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Time-varying effects of economic policy uncertainty on the volatility of China's stock market: Based on TVP-VAR Model

Huiqi Wu

School of Economics and Management, Guangxi Normal University, Guilin, China
whq175089113@163.com

Abstract: *The stock market is a fundamental component of China's modern financial system, and fluctuations in the stock market can significantly reflect China's economic performance. As China's economy undergoes transformation and upgrading, economic policy is being continuously adjusted and improved. This paper employs China's economic policy uncertainty index and stock market volatility data to examine the time-varying effect of China's economic policy uncertainty on stock market volatility using the TVP-VAR model. The research findings indicate that as the lag period increases, the impact of economic policy uncertainty on stock market volatility also increases. This impact is not constant but varies over time, and it is evident that the impact of economic policy uncertainty on stock market volatility is not limited to a specific period or event. Rather, it is a long-term phenomenon that has a significant and far-reaching impact. Based on these findings, this paper presents policy recommendations that are relevant to the observed trends.*

Keywords: *Economic policy uncertainty; Stock market volatility; TVP-VAR model*

1. Introduction

Economic policy is a set of guiding principles and specific measures formulated by the state or government to achieve pre-determined macroeconomic objectives and enhance the overall economic well-being of society. In order to regulate and steer the direction of the economy, governments constantly adjust or introduce new economic policies. Such interventions are usually accompanied by uncertainty, which can have significant volatility effects on financial markets over an extended period of time. In the wake of the international financial crisis, economists have identified two key points regarding economic policy uncertainty. First, during the recession triggered by the financial crisis, future adjustments in taxation, public spending, and monetary policy became unpredictable for both firms and individuals. This led to a sharp rise in economic policy uncertainty. Second, as a result of this uncertainty, participants in economic activity are unable to accurately determine whether, when, and how the government will adjust economic policy. This uncertainty has led to a postponement of investment, hiring, consumption, and other spending decisions, thus further affecting the process of economic recovery.

As a fundamental component of the contemporary financial system, the operation of the stock market is not only directly related to the interests of investors, but also serves as a "barometer" reflecting the health of the national economy. Currently, China's economy is undergoing a critical period of transformation, upgrading, and structural optimization. In response, government departments have frequently introduced a variety of monetary, fiscal, and other economic policies, which have greatly exacerbated the uncertainty of economic growth. Furthermore, the frequent occurrence of economic crises and emergencies around the world in recent years, such as the trade war between the United States and China and the New Crown Pneumonia epidemic, has also contributed to an increase in economic uncertainty. The Chinese stock market plays a pivotal role in China's economic transformation and development. This paper aims to study the time-varying impact of economic policy uncertainty on stock market volatility by applying modern economic and financial theories and methods. This study has significant theoretical and practical implications for understanding market dynamics and formulating effective macroeconomic adjustment and control policies. In addition to these benefits, the analysis can assist in the formulation of scientific and effective macroeconomic adjustment and control policies. Furthermore, it can assist Chinese investors in making more informed stock choices in the face of economic policy adjustments. This, in turn, can contribute to the further maturation and perfection of China's stock market and enhance the stability of the financial system.

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2. Literature review

In recent years, the constant changes in the domestic and international economic situation have led the government to introduce corresponding policies to stabilize the economy. The stock market, as an important part of the financial market, has been affected by these fluctuations, which have in turn affected the introduction and implementation of government policies through direct or indirect channels. As a result, more and more scholars have begun to pay attention to the economic policy uncertainty shock and its effect on the stock market.

Jonathan Brogaard and Andrew Detzel (2015) employed the Monte Carlo method to model the impact of economic policy uncertainty.[1] Baker et al. (2015) demonstrate that policy uncertainty is associated with increased stock price volatility and reduced investment and employment in policy-sensitive sectors, including defense, healthcare, and infrastructure development.[2] Yu et al. (2018) constructed a GARCH-MIDAS model and found a significant positive relationship between global economic policy uncertainty (GEPU) and Chinese stock market volatility.[3] Bu Lin et al. (2020) employed a generalized impulse response function and a generalized variance decomposition to ascertain the unidirectional explanatory power of China's stock market volatility on China's economic policy uncertainty.[4] Pan Changchun et al. (2022) conducted both static and dynamic analyses of cross-category and cross-country associations between three types of economic policy uncertainty and stock market volatility in China and the U.S. Their findings indicate that there are asymmetric spillover effects of economic policy uncertainty on both Chinese and U.S. stock market volatility.[5]

The existing literature contains a wealth of research on the stock market, yet there is a paucity of literature exploring the time-varying effects of economic policy uncertainty and stock market volatility. This paper employs the TVP-VAR model to investigate the specific impact mechanism between economic policy uncertainty and stock market volatility. The principal contribution of this paper is to investigate the relationship between economic policy uncertainty and stock market volatility from a time-varying and nonlinear perspective. Furthermore, this paper employs the TVP-VAR model, wherein the coefficients to be estimated and the variance-covariance matrix of the stochastic perturbation term are time-varying. The time-varying nature of the parameters enables the reflection of the characteristics of the effects of continuous changes among the variables in the model. The stochastic fluctuations in the TVP-VAR model are capable of controlling heteroskedasticity in the model and of capturing nonlinear effects, thus enhancing the scientific and reasonable nature of the conclusions.

3. Model construction and indicator selection

The constant coefficient VAR model is limited in its ability to explain the nonlinear relationship between variables that undergo sudden structural changes. However, based on the practical needs and the continuous maturation and improvement of the model theory, VAR models have gradually incorporated time-varying and drifting coefficients, which have proven to be advantageous for the study of dynamic relationships among variables. The characteristic of time-varying parameters was first introduced into the VAR model by Primiceri (2005),[6] and then Nakajima (2011) introduced stochastic fluctuations into the time-varying VAR model proposed by Primiceri by drawing on the idea of Omori et al. to form the TVP-VAR model with stochastic fluctuations.[7]

In order to investigate the influence of economic policy uncertainty on the volatility of China's stock market and to ascertain its temporal impact, this paper employs the TVP-VAR model proposed by Nakajima to conduct an empirical study.

3.1. TVP-VAR model construction

Firstly, reference is made to the structural VAR model, whose basic form is as follows in Eq. (1).

$$\mathrm{A}y_t = \mathrm{F}_1 y_{t-1} + \cdots + \mathrm{F}_k y_{t-k} + \mu_t,\ \ t = k+1, \cdots, T \tag{1}$$

The vector y_t represents a set of $n \times 1$ dimensional observable endogenous variables. The coefficient matrix $\mathrm{A}, \mathrm{F}_1, \ldots \mathrm{F}_k$ is $n \times n$-dimensional, k is the lag order of the structural VAR model, and T is the sample size. μ_t represents the stochastic perturbation term of the structural VAR model and is the structural shock matrix. $\mu_t \sim N(0, \sum\sum)$, the standard deviation of μ_t is σ_n.

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$$\sum=\begin{pmatrix}\sigma_1 & 0 & \cdots & 0\\ 0 & \sigma_2 & \cdots & 0\\ \vdots & \vdots & \ddots & \vdots\\ 0 & 0 & \cdots & \sigma_n\end{pmatrix} \tag{2}$$

In the event that the structure shock is assumed to obey recursive identification, it can be demonstrated that the parameter matrix A should be a lower triangular matrix, which can be expressed in a specific form:

$$A=\begin{pmatrix}1 & 0 & \cdots & 0\\ a_{21} & \ddots & \ddots & 0\\ \vdots & \ddots & \ddots & \vdots\\ a_{n1} & \cdots & a_{nn-1} & 1\end{pmatrix} \tag{3}$$

A simplified version of Eq. (1) is presented in Eq. (4).

$$y_t = B_1 y_{t-1} + \cdots + B_k y_{t-k} + A^{-1}\sum\varepsilon_t \tag{4}$$

In equation (4), ε_t represents the residual term, $\varepsilon_t \sim N(0, I_n)$, I_n denotes the unit array. $B_i = A^{-1}F_i, i = 1,2,3\cdots,k,$ the elements of the coefficient matrix B_i are thus stacked by rows to form the $n(1+nk)\times 1$ stacking vector β. Additionally, $X_t = I_N \otimes (y'_{t-1}, y'_{t-2}, \cdots, y'_{t-k})$, $\otimes$ is employed to denote the Kronecker product. Consequently, equation (4) is written in autoregressive form as shown in equation (5):

$$y_t = X_t\beta + A^{-1}\sum\varepsilon_t \tag{5}$$

The parameters in Eq. (5) are not time-varying. In the event of a sudden and profound transformation of the economic system, in order to portray the nonlinear relationship between the variables, it is necessary that the parameters $\beta, A, \sum$ in Eq. (5) are time-varying, so the time-varying parameter vector autoregressive model (TVP-VAR model) is set up as shown in Eq. (6):

$$y_t = X_t\beta_t + A_t^{-1}\sum_t\varepsilon_t \tag{6}$$

Suppose that $a_t = (a_{21}, a_{31}, a_{32}, \cdots, a_{nn-1})'$ is the stack vector in the lower triangular matrix A_t that does not contain the diagonal element 1 and the element 0. Suppose that $h_t = (h_{1t}, \cdots, h_{nt})'$, $h_{jt} = \ln\sigma_{jt}^2$, and σ_{jt}^2 is an element on the diagonal of $\sum_t$. Assume that the parameters in equation (6) obey the following random wandering process. Specifically, the random wandering process is represented as in Eq. (7):

$$\begin{bmatrix}\varepsilon_t\\ \mu_{\beta t}\\ \mu_{at}\\ \mu_{ht}\end{bmatrix} \sim N\left(0, \begin{bmatrix}1 & 0 & 0 & 0\\ 0 & \sum_\beta & 0 & 0\\ 0 & 0 & \sum_a & 0\\ 0 & 0 & 0 & \sum_h\end{bmatrix}\right) \tag{7}$$

$\beta_{t+1} \sim N(\mu_{\beta 0}, \sum_{\beta 0}), a_{t+1} \sim N(\mu_{a0}, \sum_{a0}), h_{t+1} \sim N(\mu_{h0}, \sum_{h0}), t = k+1, \cdots, T,$ the shock perturbations of the time-varying parameters are uncorrelated between β_t, a_t and h_t, and $\sum_\beta$, $\sum_a$ and $\sum_h$are defined as diagonal matrices.

In order to avoid potential bias in parameter estimation, this paper uses the Markov Monte Carlo simulation (MCMC) method to perform Bayesian parameter estimation, and then further calculates the impulse response shocks among variables. The impulse response functions are constructed to analyze the impact of economic policy uncertainty on the volatility of China's stock market, and to explore the difference in the degree of shocks over time.

3.2. Indicator selection and data sources

In this paper, economic policy uncertainty and stock market volatility data are selected for empirical analysis, with 252 samples of monthly data from January 2002 to December 2022, which are obtained from the database of Cathay Pacific and the official website of China's economic policy uncertainty. (http://www.policyuncertainty.com/).The selection and description of the indicators is below.

3.2.1. Indicators of economic policy uncertainty

The economic policy uncertainty index (EPU) published by Baker et al. (2012) has been widely adopted and utilized by scholars in their research. However, the economic policy uncertainty index (EPU) constructed by Baker et al. for the Chinese region is calculated based on the English version of Hong

Kong's South China Morning Post, which does not take Chinese mainland newspapers into consideration. Consequently, the representativeness of news information is somewhat lacking. Consequently, this paper selects the Chinese economic policy uncertainty index (EPU) quantified by Davis et al. using People's Daily and Guangming Daily as the information sources for subsequent empirical analysis.

3.2.2. Indicators of stock market volatility

In this paper, the SSE Composite Index and the stock market turnover rate are selected as measures of stock market volatility. The release time of the SSE Composite Index is essentially synchronized with the fluctuations of China's stock market, which serves as an indispensable reference for the study of China's stock market. The stock market trends and the stock market turnover rate are two key indicators that provide insights into the market's attention and volatility. The turnover rate is defined as the ratio of stock turnover to share capital in circulation. A higher turnover rate indicates greater market attention and, consequently, higher market volatility. The above two indicators are effective in reflecting the volatility of China's stock market. Therefore, this paper selects the closing price of the SSE Composite Index on a monthly basis and the turnover rate of the SSE A-share market (on a monthly basis) as proxies for the volatility of the stock market.As shown in Table 1.

Table 1: Symbolic representation of variables.

Variable	Variable Symbol	Variable Meaning
Indicator of economic policy uncertainty	CNEPU	China Economic Policy Uncertainty Index
Indicators of stock market volatility	SSEC	SSE Composite Index Closing Price (Monthly)
	TRM	Market turnover rate (monthly)

4. Empirical results and analysis

4.1. Unit root test and determination of the optimal lag order of the model

The actual economic operation of macroeconomic variables often lacks smoothness, which can lead to the emergence of the "pseudo-regression" problem. To avoid this, it is necessary to perform an empirical analysis and conduct a data unit root test. In this paper, the ADF test is employed to determine the smoothness of the data, which is completed with the help of the R . The test results indicate that the China Economic Policy Uncertainty Index (CNEPU), Shanghai Stock Exchange Composite Index (SSEC), and Market Turnover Rate (TRM) are stationary after first-order differencing. Therefore, this paper employs the variables after first-order differencing to construct the TVP-VAR model.

Prior to the construction of the TVP-VAR model, it is essential to ascertain the optimal lag order of the variables within the model. This can be achieved through the optimal lag order determination method of the VAR model, which involves selecting the minimum value according to the information criterion. As illustrated in Tables 2 and 3, the optimal lag order is determined to be three orders.

Table 2: SSEC and EPU optimal lag order test.

Lag order	AIC	HQ	SC	FPE
1	19.168	19.202	19.253	2.111790e-08
2	19.011	19.068	19.153*	1.805707e-08
3	18.965*	19.045*	19.164	1.724474e-08*
4	18.976	19.079	19.231	1.742997e-08
5	18.968	19.094	19.280	1.729307e-08

Table 3: TRM and EPU optimal lag order test.

Lag order	AIC	HQ	SC	FPE
1	10.73651	10.78227	10.85018	46005.53899
2	10.63685	10.70550*	10.80735*	41642.31537
3	10.62897*	10.72049	10.85630	41316.30820*
4	10.64686	10.76127	10.93102	42064.06634
5	10.65672	10.79400	10.99771	42483.49973

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4.2. Model parameter estimation

This paper employs the Markov chain Monte Carlo (MCMC) algorithm to estimate the parameters of the TVP-VAR model and analyze the effect of model estimation via Geweke's test and null factors. The number of samples utilized is 30,000, with the initial 3,000 samples discarded to form an effective sampling sample. The results are presented in Figure 1.

[ESTIMATION RESULT]

Parameter	Mean	Stdev	95%U	95%L	Geweke	Inef.
sb1	0.0023	0.0003	0.0018	0.0029	0.410	14.33
sb2	0.0023	0.0003	0.0018	0.0029	0.856	14.34
sa1	0.0057	0.0018	0.0034	0.0099	0.232	107.69
sa2	0.0057	0.0018	0.0034	0.0105	0.729	81.21
sh1	0.0058	0.0021	0.0034	0.0108	0.936	103.28
sh2	0.0057	0.0018	0.0034	0.0103	0.346	95.23

TVP-VAR model (Lag = 3)
Iteration: 30000

Figure 1: Model parameter estimation results.

Figure 1 illustrates that the posterior means of the parameters are all situated within the 95% confidence interval, and the convergence values of Geweke are all less than 1.96, which precludes the rejection of the original hypothesis at the 5% statistical level. This indicates that the posterior distributions of the parameters have converged to 0. With regard to the null factors, it can be seen that these are all less than 200, which indicates that the MCMC sampling times are valid for the subsequent impulse response analysis.

4.3. Impulse Response Analysis

The parameters in the TVP-VAR model are time-varying, and the impulse response results are calculated by iterating the MCMC simulation for each period within the sample. This allows for the simulation of the impulse response of stock market volatility in the face of economic policy uncertainty shocks from two perspectives: the number of lag periods and different time points.

4.3.1. Equal-interval impulse response

The TVP-VAR model is capable of simulating impulse response shocks with different lag orders. In this paper, lags 1, 3, and 6 are selected as the impulse response constraints in the short, medium, and long term, respectively. The resulting impulse response results are presented in Figures 2 and 3.

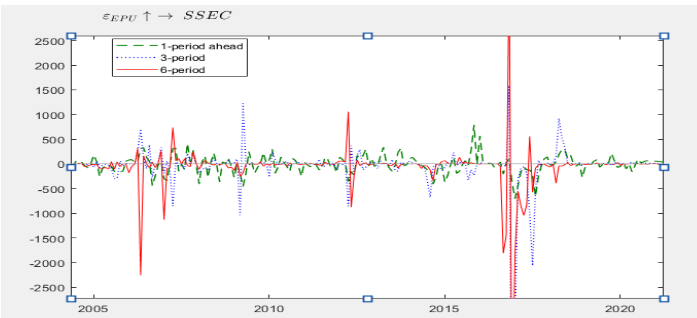

Figure 2: Equal-interval impulse response of CNEPU to SSEC.

Figure 2 depicts the equal-interval impulse response of China's economic policy uncertainty to the closing price of the Shanghai Composite Index($\varepsilon_{CNEPU} \uparrow\rightarrow$ SSEC). It can be observed that the impulse responses of the three lags exhibit alternating positive and negative impacts. The SSE Composite Index exhibits a slower and weaker short-term response to the impact of China's economic policy uncertainty, while exhibiting a stronger medium- and long-term response, which can have a strong negative impact. This phenomenon may be attributed to the fact that when there is economic policy uncertainty, investors may postpone investment decisions and wait for clearer policy signals. This wait-and-see attitude may result in a decrease in market activity, which in turn may have a weaker impact on the SSE Composite Index in the short term. However, over time, when economic policy uncertainty becomes clearer, investors may make decisions based on the new policy environment, which could have a stronger impact on the stock market trend in the medium to long term.

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In the period from 2002 to 2005, China's economic policy uncertainty had a relatively smooth impact on the SSE Composite Index. However, from 2006 to 2007, due to the compilation methodology of the SSE Composite Index, there was a false increase, resulting in a positive impact in the short to medium term. In contrast, the impulse response declined rapidly after the impact of economic policy uncertainty on the SSE Composite Index reached a stage peak in the subprime mortgage crisis in 2008, the European debt crisis in 2011, the 2015 stock market crash, and the U.S.-China trade war in 2018. This phenomenon may have arisen due to increased stock market volatility resulting from false market booms, speculative bubble inflation, and reduced financial system stability during periods of economic crisis. With the subsequent government bailout measures, the volatility of asset prices returned to the normal range.

Figure 3: Equal-interval impulse response of CNEPU to TRM.

Figure 3 illustrates the equal-interval impulse response of China's economic policy uncertainty to the turnover rate of the Shanghai A-share market(ε_{CNEPU} ↑→ TRM). The impulse response of lag 1 is predominantly negative, while the impulse responses of lag 3 and lag 6 exhibit alternating positive and negative effects, with a greater degree of negative effects. This phenomenon may be attributed to the fact that when economic policy is uncertain, investors tend to adopt a pessimistic outlook regarding the future economic situation and the trajectory of the stock market. Such pessimistic expectations may prompt investors to reduce their trading activities, thereby lowering the turnover rate. As time passes, the information about economic policy uncertainty may become increasingly clear. However, this process may not be linear, and at lag 3 and lag 6, investors may adjust their trading strategies based on the information that becomes available, leading to fluctuations in the turnover rate. Furthermore, during the subprime crisis of 2008, the European debt crisis of 2011, the stock market crash of 2015, and the U.S.-China trade war of 2018, as well as the New Crown Pneumonia outbreak of 2020, the impact of economic policy uncertainty on the turnover rate of the SSE A-share market appeared to have a peak in stages.

4.3.2. Time-point impulse response analysis

Time-point impulse response analysis is employed to assess the impact of economic policy uncertainty shocks on stock market volatility at a specific point in time. This paper draws on Shi Zizhong et al. to select the peaks of China's economic policy uncertainty indexes within the three important events: the European debt crisis, the stock market crisis, and the New Crown Epidemic. These events are represented by the following dates: October 2011 ($t = 118$), July 2015($t = 163$), and May 2020 ($t = 221$), to simulate the impacts of the economic policy uncertainty on the Shanghai Stock Exchange Composite Index and the changeover rate of the Shanghai A-shares market at the three points in time, with the results as shown in Figure 4 and Figure 5:

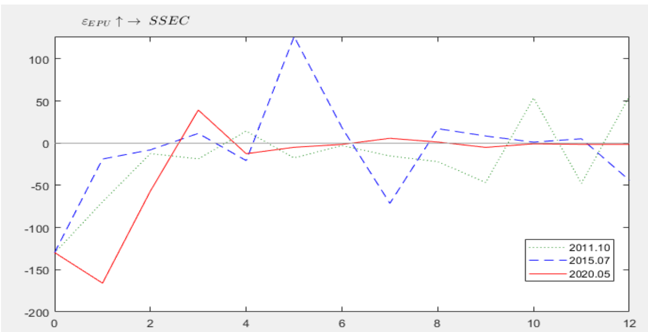

Figure 4: Time-point impulse response of CNEPU to SSEC.

Figure 4 illustrates the time-point impulse responses of China's economic policy uncertainty on the closing price of the Shanghai Composite Index (ε_{CNEPU} ↑→ SSEC). The impulse response values at each

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time point in period 0 are all negative, but then the degree of impact gradually becomes stronger, indicating that the impact of economic policy uncertainty events on the stock market is not instantaneous and is characterized by hysteresis. In particular, the 2011 European debt crisis has the most persistent impact on stock market volatility, reaching its maximum after 10 periods. The 2015 stock market crash has its maximum positive impact in period 5, which is larger than the impulse responses of the other two time points. Finally, the 2020 epidemic has its maximum positive impact in period 3, and then slowly tends to zero.

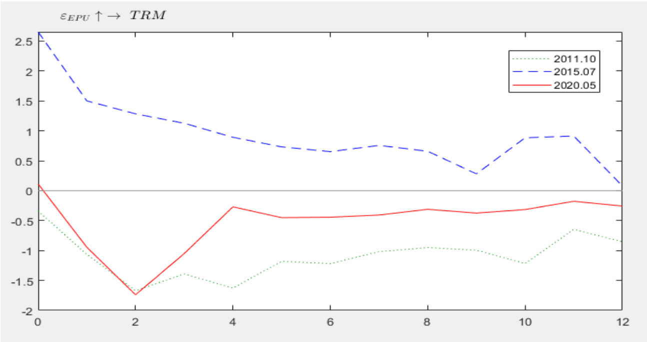

Figure 5: Time-point impulse response of CNEPU to TRM.

Figure 5 illustrates the point-in-time impulse response of China's economic policy uncertainty on the turnover rate of the SSE A-share market($\varepsilon_{CNEPU}\uparrow\rightarrow$ TRM). The European debt crisis in October 2011 and the epidemic in May 2020 are evident as negative impacts at these two points in time. The degree of impact gradually tends to zero after four periods. However, the degree of impulse response of the market turnover rate at this point in time of the 2020 epidemic is smaller. The stock market crash in October 2015 is evident as a positive impact, and the degree of impact gradually diminishes, but after 10 periods, there is a small increase again. This indicates that the stock market volatility of the stock market crash has a deeper and long-lasting influence.

5. Conclusions and policy recommendations

5.1. Conclusions

The global economic situation in the post-epidemic era is characterized by significant uncertainty, compounded by the decline of endogenous momentum in the domestic economy, which has resulted in increased macroeconomic downward pressure. In order to maintain the stability of the stock market and prevent and resolve financial risks, this paper examines the time-varying effect of China's economic policy uncertainty on stock market volatility through the TVP-VAR model based on the index of China's economic policy uncertainty from January 2002 to December 2022 and the relevant data of China's stock market. The main research conclusions drawn are as follows:

The impact of economic policy uncertainty shocks on stock market volatility is more pronounced with a lag of 3 and 6 months than with a lag of 1 month. This effect is more clearly time-varying, and the impulse response of stock market volatility reaches a peak in the face of economic policy uncertainty shocks at the point of occurrence of a special event.

The dissimilarities in the nature and scope of economic occurrences have resulted in disparate trends in the extent of the impact of economic policy uncertainty shocks on stock market volatility at different points in time. The analysis of the study has revealed that the extent of the impact of economic policy uncertainty shocks on stock market volatility is profound and enduring in the case of severe financial crisis events.

5.2. Policy recommendations

5.2.1. Maintaining the continuity, stability, and sustainability of economic policies

This paper builds upon this insight to conclude that economic policy uncertainty shocks can have a significant impact on the stock market in the medium to long term. Consequently, frequent policy changes can cause overreaction in the stock market, resulting in the impact of different policies crossing each other and increasing the instability of the financial system. In formulating economic policies, it is of the

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utmost importance that the government considers the market reaction and the long-term impacts of such policies. This is to ensure the continuity, stability and sustainability of policies. In addition, the government should conduct regular assessments and adjustments to ensure that the policies implemented are fit for purpose.

5.2.2. Enhance the transparency and predictability of economic policies

The government should focus on increasing the transparency and predictability of economic policies to reduce economic policy uncertainty. Specifically, the government should disclose key information on policy formulation and implementation in a timely and accurate manner. This includes policy objectives, implementation steps, and expected effects. By reducing information asymmetry, investors can more accurately assess the impact of policies and form reasonable expectations. This, in turn, reduces stock market volatility due to policy uncertainty. This helps to boost market confidence and promote the smooth operation of the stock market.

5.2.3. Strengthen the timeliness and relevance of economic policies at specific time nodes

It is imperative that economic policy be more precise and effective in implementing targeted regulation and camera regulation in order to realize its policy effectiveness. This paper employs a point-in-time impulse effect analysis to demonstrate that the impact of economic policy effects has a certain lag and time-varying nature. Consequently, the financial market is sometimes unable to process dynamic policy information in a timely manner, resulting in a lack of responsiveness. This phenomenon is particularly evident in the context of specific economic events. Consequently, enhancing the timeliness and relevance of economic policies is conducive to more scientific and predictable macroeconomic control by the government.

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