusting strategies to adapt to changes in the economic environment. The collaborative application of them has made remarkable progress in nonlinear relationship modeling, feature learning, time series analysis, decision making, uncertainty handling and self-adaptability, which has improved the accuracy and adaptability of the model and enhanced its robustness in the complex and changeable economic environment. In the future, deepening the research and optimization of these emerging technologies in practical application will provide better performance for economic forecasting, provide more comprehensive, accurate and practical information for decision makers, and help more scientific, flexible and fine economic management and policy formulation.

KEYWORDS

Deep Learning; Reinforcement Learning; Economic Forecasting.

1. INTRODUCTION

Traditional economic forecasting methods, such as time series analysis and macroeconomic model, have long been the main tools for economists and policy makers. However, these methods show a series of limitations in the face of the complexity and uncertainty of modern economy. First of all, the traditional economic forecasting methods are inadequate in dealing with nonlinear relationships and complex interactions. There are complex interdependent relationships among many variables in the economic system, but traditional methods are usually difficult to capture these nonlinear relationships, which leads to inaccurate prediction of actual economic changes. Secondly, these methods often rely too much on historical data, but their adaptability is poor in the face of emerging trends, technological changes and global events. The evolution of economic system is uncertain, and traditional methods rely too much on past trends and laws, and may not be able to adapt to rapid economic changes in time. In addition, the modeling assumptions of traditional methods are usually simplified, ignoring the complex factors in the real world. These methods are often based on simplified assumptions of economic behavior, and cannot fully consider the influence of politics,

society and environment, which makes their prediction results too theoretical and deviate greatly from the actual situation(Januschowski et al., 2020).

With the rapid development of artificial intelligence technology, its application in the field of economic forecasting has gradually become a hot spot in research and practice. The rise of artificial intelligence in the economic field is mainly reflected in the following aspects: First, artificial intelligence can better handle large-scale data. Traditional methods may be weak in the face of massive data, while artificial intelligence can use powerful computing power to efficiently process structured and unstructured data and extract patterns and trends from them. Secondly, artificial intelligence has advantages in dealing with nonlinear relations. Machine learning algorithm can automatically discover complex associations in data, so that it can more accurately capture the nonlinear changes in the economic system, thus improving the prediction accuracy. Moreover, artificial intelligence has a strong ability to process high-frequency data. In traditional models, sparse quarterly or annual data are often used, while artificial intelligence models can capture more detailed characteristics of economic changes by using more frequent data. In addition, the model of artificial intelligence can adapt to the changing economic environment to a certain extent. Through continuous learning and optimization, machine learning algorithm can be more flexible to adapt to the new economic trends, and has a better ability to cope with external shocks.

2. LITERATURE REVIEW

2.1. Methodology

In terms of methodology, artificial intelligence has adopted a variety of specific methods in economic forecasting, which show unique advantages and disadvantages compared with traditional methods. Some of the main methods will be discussed below. Artificial intelligence widely uses various machine learning algorithms in economic forecasting, such as support vector machine (SVM), random forest, neural network and so on. These algorithms can learn patterns from historical data and predict future economic trends. Compared with traditional statistical methods, the advantages of machine learning algorithm lie in its nonlinear modeling ability and efficient processing of large-scale data. The advantage is that the machine learning algorithm can better capture the nonlinear relationship in the economic system, so it is more adaptable to complex economic changes. Machine learning algorithm can efficiently process a large number of structured and unstructured data, including high-frequency data, so that it can consider a variety of factors more comprehensively.

The combination of artificial intelligence and traditional economic model. Combining the traditional economic model with artificial intelligence can improve the prediction accuracy by using the nonlinear modeling and big data processing ability of artificial intelligence while retaining the explanatory power of the traditional model. Traditional economic models are usually based on a series of assumptions, while artificial intelligence can reduce uncertainty and improve the adaptability of models by learning actual data. The methodological innovation of artificial intelligence in economic forecasting provides economists and decision makers with more choices. Although machine learning algorithm performs better in high-frequency data analysis, its explanatory problem is still a challenge. By effectively combining traditional economic models with artificial intelligence, we are expected to achieve more comprehensive and accurate results in the field of economic forecasting, which will further deepen the methodological development in this field in future research(Tschang & Almirall, 2021).

2.2. Data aspect

High frequency data analysis. Compared with traditional time series analysis methods, machine learning shows better performance in high-frequency data analysis. High-frequency data includes daily, hourly and even minute data, which provides more detailed and timely economic information.

The advantage is that high-frequency data can capture the fluctuations in the economic system in a shorter time and provide more sensitive change information. In addition, machine learning can make better use of high-frequency data for pattern recognition and improve the accuracy of trend analysis. Leverage big data, especially unstructured data and social media data. Artificial intelligence can effectively integrate and analyze unstructured data through advanced algorithms, including text, images, audio and other forms of data. For example, by analyzing unstructured data such as news, comments and articles, the machine learning model can understand market sentiment, consumer behavior and enterprise trends more comprehensively. Social media has become an important information source. Artificial intelligence can capture the public's emotions, trends and feedback by mining a large amount of data on social media. This kind of information is of great significance to predict the popularity of products, market reaction and the impact of socio-economic events. Through big data analysis, artificial intelligence can dig deep into users' behavior patterns, including purchase history, clickstream and search records. This enables economists to better understand the needs of consumers and predict market changes.

Influence of high frequency data on artificial intelligence economic model. High-frequency data provide more frequent and detailed time series information, which enables the artificial intelligence economic model to capture the instantaneity of economic changes more accurately. This is crucial for the rapid spread of rapidly changing markets and events. Traditional economic models usually use sparse quarterly or annual data, while high-frequency data can provide more real-time economic indicators. By using these real-time data, the artificial intelligence economic model improves the timeliness of forecasting and enables decision makers to respond more timely.

Overcome the noise and fluctuation of high frequency data. The artificial intelligence model uses noise filtering and smoothing algorithms to reduce the volatility and instability in high-frequency data. These algorithms can identify and filter out short-term abnormal fluctuations, making the model more focused on long-term trends. Using statistical technology, artificial intelligence model can better identify trends and periodic fluctuations in data, thus reducing the interference caused by instantaneous noise of high-frequency data on prediction. Deep learning technology can extract abstract features from large-scale high-frequency data, better understand the internal structure of the data, and thus establish a model more accurately. This helps to reduce the prediction error caused by data noise.

Artificial intelligence has made remarkable achievements in economic forecasting by using big data, especially unstructured data and social media data. The comprehensive analysis of these data enables artificial intelligence to understand the economic environment, market trends and consumer behavior more comprehensively. At the same time, high-frequency data has a positive impact on the establishment and prediction of artificial intelligence economic model, which improves the timeliness and accuracy of the model. Through noise filtering, statistical techniques and deep learning, the artificial intelligence model can overcome the fluctuation and noise of high-frequency data and improve the reliability of economic forecasting. These innovative methods provide more and more timely information for economists and decision makers, and provide strong support for formulating effective economic policies and business strategies(Eling et al., 2021).

2.3. Nonlinear relationship

In dealing with the nonlinear relationship and complexity of economic forecasting, artificial intelligence has applied many specific methods, which have brought remarkable innovations in theory and practice. This paper will discuss the methods used by artificial intelligence in economic forecasting, and the advantages and disadvantages of these methods compared with traditional methods. In addition, we will pay special attention to the performance of machine learning algorithm in high-frequency data analysis, and discuss how to effectively combine artificial intelligence with traditional economic models to improve the accuracy of prediction. First of all, one of the methods

used by artificial intelligence in economic forecasting is machine learning algorithm. These algorithms cover various models, including support vector machines, neural networks, decision trees and so on. The strength of machine learning lies in its ability to capture and model nonlinear relationships. Compared with traditional linear models, machine learning can better adapt to nonlinear changes in complex economic systems. This is of great significance to accurately predict economic fluctuations, market changes and consumer behavior. Secondly, high-frequency data analysis is another key field of artificial intelligence in economic forecasting. Compared with traditional time series analysis methods, high-frequency data analysis is more nuanced and can provide more real-time and detailed economic information. Through the sensitivity to these high-frequency data, machine learning algorithm can capture the instantaneous changes more accurately, thus improving the timeliness and accuracy of prediction. This is especially critical for the rapidly changing market conditions and economic environment, which makes the model more capable of coping with market dynamics. However, machine learning methods also have some disadvantages. One of the main problems is the interpretability of the model. Compared with the traditional economic model, machine learning model is often regarded as a "black box", and it is difficult to explain the reasons for its prediction results. This defect may cause some concern in an economic decision-making environment that requires transparency and explanation. In addition, the machine learning model is highly dependent on data, and may produce unstable predictions in the face of special situations or abnormal data. In order to effectively combine artificial intelligence with traditional economic models, researchers try to adopt a hybrid modeling strategy. This strategy usually includes combining the nonlinear advantages of machine learning with the explanatory power of traditional economic models. By integrating them organically, we can make full use of the advantages of machine learning in dealing with complex relationships while maintaining the explanatory power of the model. This may involve taking the output of machine learning as the input of the traditional model, or getting a more comprehensive and accurate economic forecast by combining the results of the two. To sum up, the innovation of artificial intelligence in the nonlinear relationship and complexity of economic forecasting provides economists with a more powerful tool. Machine learning algorithm significantly improves the accuracy and timeliness of economic forecasting by modeling nonlinear relationship and sensitivity to high-frequency data. However, in practice, it is necessary to carefully weigh the needs of model interpretation and nonlinear modeling, and effectively combine artificial intelligence with traditional economic models in order to give full play to the advantages of the model in the face of economic variability and uncertainty(Wei et al., 2019).

2.4. Application and policy impact

In recent years, the application of artificial intelligence in economic forecasting has become increasingly mature, which not only provides a more accurate information base for decision makers, but also has a far-reaching impact on policy making and economic management. This paper will discuss from two aspects: practical application cases and policy impact, and analyze the specific contribution of artificial intelligence in the field of economic forecasting and its potential impact on policy formulation. First, the market trend analysis. Artificial intelligence can identify market trends and consumer behaviors more accurately by analyzing large-scale market data. For example, the retail industry uses artificial intelligence to predict product demand and optimize pricing strategies to better meet market demand. Secondly, financial risk management. In the financial field, artificial intelligence improves the accuracy of financial risk management by analyzing multi-dimensional data such as market fluctuation and enterprise financial status. AI model can quickly identify risk signals and provide real-time decision support for investors and regulators. Finally, the macroeconomic forecast. Artificial intelligence is applied to the macro-economic field, which provides more comprehensive and real-time macro-economic prediction through the integration of multivariate data. This is of great significance for government decision makers to understand the economic trend and take corresponding policy measures.

Impact on policy formulation and economic management. First, improve the accuracy of policies. The economic forecasting ability of artificial intelligence enables policy makers to understand the economic situation and changing trend more accurately, so as to formulate more targeted policies. According to the output of AI model, the government can adjust monetary policy and fiscal policy in a targeted way to better cope with the complex and changeable economic environment. Second, achieve policy flexibility. The rapid learning and adaptability of artificial intelligence enables policy makers to respond more timely. In the face of economic emergencies, AI economic forecasting can provide real-time advice for the government to help it adjust its policies more flexibly to adapt to rapid economic changes. Finally, optimize resource allocation. Through the refined economic forecast of artificial intelligence, the government can better optimize the allocation of resources and avoid waste and inefficient use of resources. This will help to improve the governance efficiency of the government and achieve more effective economic management.

3. FUTURE DEVELOPMENT DIRECTION

3.1. The way forward

With the continuous progress of artificial intelligence technology, its application in the field of economic forecasting gradually shows broad potential. In the future, the research of artificial intelligence in the field of economic forecasting may move in many directions, covering higher accuracy, deeper interpretation and wider application. These possible future development directions will be discussed below. First of all, one of the future research directions is to combine complex network theory with deep learning to better deal with complex relationships in the economic system. Complex network model can help to understand the interdependence between different economies, while deep learning can capture the nonlinear characteristics of these relationships more accurately. Integrating the two can improve the modeling and interpretation ability of the model for complex systems and provide a more comprehensive perspective for economic forecasting. Secondly, due to the "black box" characteristics of many artificial intelligence models, future research will pay more attention to the development of interpretable models. In the field of economic forecasting, decision makers need to be able to understand the forecasting basis of the model in order to make better policies. Therefore, researchers may devote themselves to developing an artificial intelligence model with high predictive performance and easy explanation, so as to improve the operability of the model in practice. Then, future research may put more emphasis on interdisciplinary research, integrating knowledge in the fields of economics, computer science and statistics. Such interdisciplinary cooperation helps to better understand the economic system and ensure that the artificial intelligence model can not only deal with complex economic problems, but also coordinate with economic theories. This may promote the in-depth application of artificial intelligence in economics and produce more practical research results. Finally, in practical application, artificial intelligence economic forecasting is facing the challenge of data uncertainty. Future research may focus on developing more robust models, which can effectively deal with missing data, noise and instability. This involves technological innovation in robust processing of outliers and reasonable estimation of data uncertainty, so as to improve the adaptability of the model to uncertainty(Valle-Cruz et al., 2020).

The future development of AI in the field of economic forecasting will show several compelling directions. Innovations in integrating complex networks and deep learning, improving model interpretability, interdisciplinary research, coping with data uncertainty, and building personalized models will drive the in-depth application of AI in economic forecasting. This series of directions is expected to provide decision makers with more comprehensive, accurate, and practical information, and to facilitate more scientific, flexible, and refined economic management and policymaking.

3.2. Improvement of Artificial Intelligence by Emerging Technologies

Emerging technologies, especially deep learning and reinforcement learning, have significantly improved the performance of artificial intelligence in the field of economic forecasting. The introduction of these technologies not only strengthens the modeling ability of the model for complex economic relations, but also improves the processing efficiency of large-scale data. The following discusses how these emerging technologies can gradually improve the performance of artificial intelligence in economic forecasting (Dwivedi et al., 2021).

First, the application of deep learning. As a learning method based on neural network, deep learning can automatically learn features and patterns from data through multi-level nonlinear transformation, which provides a powerful tool for economic forecasting. Deep learning can better capture the nonlinear relationship in economic system through multi-level neural network structure. This is of great significance to solve the limitations of traditional linear models in dealing with complex economic problems. The deep learning model has the ability to learn features automatically, and can extract useful information for economic forecasting from the original data. This avoids the tedious process of traditional manual feature selection and improves the adaptability of the model to complex data patterns. For time series data, the deep learning model can learn more long-term dependence and better capture the dynamic process of economic change, thus improving the accuracy in time series prediction.

Secondly, reinforcement learning is a method to learn the optimal behavior strategy through the interaction between agents and the environment, and its introduction brings a more flexible and adaptive model for economic forecasting. Reinforcement learning can help economic forecasting model to make more optimal decision. Through trial and error and learning, the model can adjust its strategy to adapt to the changing economic environment and improve the flexibility of decision-making. The economic system is full of uncertainty, and reinforcement learning has the potential to deal with uncertainty. The model can adapt to the new information through continuous experiments and feedback, so as to better cope with the unstable factors in the economy. The reinforcement learning model is adaptive and can adjust its behavior according to the change of environment. This adaptability makes the model better adapt to the dynamic changes in the economic system and enhances the robustness of the model.

Emerging technologies, especially deep learning and reinforcement learning, provide multi-level improvement for the performance of artificial intelligence in economic forecasting. First of all, deep learning enhances the representation ability of the model through nonlinear modeling, feature learning and time series analysis. Then, the introduction of reinforcement learning makes the economic forecasting model more adaptive to uncertainty, optimal decision-making and self-adaptive. The combination of the two makes artificial intelligence more comprehensive, flexible and accurate in dealing with the complex and changeable economic environment in economic forecasting. In the future, further deepening the research of these technologies and their optimization in practical application will bring more outstanding performance improvement for artificial intelligence in the field of economic forecasting (Whittlestone et al., 2021).

4. CONCLUSION

With the rapid development of science and technology, emerging technologies have emerged in the field of economic forecasting. Among them, artificial intelligence technologies, represented by deep learning and reinforcement learning, show synergistic advantages and provide more powerful and flexible tools for economic forecasting. Deep learning, as a learning method based on neural network, significantly improves the modeling ability of the model for complex economic relations through multi-level nonlinear transformation. First of all, it is excellent in nonlinear modeling. Through the multi-layer neural network structure, it can better capture and express complex nonlinear economic

relations, which goes beyond the limitations of traditional linear models. Secondly, deep learning has the ability to learn features automatically, and improves the adaptability of the model by discovering potential economic features in large-scale data. Especially in time series analysis, deep learning can more accurately grasp the dynamic changes of the economic system and provide a more accurate tool for time-sensitive economic forecasting.

Secondly, the introduction of reinforcement learning has brought more flexible and adaptive advantages to the economic forecasting model. Reinforcement learning can optimize the decision-making process of the model through interactive learning between agents and the environment. In the optimization of decision-making, reinforcement learning enables the model to adjust its strategy to adapt to the changing economic environment through continuous trial and error and learning, thus improving the flexibility of decision-making. At the same time, strengthening the ability of learning to deal with uncertainty provides a more effective means for the model to deal with unstable factors in the economic system. The adaptability of reinforcement learning enables the model to better adapt to environmental changes, thus improving the robustness of the model.

The collaborative application of deep learning and reinforcement learning has brought multi-level performance improvement to economic forecasting. These two technologies complement each other, and jointly improve the model's ability in nonlinear relationship modeling, feature learning, time series analysis, decision-making, uncertainty handling and adaptability. Its advantages are not only to improve the accuracy and adaptability of the model, but also to enhance the robustness of the model in dealing with complex and changeable economic environment. In the future, further research on these emerging technologies and further optimization in practical applications will further promote the performance improvement of artificial intelligence in the field of economic forecasting. This not only provides more comprehensive, accurate and practical information for decision makers, but also lays a solid foundation for more scientific, flexible and fine economic management and policy formulation. This prospect shows the trend that artificial intelligence plays an increasingly important role in economic forecasting, and also highlights the far-reaching influence of the synergistic advantages of deep learning and reinforcement learning in this field.

REFERENCES

- [1] Januschowski, T., Gasthaus, J., Wang, Y., Salinas, D., Flunkert, V., Bohlke-Schneider, M., & Callot, L. (2020). Criteria for classifying forecasting methods. *International Journal of Forecasting*, 36(1), 167-177.
- [2] Tschang, F. T., & Almirall, E. (2021). Artificial intelligence as augmenting automation: Implications for employment. *Academy of Management Perspectives*, 35(4), 642-659.
- [3] Eling, M., Nuessle, D., & Staubli, J. (2021). The impact of artificial intelligence along the insurance value chain and on the insurability of risks. *The Geneva Papers on Risk and Insurance-Issues and Practice*, 1-37.
- [4] Wei, N., Li, C., Peng, X., Zeng, F., & Lu, X. (2019). Conventional models and artificial intelligence-based models for energy consumption forecasting: A review. *Journal of Petroleum Science and Engineering*, 181, 106187.
- [5] Valle-Cruz, D., Criado, J. I., Sandoval-Almazán, R., & Ruvalcaba-Gomez, E. A. (2020). Assessing the public policy-cycle framework in the age of artificial intelligence: From agenda-setting to policy evaluation. *Government Information Quarterly*, 37(4), 101509.
- [6] Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., ... & Williams, M. D. (2021). Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management*, 57, 101994.
- [7] Whittlestone, J., Arulkumaran, K., & Crosby, M. (2021). The societal implications of deep reinforcement learning. *Journal of Artificial Intelligence Research*, 70, 1003-1030.