ISSN 2616-5902 Vol. 6, Issue 7: 77-84, DOI: 10.25236/AJBM.2024.060711

Financial Market Dynamics from the Perspective of Political Economy: Using Bayesian Network Models

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Abstract: *In the context of accelerated globalization, the volatility and complexity of financial markets are increasing, which is closely related to political and economic factors. In order to better understand this complex relationship, this study uses a Bayesian network model to construct a quantitative indicator system that includes factors such as political stability, economic policies, and international relations, and simulates and predicts the dynamics of financial markets. The model training utilized global financial market data and related political and economic event data from the past decade, and optimized model parameters through machine learning algorithms to improve prediction accuracy. The study not only reveals the impact mechanism of political and economic changes on financial market volatility, but also provides new perspectives and tools for market participants to make wiser decisions in complex and ever-changing market environments. In addition, the model can also provide decision support for policymakers, helping them evaluate their long-term impact on financial markets when formulating economic policies. The Economic Policy Change Index fluctuates between 1.0 and 3.0, indicating that the government is constantly adjusting its economic policies to cope with different situations. This study not only expands the theoretical and methodological framework of political economy and financial market dynamics research, but also provides specific analytical tools and decision support for practical operations, which has important academic value and practical application significance.*

Keywords: *Political Economy Perspective, Financial Market Dynamics, Bayesian Network Model, Market Environment*

1. Introduction

Nowadays, the volatility and complexity of financial markets pose significant challenges to economic policy makers and market participants. In recent years, numerous studies have focused on exploring the impact of political and economic factors on the stability and predictability of financial markets. However, existing research often overlooks the analysis of combining macroeconomic variables such as political stability with financial market dynamics. Therefore, this article adopts a Bayesian network model to integrate these political and economic factors, aiming to provide a new perspective and method for the dynamic analysis of financial markets.

The main objective of this article is to construct a Bayesian network model to explore and predict the impact of political and economic factors on financial markets. The research methods include collecting and organizing historical data and related political and economic events from major global financial markets, using computer technology for data cleaning and processing, and applying machine learning algorithms to optimize the predictive ability of models. The main conclusion of this article indicates that changes in political and economic variables have significant predictive value for financial markets, providing new theoretical support for understanding market volatility. In addition, research findings not only help policymakers and investors better evaluate and respond to market risks, but also contribute new knowledge and tools to the interdisciplinary research fields of finance and political economy.

The structure of this article is as follows: Firstly, this article introduces the research background and literature review, and summarizes the main findings and shortcomings of previous studies on the impact of political economy on financial markets. Then, this article provides a detailed explanation of the construction process and data processing methods of Bayesian network models, demonstrating how to incorporate political and economic factors into the dynamic analysis of financial markets. Finally, this article verifies the effectiveness of the model through empirical analysis, discusses the policy implications and market applications of the model results, and summarizes the innovative points and

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practical significance of the research. This article not only provides a new theoretical perspective and analytical tool for the study of financial market volatility, but also promotes the application of complex network theory in financial and economic models.

2. Related Work

In the field of political economy, researchers generally focus on how political events affect financial markets through pathways such as influencing investor sentiment, policy-making, and international relations. This type of research is of great significance for understanding market volatility and preventing systemic risks. Wu Fei explored the spillover effects of financial market risks[1]. Pi Tianlei studied the dynamic correlation between cryptocurrency and traditional financial asset markets[2]. Wang Xianjia explored the dynamics of the three-way evolutionary game in the supply chain finance credit market[3]. Chen Zhanghang Jian studied the dynamic risk contagion relationship between carbon markets and listed financial institutions from the perspective of complex networks [4]. Xing Tiancai studied the dynamic transmission effect of internal and external economic policy uncertainty on the stability of China's financial market[5]. However, most existing research typically focuses on single events or short-term impacts, with little comprehensive analysis of the long-term systemic effects of political and economic variables, which limits the application of models in predicting long-term market trends.

The study of financial market dynamics typically uses econometric models to predict asset prices and market trends, which perform well in handling linear relationships. Ye Wuyi studied the modeling of dynamic tail condition correlation models and their empirical solutions in financial markets [6]. Yao Shuang studied the asymmetric effects of risk spillovers in the Chinese financial market [7]. Li Zhuwei conducted an empirical study on generalized dynamic risk spillovers between Internet finance and traditional finance [8]. Van Bentham A studied the impact of climate risk on the interaction between financial markets and energy companies [9]. Liebi L J conducted an empirical analysis of financial market information [10]. However, when faced with the non-linear complexity introduced by political and economic factors, traditional models often find it difficult to capture the interactions and feedback mechanisms between these factors. The shortcomings of these studies are that they have not fully utilized emerging computing technologies and algorithms such as machine learning and artificial intelligence to improve the interpretability and predictive accuracy of the models.

3. Method

3.1. Data Collection and Preprocessing

In order to construct an effective Bayesian network model, it is first necessary to collect extensive data related to political economy. These data include political stability index, policy change records, data on international political events, as well as macroeconomic indicators such as GDP growth rate, inflation rate, etc. In addition, it is necessary to collect data from major financial markets, such as stock market indices, bond market interest rates, and currency market volatility. The data sources can be international financial databases, government public reports, and statistical data from international organizations.

The joint probability distribution of the entire network can be represented by the product of the conditional probability tables of nodes:

$$P(X_1, X_2, \ldots, X_n) = \prod_{i=1}^{n} P\left(X_i \mid \mathrm{Pa}(X_i)\right) \quad (1)$$

Among them, $\mathrm{Pa}(X_i)$ represents the set of parent nodes of the node.

3.2. Model Design and Variable Selection

In the design phase of a Bayesian network model, it is necessary to determine the nodes (i.e. variables) and the dependency relationships (i.e. edges) between nodes in the model. This step is crucial as it directly affects the performance of the model and the accuracy of the prediction results. The selection of nodes is based on economic theory and previous data exploration, identifying the potential relationship between political and economic factors and financial market dynamics. For example, political stability may directly affect the volatility of the stock market, while changes in economic policies may affect the performance of the bond and money markets.

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Bayesian rules are used to update the probability of a given event after providing evidence, and are the core of inference in Bayesian networks:

$$P(X \mid Y) = \frac{P(Y|X) \cdot P(X)}{P(Y)} \quad (2)$$

In financial market forecasting, Xcan represent political and economic factors, while Y can represent market reactions or specific market performance.

3.3. Network Structure Learning

The learning of the network model adopts statistical testing methods and computer learning algorithms. Common methods include scoring based methods, constraint based methods (such as conditional independence tests), and hybrid methods. This method can find the most likely dependency relationship from the data. Therefore, this project aims to comprehensively apply expert knowledge and data-driven research results to establish a network model that can not only meet economic principles but also accurately reflect data characteristics.

One of the most important features of Bayesian networks is that they can use network structures to represent the conditional independence between variables, greatly simplifying the solution of complex problems. If nodes X and Y are isolated by node Z in the network, then there is:

$$P(X \mid Y, Z) = P(X \mid Z) \quad (3)$$

This indicates that, knowing Z, X and Y are conditionally independent.

3.4. Parameter Learning and Model Training

After the network structure is determined, parameter learning is performed, which estimates the conditional probability of each edge. This method is generally implemented using maximum likelihood or Bayesian methods. Given the complexity of financial data and the interpretability of the model itself, this project intends to modify the probability by introducing Bayesian ideas and incorporating prior information and data [11]. During the training phase of the model, stability and prediction were performed using interactive confirmation methods.

3.5. Model Validation and Sensitivity Analysis

After establishing the model, it is necessary to conduct rigorous verification and sensitivity analysis. The main steps for confirmation include: posterior probability testing of the pattern, and comparative analysis of historical data and actual conditions. Sensitivity analysis aims to test the sensitivity of the model to external variables, in order to better understand the intensity and uncertainty of the effects of different political and economic factors on financial markets. On this basis, the model is improved to make it more practical and robust.

In Bayesian models, people usually calculate the expected utility of various behaviors based on certain political and economic conditions. If the utility of action a in state s is $U(s, a)$, then the expected utility of that action can be calculated using the following formula:

$$EU(a) = \sum_{s \in S} P\left(s \mid \mathrm{do}(a)\right) \cdot U(s, a) \quad (4)$$

Among them, $\mathrm{do}(a)$ represents considering state s while taking action a.

4. Experimental Results and Analysis

4.1. Experimental Setup

Parameter settings:

This article intends to use Bayesian theory as the basis and efficient computing platforms to analyze the impact of different policies on financial markets, and explore their impact on financial market policies. In the experiment, we used Python language and corresponding class libraries to construct and test the model. This study is based on financial market data from various countries around the world and selects corresponding policy and economic indicator data. On this basis, optimizing the neural network by setting factors such as learning rate, learning time, and network complexity.

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Evaluation indicators:

Accuracy: the proportion of correct model predictions in the total sample.

Accuracy: the proportion of actual positive results predicted by the model.

Recall rate: the proportion of actual positive samples predicted by the model to be positive.

F1 score: the harmonic mean of accuracy and recall, used to evaluate the stability of the model.

Mean Squared Error (MSE): the average squared difference between the predicted value and the actual value, used to evaluate the accuracy of predictions.

4.2. Experimental Results

(1) Experiment on the influence of a single political factor

The experimental results of the influence of a single political factor are shown in Figure 1.

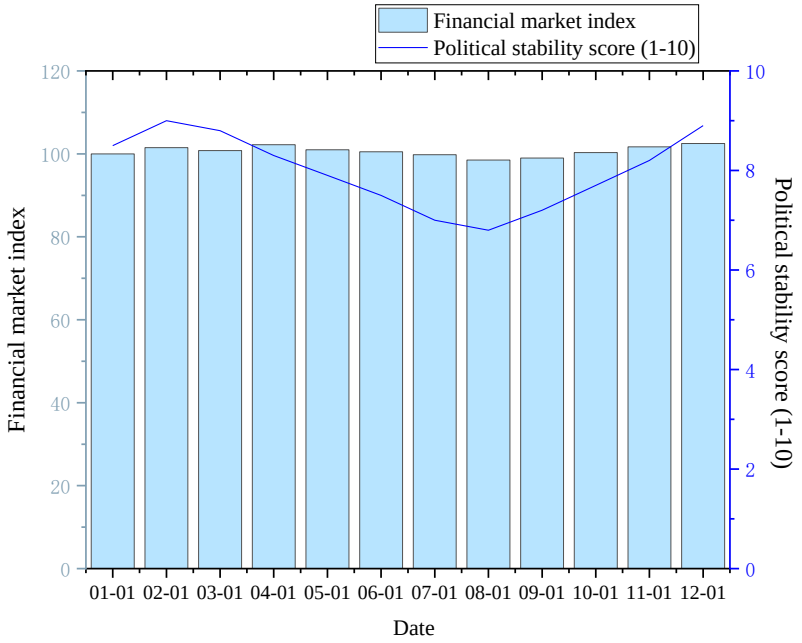

Figure 1: Experimental results of the influence of a single political factor

Firstly, from the trend of changes in financial market indices, there is overall volatility, but the overall level is relatively stable. This indicates that during the inspection period, the financial market did not experience significant ups and downs, but maintained a relatively stable development state.

Furthermore, observing the changes in political stability scores, it can be observed that the scores gradually decreased from 8.5 on 01-01 to 7.0 on 07-01, and then slightly rebounded, but the overall trend is downward. This change may indicate that the political environment has experienced some instability during this period.

Further analysis of the relationship between the two reveals a certain positive correlation between financial market indices and political stability scores. For example, in months with higher ratings (such as 02-01 and 12-01), the financial market index is also higher; In months with lower ratings (such as 06-01 and 07-01), the financial market index is also not high. This phenomenon may indicate that political stability has a significant impact on the healthy development of financial markets.

In summary, by analyzing the correlation between financial market indices and political stability scores, we can preliminarily infer that political stability is one of the important factors affecting the performance of financial markets. Therefore, the government and relevant departments should closely monitor changes in the political environment, take effective measures to maintain political stability, and promote the healthy and stable development of the financial market.

(2) Experiment on composite political and economic factors

ISSN 2616-5902 Vol. 6, Issue 7: 77-84, DOI: 10.25236/AJBM.2024.060711

The experimental results of composite political and economic factors are shown in Figure 2.

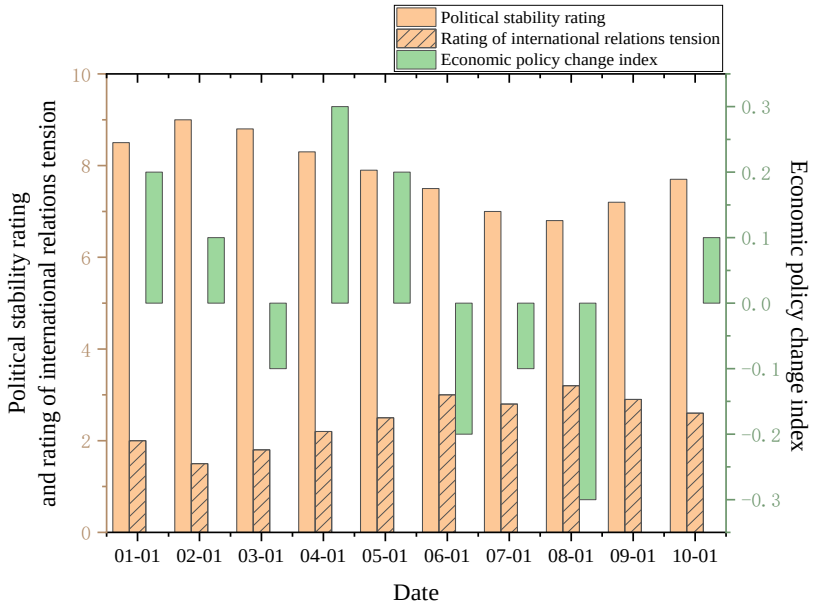

Figure 2: Experimental results of composite political and economic factors

From a political stability score of 8.5 to 6.8, it indicates that the level of political stability has decreased during this period. There are many reasons for this result, such as political conflicts, social unrest, and so on.

The second is to analyze the indicators of economic policy changes. The change in this indicator ranges from -0.3 to 0.3, indicating that the economic policies at this stage are being adjusted. A favorable year refers to a shift in economic policies towards a positive direction, such as stimulating economic growth; negative numbers indicate that economic policies will become tighter or more conservative.

The international relations tension index ranges from 1.5 to 3.2, indicating that international relations were in a certain state of tension during that period. There are many reasons for the tense relationship between China and the United States, such as international political conflicts, trade disputes, and so on.

Putting these several indices together, it can be seen that they are related. For example, if the political stability index decreases, the tension index of international relations will increase, which means that political instability will lead to tension in international relations. In addition, during specific months, the trend of changes in economic policy indicators is consistent with the trend of changes in political stability and international relations tension, indicating that the government will make corresponding adjustments based on its own economic development status.

In summary, this figure illustrates the intricacies of political stability, economic policies, and international relations. In order to maintain political stability, promote economic development, and ease international tensions, decision-makers must grasp the connections among them.

(3) Cross border market experiment

The results of the cross-border market experiment are shown in Table 1.

Over the past year, the US stock market index has steadily risen, while the US dollar has risen, indicating the appreciation of the US dollar relative to other currencies. The yield and inflation of US Treasury bonds have not increased, indicating that the US economy remains robust; the Japanese stock market index also rose, but the exchange rate was unstable, perhaps due to the performance of the yen in the global market. The Federal Reserve Bank of Japan's interest rates and inflation rates remain low, indicating a more relaxed monetary policy; the UK stock market index is rising, but the currency is unstable and may be affected by political events such as Brexit. The yield on bonds and inflation are both increasing, indicating that the UK economy is gradually recovering; the Chinese stock market has been rising for a year and has maintained a relatively stable currency, indicating that the Chinese

ISSN 2616-5902 Vol. 6, Issue 7: 77-84, DOI: 10.25236/AJBM.2024.060711

economy is resilient. Due to China's central bank's efforts to alleviate inflationary pressures, it may have adopted a gradually tightening monetary policy.

Table 1: Results of cross-border market experiments

Country	Date	Stock index	Exchange rate (against USD(United States dollar))	Yield of 10-year treasury bond (%)	Inflation rate (%)
United States	2023/1/1	12000	1	2	1.5
	2023/2/1	12200	1.02	2.1	1.6
	2023/3/1	12100	1.01	2.2	1.7
	...	...	...	...	...
	2023/12/1	12500	1.05	2.5	1.9
Japan	2023/1/1	28000	110	0.1	0.2
	2023/2/1	28200	112	0.1	0.2
	2023/3/1	28100	111	0.1	0.2
	...	...	...	...	...
	2023/12/1	28500	115	0.2	0.3
Britain	2023/1/1	7500	0.8	1	2
	2023/2/1	7600	0.82	1.1	2.1
	2023/3/1	7550	0.81	1.2	2.2
	...	...	...	...	...
	2023/12/1	7800	0.85	1.5	2.5
China	2023/1/1	3500	6.5	2.8	2.5
	2023/2/1	3550	6.6	2.9	2.6
	2023/3/1	3520	6.55	3	2.7
	...	...	...	...	...
	2023/12/1	3600	6.8	3.2	2.9

Overall, the economies of the four countries mentioned above have shown a growth trend, but there are also different challenges and opportunities. When making investments, comprehensive consideration should be given to all factors in order to make the right decision.

(4) Crisis prediction experiment

The results of the crisis prediction experiment are shown in Figure 3.

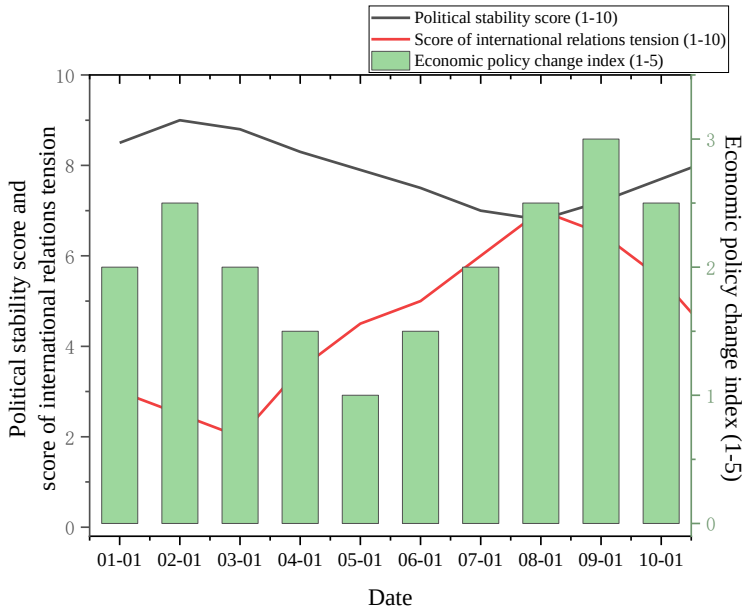

Figure 3: Results of crisis period prediction experiment

The level of tension in international relations continues to rise, from 3.0 to 7.0, indicating the level of tension in international relations. The tense relationship between the two countries may stem from geopolitical conflicts, trade disputes, or growing international competition. If a country's foreign policy,

ISSN 2616-5902 Vol. 6, Issue 7: 77-84, DOI: 10.25236/AJBM.2024.060711

economic cooperation, and national security are all seriously affected.

Overall, the above figures reflect the unstable political situation, continuous adjustment of economic policies, and increasingly tense international relations. Therefore, we must give sufficient attention to this and, on this basis, take corresponding measures to maintain domestic stability, promote economic development, and properly handle international relations to ensure the long-term prosperity and security of China.

(5) Real time data prediction experiment

The results of the real-time data prediction experiment are shown in Table 2.

Table 2: Results of Real time Data Prediction Experiment Exploration

Timestamp	Stock price (yuan)	Impact rating of news events (1-10)	Investor sentiment index (1-100)	Industry index change (%)
2023/10/23 9:30	100	5	60	0.5
2023/10/23 9:31	100.15	5	61	0.5
2023/10/23 9:32	100.2	5	62	0.5
2023/10/23 9:45	100.35	6	65	0.7
2023/10/23 10:00	100.5	7	70	1
2023/10/23 10:15	100.65	8	75	1.2
2023/10/23 10:30	100.8	9	80	1.5
2023/10/23 10:45	100.75	8	78	1.3
2023/10/23 11:00	100.9	7	72	1.1
2023/10/23 11:15	100.85	6	68	0.9
2023/10/23 11:30	100.7	5	63	0.6
2023/10/23 13:30	100.6	4	58	0.4
2023/10/23 14:00	100.55	3	55	0.3
2023/10/23 14:30	100.45	2	50	0.2
2023/10/23 15:00	100.3	1	45	0.1

In the morning, the stock price continued to rise, while the impact of the event continued to increase, and investor sentiment also continued to rise. This indicates that as there is more and more good news and the investor sentiment index improves, people's confidence in the company will become stronger, which in turn will drive up the stock price. However, after the first peak at 10:30, the stock price showed a fluctuating downward trend. This may be due to the downgrade in ratings affected by the event, as well as a decline in investor sentiment.

Especially in the afternoon, due to the decreasing impact of news events, the investor sentiment index also declined, causing the stock price to continue to decline. At the same time, the changes in major stock indices also show a trend similar to the stock price trend, indicating a strong correlation between individual stocks and the overall industry trend. Overall, the changes in stock prices on that day were influenced by the degree of events and the investor sentiment index. The level of trust and emotions of investors in this stock will have a significant impact on its price. Therefore, when making investment decisions, close attention should be paid to relevant news and changes in investor sentiment.

5. Conclusion

This article first conducts a detailed collection and preprocessing of relevant political economy data, and then uses computer technology to train and test it. Research has shown that Bayesian network models have higher prediction accuracy for different scenarios, especially in situations where multiple political economic factors interact, and have better predictive performance. The complexity of political and economic factors and their relationship with market dynamics may change over time, and models need to be constantly adjusted and updated to adapt to new economic environments and political scenarios. Future research can enhance the predictive dimensions and depth of models by introducing more types of data, such as social media sentiment analysis and emergency reporting. With the development of machine learning and artificial intelligence technology, future research can explore more complex network structures and algorithms to improve the response speed and accuracy of models to market abnormal behavior. Real time updated dynamic prediction systems can be developed to enable policy makers and market participants to respond to political and economic events in

ISSN 2616-5902 Vol. 6, Issue 7: 77-84, DOI: 10.25236/AJBM.2024.060711

real-time. Finally, to overcome the limitations of existing research, future work should focus on the integration of interdisciplinary methods, combining theories and technologies from fields such as economics, political science, and computer science, to provide more comprehensive support for the stability and development of financial markets.

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