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Research on the Effectiveness of China's Macro Control Policy on Output and Technological Progress under Economic Policy Uncertainty

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Abstract: The uncertainty of economic policy, a specific form of uncertainty, can affect both economic growth, and the effectiveness of the macroeconomic regulation and control policy. Existing studies have analyzed the impacts of economic policy uncertainty on investment, consumption, trade, and total factor survival, but there is no analysis of the effectiveness of macroeconomic regulation and control policies on output and technological progress in a deterministic environment. Output growth and technological progress show the performance of economic growth in gross and efficiency, respectively, which is the external performance and internal driving force of economic growth. To achieve long-term sustainable economic development, it is necessary to consider both the aggregate problem and technological progress. In this context, this paper attempts to explore the effectiveness of China's macroeconomic regulation and control policy on output growth and technological progress under the economic policy uncertainty. Specifically, this paper first analyzes the effectiveness of macroeconomic regulation and control policy on China's output growth and technological progress in an uncertain environment, and then makes an empirical study by constructing a time-varying parameter vector autoregression model (TVP-VAR). Furthermore, the simulation test of the relevant results is carried out using the counter-fact analysis method. The empirical results show that: (1) under the uncertainty environment, the direction of the effect of price monetary policy on output has not changed, the effect of interest rate increase on output growth is negative, and the impact is stronger in the short term than in the medium and long term; the effect of rising interest rates on technological progress is positive, and the effect intensity is also significant in the short term, but weak in the medium and long term, the effect of price monetary policy on output is stronger under moderate uncertainty. (2) Credit growth can promote output growth, and the regulation effect of credit growth on output growth is mainly reflected in the short term under the TVP-VAR model, the effect of credit growth on technological progress is not significant. Further research using counterfactual analysis shows that the uncertain environment will reduce the effect of credit policy on output growth, but the effect is not significant.



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1. Introduction

China's economy has entered a new normal. To achieve economic growth in the future, it is important to consider both the scale of total output and the efficiency of growth. Exploring how macroeconomic regulation and control policies affect economic growth under policy uncertainty, especially in terms of growth efficiency and output size, is a frontier and difficult topic in the current research.

Uncertainty is a relatively broad concept. In the field of economics, uncertainty is often classified into economic uncertainty and policy uncertainty. Economic uncertainty refers to the deviation of economic participants in judging the future economic trend, or, in other words, the error between the actual results and the expectations. The measurements of macroeconomic uncertainty index include the fluctuation of GDP, investment, exchange

rate and other macroeconomic variables [1,2], the volatility of stock index or futures price index [3,4], political election or transition [5,6], changes in the political landscape [7], and divergent predictions of the future economy by professionals [8,9], etc. At the micro level, economic uncertainty indicators generally use the change of capital market price as their proxy variables, such as the variance or standard deviation of stock price, the fluctuation of business performance, etc., [10]. The research on policy uncertainty is relatively detailed. Scholars from different fields have discussed the impacts of policy uncertainty in different fields, such as energy policy uncertainty [11], fiscal or monetary policy uncertainty [12], tariff policy uncertainty, and trade policy uncertainty. Economic policy uncertainty refers to the uncertainty of whether, when, and how the government will change the current economic policy [13]. As a specific form of uncertainty, economic policy uncertainty is a collection of uncertain factors of future economic growth caused by a series of policies [14]. This paper focuses on economic policy uncertainty.

The uncertainty of one country's economic policy can come from two sources: (1) the change of its internal economic environment, the process of policymaking and changing; and (2) the transmission of the uncertainty from other countries' economic policies. The sharp rise in international economic policy uncertainty is mainly due to large-scale policy changes, financial crisis, geopolitical risks, European sovereign debt crisis, Brexit, Sino-US trade friction, and other unexpected economic and political events. As the world's second-largest economy, China is affected by international economic policy uncertainties, such as trade frictions between China and the US in recent years, and the US containment policy of "Decoupling" from China. At the same time, as China is undergoing an economic structure transformation and upgrade, there are internal conflicts and dilemmas among the four objectives of macro-control, namely, stabilizing growth, adjusting the economic structure, promoting reform, and preventing risks, which are difficult to be solved by the combination of one or several policies [15]. Economic policy switching between regulatory objectives will further increase the degree of economic policy uncertainty [14].

Since the global financial crisis in 2008, governments have made a series of policy changes to promote economic recovery. However, in the past 10 years, the world economy has recovered much more slowly than expected. In this context, some scholars began to explore whether the uncertainty of economic policy has slowed down the economic recovery. Relevant studies mainly explored the impacts of economic policy uncertainty on investment [5,16–18], imports and exports [19,20], and innovation [6,21]. However, there are only a few studies on the effectiveness of macro-control policies in the uncertain environment. At present, China insists that the market plays a fundamental role in the allocation of resources, and China's market economy is constantly improving. However, the opening level of China's market economy still lags behind that of the developed countries, especially when it is hit by uncertainties, the hand of government still plays a huge role in economic activities. Therefore, taking China as the research object to study the effectiveness of macro-control policies in the uncertain environment will make the research results more effective.

Government macro-control is also called national macro-control. It refers to the overall management of the national economy by the government through administrative and economic means. The main purpose is to promote the balance between economic structure and sustainable economic development. Smoothing the economic fluctuations is the core task of the government's macro-control. Monetary policy and credit policy are the main means of the central bank's macro-control. The monetary policy mainly regulates the total social demand by controlling the money supply, and then acts on the output. The function of macro-control policy is to adjust monetary policy or credit policy to achieve the established economic goals. For example, in the COVID-19 era, the Central Bank of China adopted a structural monetary policy to lower interest rates, delay repayment of loans, and issue vouchers by local governments. China's economy has recovered significantly. This shows that the Chinese government plays a positive role in macroeconomic regulation and control. However, if the macro-control policy is restricted under some conditions, its

effectiveness could be damaged. The existing research on the effectiveness of an uncertain environment mainly focuses on monetary policy. Balcilar et al. [22] found that changes in US policy can affect the effectiveness of monetary policy in the Euro area. When US policy uncertainty is low, the impact of monetary policy in the Euro area on output and price is more significant. The research of Aastveit et al. [23] showed that when the uncertainty is large, the impact of US monetary policy shocks on economic activities is small, which is in line with the theoretical “real option” effect. This also proves that monetary policy is less effective in an environment of high uncertainty. Pellegrino [24] used a non-linear interactive vector autoregressive (VAR) model to study whether the level of European uncertainty affects the effectiveness of monetary policy shocks in the Euro area. The study found that the impact effect of monetary policy shocks in the low uncertainty period is higher than that in the high uncertainty period. Similarly, Carriero et al. [25], Jin and Zhang [26] studied the relationship between economic uncertainty and the effectiveness of the monetary policy, and also concluded that uncertainty will affect the effectiveness of the monetary policy. In related studies, some scholars regard macroeconomic uncertainty as exogenous shocks. However, macroeconomic uncertainty has strong countercyclical characteristics, and economic recession is often accompanied by an increase in economic uncertainty. Therefore, it is worth discussing that macroeconomic uncertainty accompanying economic recession should be regarded as an exogenous variable. At the same time, Pellegrino [24] and Carriero et al. [25] use a single index, such as stock market volatility as the proxy index of macroeconomic uncertainty, which is difficult to reflect the overall situation of macroeconomic uncertainty. In addition, there is a lack of discussion on the effectiveness of credit policy in an uncertain environment.

With the development of a market-oriented economy and the improvement of interest rate transmission channels, the role of quantitative monetary policy has been greatly reduced, and China’s monetary policy framework is changing from quantitative type to price type. According to the national development strategy and the industrial policy, the credit policy provides either the credit support or the restriction to the specific object, thus achieves the adjustment economic structure function. China’s capital market is not yet perfect, and financing difficulties are still important problems faced by many enterprises. Especially for small and medium-sized enterprises, loans from banks are the main way to obtain funds, the adjustment of credit policy will have an important impact on the market. In the current uncertain market environment, stable growth and structural adjustment are the keys to maintain China’s economic development in the future. The uncertainty of economic policy not only brings pressures to the economic operation, but also makes it difficult to select and operate the macroeconomic regulation and control policy. At the same time, it has been found that economic policy uncertainty has a non-linear effect on the macroeconomy. For example, Nodari [27] empirically tested the impact of policy uncertainty on the US macroeconomy using a non-linear smooth-switching VAR model, and found that, compared with economic booms, policy uncertainty has a more negative impact on the US macroeconomy during the economic downturn. Zhang and Wang [28] investigated the non-linear macroeconomic effect of China’s policy uncertainty based on threshold VAR model and counterfactual analysis, it was found that policy uncertainty has a negative impact on output growth during the economic boom, while in an economic downturn, policy uncertainty will have a positive impact on output growth by stimulating consumption and business investment. As a result, macroeconomic regulation and control policies in different uncertain environments may also be heterogeneous. This leads us to the following questions: in the face of varying degrees of economic policy uncertainty, how effective are monetary policy and credit policy? At the same time, are there any differences and similarities in the effects of these two kinds of regulation policies on output and technological progress? Sorting out these questions will not only enrich existing research, but also provide empirical evidence for policymaking in the macroeconomic regulation and control.

For the discussion of the above questions, this paper will build the corresponding econometric model for empirical analysis. The rest of this paper is arranged as follows: Section 2 analyzes the effectiveness of price monetary policy and credit policy in macro-control policy, and then further investigates the impact mechanism of macro-control policy on output and technological progress under an uncertain environment. Section 3 constructs the time-varying parameter vector autoregression (TVP-VAR) and describes relevant variables. According to the research problems, the corresponding TVP-VAR model is constructed, the main variables and data sources are explained, and the unit root test of the data is done. Section 4 is the empirical analysis. This section tests and analyzes the time-varying effects of monetary policy and credit policy on output and technological progress in the short, medium, and long term, and then discusses the differences of monetary policy and credit policy on output and technological progress under the uncertainty of different economic policies. Section 5 is counterfactual analysis. To test the results of the previous study, this part uses vector autoregression counterfactual analysis method to simplify simulation re-test the relevant conclusions. Section 6 concludes.

2. Effectiveness Analysis of Macroeconomic Regulation and Control Policy

Promoting economic growth, maintaining price stability, increasing employment, and maintaining the balance of payments are four major goals of the government's macroeconomic regulation and control. To adapt to the characteristics of development in different periods, regulatory policies will switch among different goals. This paper focuses on the effect of price-based monetary policy and credit policy on output and technological progress.

2.1. The Effectiveness of Price-Based Monetary Policy

In the case of irrational expectations, monetary policy is non-neutral, the adjustment of monetary policy plays an important role in macroeconomic regulation. However, the financial development and the market economy's consummation causes the interest rate tool gradually to become the main means of the central bank's monetary policy regulation. On the one hand, the central bank can change the cost of borrowing by adjusting the interest rate, and, hence, cause the change of investment demand. Investment demand accounts for a high proportion of China's economic and social aggregate demand, and it is also the link between monetary policy and aggregate demand. The change of investment demand will significantly affect aggregate demand. Finally, the level of output will change as aggregate demand changes. On the other hand, the high financing and adjustment costs of research and development (R & D) activities require enterprises to have adequate financial security, the change of enterprise's loanable fund caused by the change of market interest rate will affect the allocation of an enterprise's fund in R & D investment, equipment and technology renewal, personnel turnover, etc. Research by Xu et al. [29] confirmed this, they found that monetary policy can significantly affect corporate R & D spending, while tight monetary policy can reduce corporate R & D activity.

The uncertainty of economic policy will bring some problems to market participants, such as information asymmetry and incomplete information. In the face of uncertainty, it becomes more difficult for financial institutions to evaluate the loan purpose and investment projects of enterprises, and banks and other lending institutions will become more cautious. For risk prevention, it will increase the level of credit interest margin and cause the rise of the enterprise loan cost. At the same time, the increase in uncertainty will lead to the aggravation of investment risk. According to the real option theory, investors are likely to delay the investment decision out of "prudent investment". The above two factors will reduce the sensitivity of investment demand to interest rate changes under the uncertainty of economic policy, and the macroeconomic regulation effect of monetary policy will be weakened. Although China's highly centralized political structure promotes the rapid economic growth to a great extent, and has a decisive impact on the output effect of economic policy uncertainty [28], the change of macro-control policy itself is an important source of economic policy uncertainty, and the control effect of policy will be

greatly reduced. Bonciani and Roye [30] showed that due to the existence of interest rate stickiness, uncertainty will affect economic activities through credit friction, thus reducing the effectiveness of the monetary policy. Aastveit et al. [23] found that uncertainty will not change the direction of monetary policy, but will weaken the effectiveness of the monetary policy.

When the external environment changes dynamically, enterprises lack complete information about customer demand, and the uncertainty of macroeconomic policy can also urge enterprises to seek a “self-development” effect by increasing R & D investment. Atanassov et al. [6] believe that EPU will have an incentive effect and selection effect on enterprise innovation, and the rise of policy uncertainty will positively affect the R & D investment and the number of patent applications of listed companies. In addition, based on the Schumpeter model, Brouwer [31] also found that uncertainty can stimulate the diffusion of knowledge and other information, improve the utilization rate of human capital, and then improve the innovation efficiency of enterprises. However, Manso [21] believes that the success of innovation projects is largely related to economic policies, so the value of waiting options is more important for enterprises’ R & D and innovation activities. When enterprises are faced with high uncertainty environment, enterprise innovation projects will be delayed. Therefore, this paper puts forward the following hypotheses.

Hypothesis 1 (H1). *Under the uncertainty environment, the rise of interest rate will lead to the decline of output, but will promote technological progress, and this effect is different under different degrees of uncertainty.*

2.2. The Effectiveness of Credit Policy

Credit policy, another important means for the central bank to regulate and control the macroeconomy, is made according to the national macroeconomic policy, industrial policy, and fiscal policy, etc. Credit policy plays an important role in improving credit structure, adjusting the industrial structure, increasing factor ration in specific fields, and implementing important strategies. It is generally believed that credit policy has an output effect in the short term. However, since credit policy is a kind of discriminatory policy in nature, it is likely to reduce the effectiveness of resource allocation in market economy, thus reducing the output efficiency. In addition, the formulation and implementation of credit policies need the coordination and cooperation of departments at all levels. The step-by-step transmission through departments is time-consuming. Furthermore, different departments have inconsistent cognition of the policy, which often lowers the effect of credit policy implementation than expected. Research by Xie and Liu [32] suggested that green credit is good for both green output growth, and green technological progress. Research by Lv and Wang [33] showed that although credit imbalance will have a negative impact on the innovation output for some high-efficiency enterprises, it will help low-efficiency enterprises with strong financing ability realize technological innovation, so as to enhance the technological innovation output of the whole society. However, some studies have found that only reasonable credit arrangements or structural credit policies can effectively promote economic development [34]. Studies by Pan and Zhang [35] showed that there is a negative correlation between short-term credit and output, while the relationship between medium and long-term credit and output is not significant.

In the aspect of credit policy, in the face of uncertain market environment, in order to stimulate economic growth, the government will strategically provide low-cost loans or financial support to enterprises in some industries. This process will not only increase output, but also reduce efficiency. Therefore, the formulation and implementation of credit policy has higher requirements for policy makers. Research by He and Wu [36] showed that economic policy uncertainty will weaken the risk-taking and credit growth of banks, while Chinese state-owned banks tend to take risks. Balcilar et al. [22] found that economic policy uncertainty can be transmitted to economic fluctuations by influencing medium and long-term loans.

For a long time in the past, economic growth has been the assessment target of local governments in China. Local governments are likely to intervene or guide credit funds into state-owned enterprises which are more related to the government but have lower innovation efficiency, or support backward enterprises, which will lead to the decrease in resource allocation efficiency of credit funds. In addition, the rapid development of the real estate industry has not only squeezed the investment scale of the manufacturing industry, increased the survival difficulty of the manufacturing industry, but also caused price distortion and reduced the allocation efficiency of market resources [37]. Therefore, this paper puts forward the second hypothesis.

Hypothesis 2 (H2). *Under the uncertainty of economic policy, credit growth can still bring output growth, but the impact on technological progress may be either promoted or inhibited.*

3. Construction of TVP-VAR Model and Variables Description

In view of the non-linear effect of economic policy uncertainty on economic growth, this chapter uses time-varying parameter vector autoregression (TVP-VAR) to analyze the effectiveness of macroeconomic regulation and control policy under uncertainty, the model can describe the time-varying and non-linear effects of macroeconomic regulation and control policies on output and technological progress, and can also reflect the effects of regulation policies in the short, medium and long term.

3.1. TVP-VAR Model Construction

TVP-VAR model was first proposed by Nakajima et al. [38], which introduced stochastic volatility into time-varying VAR and was based on structural vector autoregression (SVAR). The basic vector autoregression can be written in the following form:

$$Ay_t = F_1y_{t-1} + \cdots + F_sy_{t-s} + \mu_t, \quad t = s+1, \dots, n \quad (1)$$

In Equation (1), y_t is $k \times 1$ dimensional variable vector. A is a parameter matrix in dimension $k \times k$. $F_1, \dots, F_s$ is the $k \times k$ dimensional coefficient matrix, and a random perturbation term μ_t , which is $k \times 1$ structural shock. The parameter matrix A is a lower triangular matrix, which can be expressed as:

$$A = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ a_{21} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ a_{k1} & \cdots & a_{k,k-1} & 1 \end{bmatrix} \quad (2)$$

Multiply both sides of Equation (1) by A^{-1} , and the SVAR model can be written as:

$$y_t = B_1y_{t-1} + \cdots + B_sy_{t-s} + A^{-1}\sum \varepsilon_t, \quad \varepsilon_t \sim N(0, I_k) \quad (3)$$

where $B_i = A^{-1}F_i$, for $i = 1, 2, \dots, s$, and:

$$\Sigma = \begin{bmatrix} \sigma_1 & 0 & \cdots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_k \end{bmatrix} \quad (4)$$

$B_i = A^{-1}F_i$, $i = 1, 2, \dots, s$. We can combine B_i into $k^2s \times 1$ dimension vector β , and define it as the Leopold Kronecker product, the Equation (4) can be simplified as:

$$y_t = X_t\beta + A^{-1}\sum \varepsilon_t, \quad \varepsilon_t \sim N(0, I_k) \quad (5)$$

Then, if all the parameters are time-varying, Equation (5) can be written as:

$$y_t = X_t \beta_t + A_t^{-1} \sum_t \varepsilon_t, \varepsilon_t \sim N(0, I_k) \quad (6)$$

Furthermore, β_t , A_t , $\sum_t$ are time-varying. Let α_t be a stacked vector of the lower triangular elements in A_t and $h_t = (h_{1t}, \dots, h_{kt})'$ with $h_{it} = \log \sigma_{it}^2$. The time-varying parameters are assumed to follow a random walk:

$$\beta_{t+1} = \beta_t + \mu_{\beta t}, \alpha_{t+1} = \alpha_t + \mu_{\alpha t}, h_{t+1} = h_t + \mu_{ht}, h_{i,t} = \log \sigma_{it}^2 \quad (7)$$

Which $i = 1, \dots, k$, $\beta_{t+1} \sim N(\mu_{\beta 0}, \Sigma_{\beta 0})$, $\alpha_{t+1} \sim N(\mu_{\alpha 0}, \Sigma_{\alpha 0})$, $\beta_{t+1} \sim N(\mu_{h0}, \Sigma_{h0})$, and $\varepsilon_t, \mu_{\beta t}, \mu_{\alpha t}, \mu_{ht}$ met the following condition:

$$\begin{pmatrix} \varepsilon_t \\ \mu_{\beta t} \\ \mu_{\alpha t} \\ \mu_{ht} \end{pmatrix} \sim N \left(0, \begin{pmatrix} i & 0 & 0 & 0 \\ 0 & \Sigma_{\beta} & 0 & 0 \\ 0 & 0 & \Sigma_{\alpha} & 0 \\ 0 & 0 & 0 & \Sigma_h \end{pmatrix} \right) \quad (8)$$

It is further assumed that the time-varying parameters β_t , α_t , and h_t are not correlated when subjected to an innovation shock. Σ_{β} , Σ_{α} , and Σ_h are time-varying. Under the above assumptions, the time-varying parameters in the model can be estimated by using MCMC process, and then the impulse response among the variables can be analyzed.

3.2. Variable Description

Except for the economic policy uncertainty index, the other variables in this section use the data of 29 provinces from the first quarter of 2003 to the fourth quarter of 2017. (1) output growth rate (OGR). The real quarterly GDP is selected as the proxy variable of output, and the logarithm is taken after the GDP data are seasonally adjusted. Then, the quarterly GDP growth rate is obtained by logarithmic difference. (2) Technological progress (TFP). According to the research method of Fare et al. [39], this paper uses Malmquist index based on data envelopment analysis (DEA) to represent the technological progress index. The technology progress index from t to $t + 1$ is defined as:

$$M(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{d^t(x^{t+1}, y^{t+1})}{d^t(x^t, y^t)} \times \frac{d^{t+1}(x^{t+1}, y^{t+1})}{d^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}} \quad (9)$$

In the above equation, x^t and y^t are the input and output variables for period t . $d^t(x^t, y^t)$ represent the distance function, and other variable definitions are similar. $M > 1$ means that the current technological progress of the decision-making units has increased compared with the previous period. $M < 1$ means the technological progress of the decision-making units has degraded compared with the previous period. The input variables are labor and capital stock, and the output is real GDP. Capital stock is defined as follows. According to the research of Shan [40], the capital stock data of each province in 2002 is obtained (and the base period is converted to 2003). Then, the quarterly capital stock of each province is estimated using the national fixed asset investment price index and the quarterly fixed asset investment completed amount with the quarterly depreciation rate of 2.63%. Among them, the national fixed asset investment price index and the fixed asset investment completed amount data can be converted according to the fixed asset investment price index and the quarterly fixed asset investment completed amount of each province, the unit is billion yuan, the data are from the WIND database. The number of labor force is expressed by the sum of the number of employees in China's three major industries at the end of the period. China does not release quarterly labor statistics. In fact, the employment changes of employees in the three major industries and inter provincial floating population in the year are relatively small. The number of employees in the four quarters of the same year does not change much. Therefore, the second matching average

method is used to convert the annual number of employees into the quarterly number of employees. The unit is 10,000 people, and the data come from the China Statistical Yearbook and provincial statistical yearbook. In order to ensure the consistency of input-output data, quarterly GDP is expressed by the actual value of 2003 as the base period, with the unit of RMB 100 million. Both GDP and GDP deflator are from the wind database. In addition, Chongqing was established in 1997, and the relevant capital stock data were incorporated into Sichuan Province before that. Therefore, this study also incorporated all the data of Chongqing into Sichuan Province. (3) Economic policy uncertainty index (EPU). The index of China's economic policy uncertainty is composed of news index, which is obtained by weighting the frequency of three key words "economy", "policy", and "uncertainty" in the articles of South China Morning Post in Hong Kong. According to the uncertainty index of China's economic policy published by Baker et al. [14], the uncertainty index of China's quarterly economic policy is obtained using the weighted average method, and the trend separation data are obtained after HP Filtering. (4) Interest rate (R) uses the monthly data of China's interbank offered rate weighted into quarterly data as the proxy variable of price monetary policy, and HP filtering processing. (5) Credit scale (RGL). As there is a high correlation between the total amount of credit and the target variables of monetary policy, this paper, like Zhang and Wang [28], selects the growth rate of total loans of banking institutions as the credit scale index to reflect the changes of credit policy. All the above basic data except TFP are from the National Bureau of Statistics and WIND database. The unit root test results of all variables are shown in Table 1.

Table 1. Data unit root test results.

Variable	Inspection Method	ADF Statistics	p Value
OGR	(c, 0, 0)	−3.1235	0.0303
TFP	(0, 0, 6)	−6.7268	0.0000
EPU	(0, 0, 0)	−3.6447	0.0005
R	(0, 0, 0)	−2.9300	0.0041
GRL	(c, 0, 4)	−2.9544	0.0458

Note: C, T, and K in Test Type (C, T, K) denote constant term, time trend term and lag term, respectively, and 0 in parentheses denote no corresponding term.

4. Analysis of Empirical Results

At present, the number of executable variables in TVP-VAR model is at most four, and cannot be expanded to five or more. However, there are five core variables in this paper after adding macro-control policy variables. Therefore, in the actual analysis, we first discuss the effectiveness of price monetary policy when the variable order is (OGR, TFP, R, EPU), and then analyze the effectiveness of credit policy when the variable order is (OGR, TFP, GRL, EPU).

4.1. TVP-VAR Model Parameter Estimation

The parameters of TVP-VAR model with variable order (OGR, TFP, R, EPU) and variable order (OGR, TFP, GRL, EPU) were estimated, respectively. The parameter estimation results are shown in Tables 2 and 3.

Table 2. The estimation results of the efficiency parameters of price monetary policy.

Parameters	Mean Value	Standard Deviation	95% Confidence Interval	CD Statistic	Inefficiency Factor
$(\Sigma_{\beta})_1$	0.0022	0.0001	(0.0021, 0.0024)	0.096	1.41
$(\Sigma_{\beta})_2$	0.0022	0.0001	(0.0021, 0.0024)	0.401	1.39
$(\Sigma_{\alpha})_1$	0.0055	0.0017	(0.0033, 0.0099)	0.671	15.88
$(\Sigma_{\alpha})_2$	0.0055	0.0016	(0.0034, 0.0096)	0.104	17.74
$(\Sigma_h)_1$	0.0057	0.0017	(0.0034, 0.0102)	0.228	21.04
$(\Sigma_h)_2$	0.0056	0.0016	(0.0034, 0.0096)	0.011	13.63

Table 3. The estimation results of credit policy effectiveness parameters.

Parameters	Mean Value	Standard Deviation	95% Confidence Interval	CD Statistic	Inefficiency Factor
$(\Sigma_{\beta})_1$	0.0023	0.0002	(0.0019, 0.0026)	0.007	1.84
$(\Sigma_{\beta})_2$	0.0023	0.0002	(0.0019, 0.0027)	0.942	1.5
$(\Sigma_{\alpha})_1$	0.0056	0.0016	(0.0034, 0.0094)	0.026	6.97
$(\Sigma_{\alpha})_2$	0.0054	0.0015	(0.0034, 0.0092)	0.09	13.74
$(\Sigma_h)_1$	0.0056	0.0017	(0.0034, 0.0098)	0.791	20.16
$(\Sigma_h)_2$	0.0057	0.0016	(0.0035, 0.0097)	0.285	19.05

It can be seen from the parameter estimation results in Tables 2 and 3 that the parameters selected in the model basically meet the hypothesis of converging to a posteriori distribution, and the inefficiency factor of variables is also very low (the extreme values are 21.04 and 20.16 respectively), which indicates that the sampling process can produce enough unrelated samples, and the model parameter estimation results are more effective.

4.2. The Effectiveness of the Impact of Price Monetary Policy on Output and Technological Progress

4.2.1. Short, Medium, and Long-Term Responses of Output and Technological Progress to Interest Rate Shocks

According to the impulse response of each time point, this paper defines the impulse response of the fourth, eighth, and twelfth quarters after the impact of variables as short, medium and long-term effects, respectively, so as to reflect the impact of macro-control policies on output growth and technological progress in different stages of the control period. Figures 1 and 2 show the impulse response of output growth and technological progress to interest rate shocks in the short, medium and long term, respectively.

From the response of output growth to an interest rate shock in Figure 1, we can see that for the positive impact of interest rate standard deviation innovation, the response value of output growth is negative throughout the sample period. This shows that in the environment of economic policy uncertainty, the impact direction of price based monetary policy on output growth has not deviated. The research believes that the direction of monetary policy on macroeconomy will not change under the uncertainty environment. From the overall response value, the regulatory effect of price monetary policy has a time-varying effect, and the regulatory effect of price monetary policy is gradually enhanced. Compared with before 2006, the absolute value of response value after 2006 is larger, which also shows that with the development of market economy and the continuous improvement of financial system. China's monetary policy framework is gradually shifting from quantity type to price type, which is the embodiment of the gradual improvement of the monetary policy system. However, we can find that the effect of interest rate policy is the best around 2009, and then tends to be stable. The main reason is that the uncertainty under the financial crisis will increase the difficulty of market participants' expectation of the future economy, and the interest rate tools in the macro-control policy can play an effective role.

From the short-term, medium-term and long-term effects of interest rate impact on output growth, the short-term response curve is at the bottom of the negative half axis, while the medium-term and long-term response curves are above the short-term response curve. This shows that the short-term effect of price monetary policy on output growth is the most obvious, and the effect gradually decreases over time, indicating that timely adjustment of interest rate policy under uncertainty can better stabilize output growth.

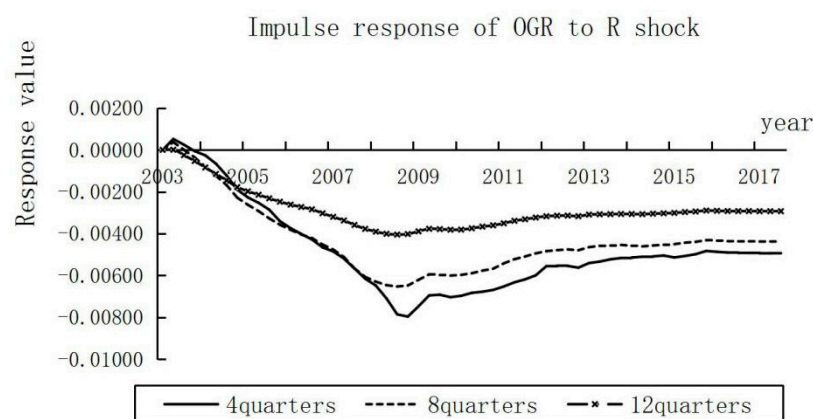


Figure 1. Impulse response of output growth to interest rate shocks in short, medium, and long term.

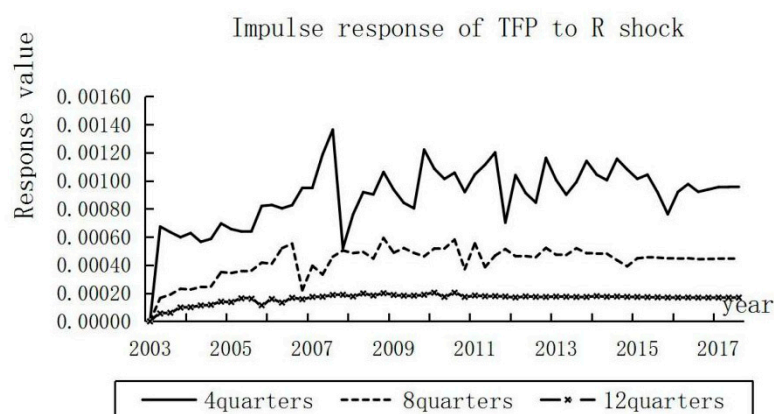


Figure 2. Impulse response of technological progress to interest rate shocks in short, medium, and long term.

According to the response of technological progress to interest rate shocks. The response curves of technological progress during the sample period are all in the positive half axis, which indicates that the rise of interest rate under uncertainty is helpful to the promotion of technological progress. On the one hand, it is more difficult for industries and inefficient enterprises to survive when the environment is uncertain. Compared with normal enterprises, it is more difficult for them to obtain bank loan support, and the increase in financing difficulty caused by uncertainty is more helpful for the market to eliminate backward enterprises and retain more high-quality enterprises. On the other hand, although uncertainty may affect the investment behavior of enterprises through the “real option” effect, normal enterprises may also seek their own development by increasing R & D investment in the face of uncertainty [41]. In addition, uncertainty may also have innovation incentive and selection effects on enterprises [42]. The existence of the above factors gives the rise of interest rates a positive role in promoting technological progress.

It can also be found from Figure 2 that, there are obvious differences in the response of technological progress to interest rate shocks in the short, medium, and long term. The response of technological progress to interest rate shocks tends to zero in the long run, and the response value is consistent over different years, showing non time-varying. Under the impact of interest rate changes, the response value of technological progress in the medium term is higher than that in the long term, showing a slight time-varying. However, in the short term, the impact of technological progress on interest rate shows obvious time-varying under uncertainty, and the effect is significantly higher than that in the medium and long term, indicating that the impact of price monetary policy on technological progress is more obvious in the short term. It is worth noting that in the short-term effect, the rise of

interest rate under the 2008 financial crisis has the worst positive effect on technological progress. The reason may be that the impact of the financial crisis not only accelerates the elimination of inefficient and backward enterprises, but also affects the production and operation activities of normal enterprises, that is, the financial crisis has a general destructive effect on the market, so as to reduce the overall technological progress.

4.2.2. Response of Output and Technological Progress to Interest Rate Shocks at Specific Time Points

According to the fluctuation characteristics of economic policy uncertainty index, this section selects the representatives of low, medium, and high degree of economic policy uncertainty in the fourth quarter of 2006, the first quarter of 2012 and the first quarter of 2017 to analyze the effectiveness of macro-control policies under different degrees of uncertainty. In fact, the uncertainty indexes of the three time points are close, and the empirical results near the three time points are also close to those of the corresponding points. The response of output growth and technological progress to interest rate shocks at a specific time point is shown in Figures 3 and 4.

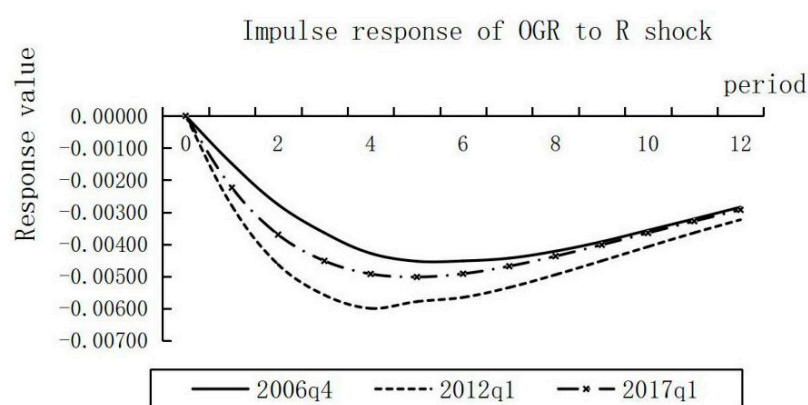


Figure 3. Response of output growth to interest rate shocks at a given point in time.

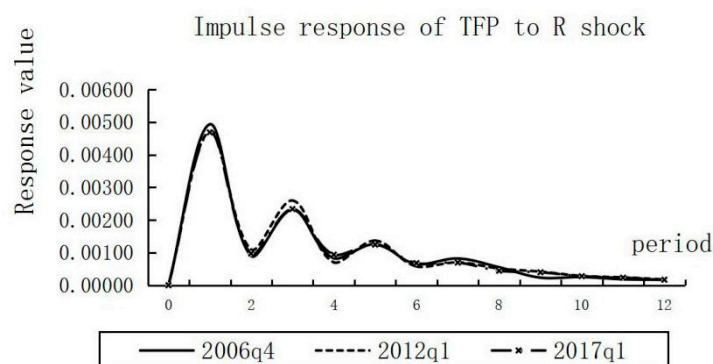


Figure 4. Response of technological progress to interest rate shocks at a given point in time.

It can be seen from Figure 3 that output growth is negative when it is impacted by positive interest rate, which indicates that the effect of interest rate rise on output growth is negative even in different uncertain environments. From the perspective of volatility, the output growth impulse response curve changes from large to small are in the order of the first quarter of 2012, the fourth quarter of 2006, and the first quarter of 2017, which shows that the effectiveness of price based monetary policy is stronger when the uncertainty index is low, and the regulation effect of interest rate on output growth is the strongest under the medium degree of economic policy uncertainty. In the previous analysis, we can also find that the effect of interest rate changes on short-term output is the most obvious around

2009. In fact, the uncertainty index at this time is closer to the mean value of economic policy uncertainty in the sample period. In addition, the three impulse response curves have similar convergence characteristics, reaching the maximum absolute value of the response near the fourth period, and converging near (-0.003) in the long term.

The response of technological progress to interest rate shocks at a particular point in time is shown in Figure 4. For the positive impact of interest rate per unit standard deviation, the technical progress can be improved. It is obvious that the specific impulse response functions of the three time points are almost coincident and have the same fluctuation characteristics. After positive interest rate shocks, technical progress peaked in the first quarter (0.0048), then declined and converged to zero in the 12th quarter.

4.3. The Effectiveness of Credit Policy on Output and Technological Progress

4.3.1. Short, Medium, and Long Term Responses of Output and Technological Progress to Credit Shocks

As in the case of price-based monetary policy, in the analysis of the impact of credit policy shocks on output and technological progress, this paper maps the short-term, medium-term, and long-term impulse responses of output growth and technological progress under credit shocks. These are shown in Figures 5 and 6.

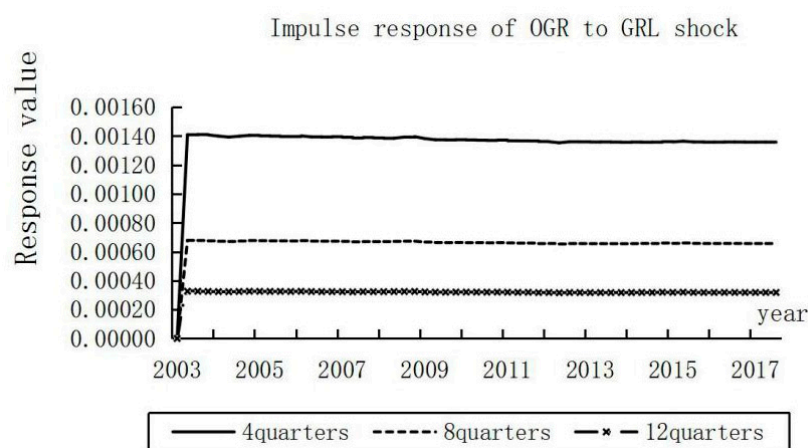


Figure 5. Impulse response of output growth to credit shocks in short, medium, and long term.

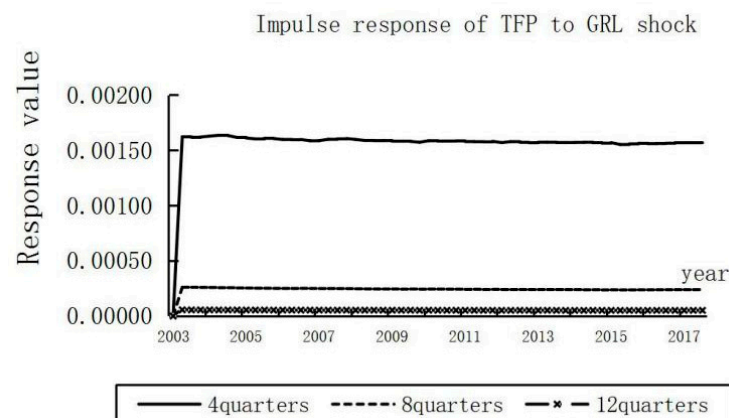


Figure 6. The impulse response of technological progress to credit shock in short, medium, and long term.

Figure 5 shows the impulse response of output growth to credit growth. The positive impact on credit growth shows that output growth is positive in the whole sample period, which indicates that credit growth is conducive to the growth of output. The increase in

credit is conducive to ease the financing constraints of enterprises, and the increase in investment demand drives the increase in total demand, thus promoting the growth of output. Different from the effect of price monetary policy, the response of output growth to credit growth tends to be stable and linear. This shows that under different uncertainties, the effect of credit growth on output growth is consistent, and it will not produce heterogeneous effect with the change of uncertainty. From the short-term, medium-term and long-term response of output growth, the short-term curve is the highest, followed by the medium-term curve, and finally the long-term curve. This shows that the credit growth's pulling effect on output growth is mainly reflected in the short term, and this pulling effect is gradually declining in the medium and long term of the whole sample period.

The response of technological progress to credit shocks. The positive impact on credit growth in Figure 6 shows that technological progress is positive in the fourth, eighth, and twelfth quarters, indicating that credit growth is conducive to promoting technological progress in the response period. Different from the change of interest rate, the effect of credit growth on technological progress has no time-varying effect, and the short-term, medium-term, and long-term effects of credit growth are linear. In addition, the positive impact of credit growth on technological progress is mainly reflected in the short-term, and the medium-term impact is weak, while the long-term response value tends to zero, indicating that credit growth has no long-term impact on technological progress. However, whether the above conclusions are robust in all periods still needs to be tested in combination with the impulse response of technological progress to credit shocks at different time points below. Unfortunately, the conclusion that the impact of credit growth on technological progress is positive is not robust.

4.3.2. The Response of Output and Technological Progress to Credit Shocks at Specific Time Points

In order to find out whether there are differences in the impact of credit shocks on output and technological progress at different time points, the impulse response graphs of output growth and technological progress on credit shocks at different time points are given in Figures 7 and 8.

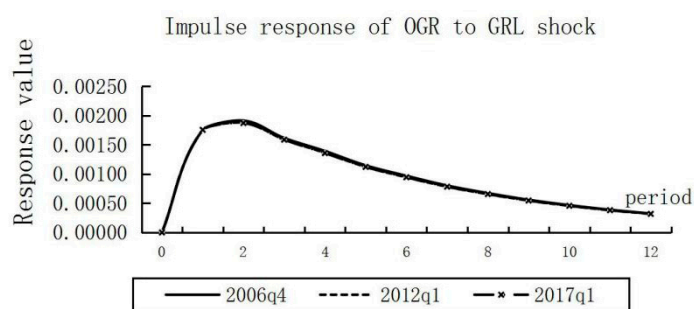


Figure 7. Impulse response of output growth to credit shock at specific time point.

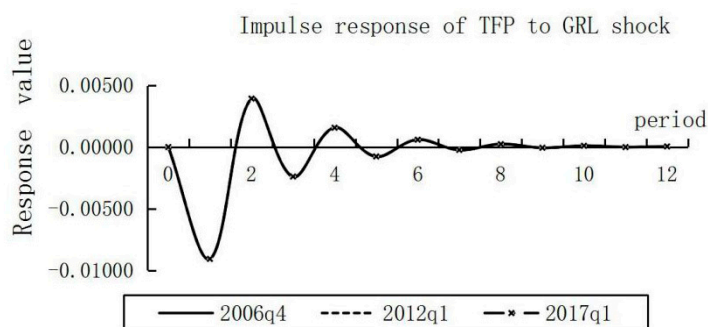


Figure 8. Impulse response of technological progress to credit shock at a given time point.

From the response of output growth to credit growth shock at a specific time point, the response of output growth to credit growth is significantly positive at the three time points selected in this paper, which indicates that the macro-control effect of credit growth on output growth is robust. The three impulse response curves are almost coincident, which shows that the impact of output growth on credit growth is the same under different economic policy uncertainty environment, and there is no time-varying effect of credit growth on output. Specifically, after the impact of credit growth on output growth, under different uncertainty environments, output growth began to rise from period 0, reached the maximum response value (0.0019) in the second quarter, and then gradually decreased until it converged to a stable state (0.0003) after the 12th quarter.

The impact of credit growth on technological progress at different time points is similar to that of output growth, and the impulse response functions at three time points are also coincident, which indicates that there is no time-varying effect of credit growth on technological progress. It is worth noting that after the impact of credit growth, the response value of technological progress fluctuates around 0, reaching the maximum negative response value (−0.0091) in the first quarter, and the maximum positive response value (0.0039) in the second quarter, and then converges to 0. This shows that the effect of credit policy on technological progress is not significant in the environment of economic policy uncertainty, and the impact of credit policy on technological progress needs to be further tested.

5. Further Discussion on the Influence of Credit Regulation on Output Growth and Technological Progress

In order to further examine whether the uncertain environment will affect the effect of credit policy regulation and to analyze the impact of credit shocks on the direction of technological progress, this chapter refers to the counterfactual study of Zhang and Wang [28], simplify the model and perform simulation analysis. Specifically, the model is simplified as a general unconstrained VAR, and the order of variables is estimated as (OGR, TFP, GRL, EPU). The result of orthogonal impulse response is preserved, and the equation covariance matrix $\hat{\Sigma}$ and the coefficient estimation matrix of residual $\hat{\Phi}$ are obtained. Then, the row and column elements corresponding to the variable EPU in $\hat{\Sigma}$ are given zero constraints to get $\hat{\Sigma}_s$, and the row elements corresponding to the EPU in $\hat{\Phi}$ (all estimated coefficients of the fourth row except the intercept term) are given zero constraints to get $\hat{\Phi}_s$. Finally, a new orthogonal impulse response function is obtained according to $\hat{\Sigma}_s$ and $\hat{\Phi}_s$, and the difference between the two impulse response functions is compared. If there are differences, it shows that the uncertain environment will affect the regulatory effect of credit policy. Figures 9 and 10 show the response of output and technological progress to credit growth shocks with or without uncertain environmental constraints, respectively.

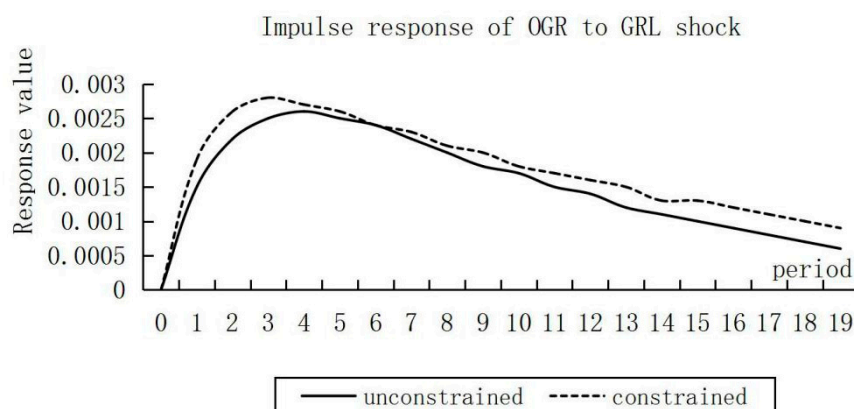


Figure 9. Response of output growth to credit growth shock under uncertainty constraints.

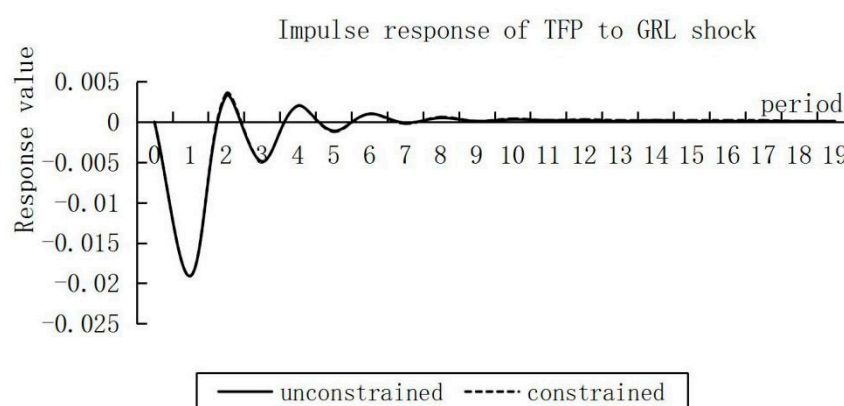


Figure 10. Response of technological progress to credit growth shock under uncertainty.

It can be seen from Figure 9 that, when the uncertainty of economic policy is closed, the effect of credit growth on output growth is better (the dotted line is slightly higher than the solid line), indicating that the uncertainty environment will affect the regulation effect of credit policy on output, but the impact is not significant. Figure 10 shows the unconstrained and constrained response curves of the impact of technological progress on credit growth coincide, indicating that the uncertain environment does not affect the effect of credit growth on technological progress. The response of technological progress to the impact of credit growth reaches the maximum negative value (-0.0191) in the first period, and the maximum positive response value (0.0032) in the second period, and then the shock converges to 0, indicating that the overall effect of credit growth on technological progress is still not significant. The reasons for this result may lie in the following aspects. First, there is a positive correlation between the degree of credit marketization and the level of economic development. In the process of continuous improvement of credit marketization, under the stimulation of the political tournament with GDP as the core, local governments are likely to intervene in the flow of credit funds [43], and guide funds to flow into state-owned enterprises with higher degree of correlation with the government but lower innovation efficiency. Or developing backward industries blindly, resulting in low-level duplication of construction, thereby reducing the efficiency of resource allocation of credit funds; the second is the rapid development of the real estate industry in the past. Driven by high income and high return, a large number of credit funds directly or indirectly flowed into the real estate industry, which not only squeezed the investment scale of the manufacturing industry, and hence making the survival of the manufacturing industry difficult, but also caused price distortion and reduced the efficiency of market resources allocation [37]. To sum up, these factors will lead to the impact of credit scale on technological progress is not significant.

6. Conclusions

6.1. Results and Discussion

The existing research mostly analyzed the effectiveness of macro-control policies in a linear framework, which cannot describe the effect of macro-control policies under the uncertainty of economic policies. In order to clarify the effectiveness of the macroeconomic regulation and control policy in the context of economic policy uncertainty, this paper analyzes the effectiveness of the macroeconomic regulation and control policy using China's data from the second quarter of 2003 to the fourth quarter of 2017. TVP-VAR model and counterfactual analysis are used to study the effectiveness of price monetary policy and credit policy in regulating output and technological progress under uncertainty.

The results show that: under the uncertainty environment, the direction of price monetary policy on output has not changed, and the effect of interest rate rise on output is negative, and this impact is stronger in the short term than in the medium and long term. However, different from the results in the main literature, this paper finds that

under the uncertainty environment, the effect of interest rate rise on technological progress is positive, and the effect intensity is also stronger in the short term, and weaker in the medium and long term. Under the uncertainty, the effect of interest rate change on output and technological progress is time-varying. Under the moderate uncertainty, the effect of price monetary policy on output is stronger. This implies that the degree of uncertainty of economic policy should be fully considered in the implementation of price oriented monetary policy to ensure the expected regulatory effect.

Credit growth can promote output growth, and the regulation effect of credit growth on output growth is mainly reflected in the short term. The effect of credit growth on output growth and technological progress is not time-varying. It is worth noting that the impact of credit growth on technological progress is not significant in the uncertain environment. Further research using the counterfactual analysis method shows that the uncertainty environment will reduce the regulation effect of credit policy on output growth, but the impact is not significant. Generally speaking, the impact of credit growth on technological progress is not significant.

6.2. Theoretical Contributions and Practical Implications

This study provides empirical support for the theoretical research of monetary policy under the uncertainty of economic policy. Although the theoretical literature on macro-control policy under uncertainty environment is relatively thin, some scholars have begun to explore the impact of economic policy uncertainty on macroeconomy from the theoretical perspective [5,17,20]. This paper empirically analyzes the effectiveness of price monetary policy and credit policy under uncertainty environment using a non-linear model. The results can provide empirical support for further theoretical research.

In addition, this study has a certain reference significance for the choice of macro-control policy in the uncertain environment. On the one hand, due to the uncertainty of economic policy, the regulation effect of price monetary policy on output is mainly reflected in the short term. Relevant countries should actively implement the monetary policy of “price dominating and quantity assisting”, guide the monetary policy to gradually change from quantitative regulation to price regulation, and improve the framework system of modern monetary policy. According to the different effects of price oriented monetary policy on economic growth under different degrees of uncertainty, the implementation of price oriented monetary policy should also be comprehensively evaluated from the aspects of response cycle, response range and long-term and short-term effects in combination with the degree of uncertainty. On the other hand, there is no time-varying effect of credit policy on economic growth under uncertain environment. Credit growth cannot effectively promote technological progress when it promotes output growth. In order to achieve economic goals, we should coordinate credit policy with other monetary and industrial policies, improve the efficiency of credit funds allocation, and promote technological progress.

6.3. Limitations and Future Research

There are several limitations to this study. This paper chooses China as the research object, which is conducive to the development of the research and obtaining rich conclusions. However, different countries have different economic systems and monetary policy frameworks, so whether the research results are more widely applicable needs to be further verified with regards to different countries. This paper focuses on the empirical analysis of the impact of China’s macro-control policy on output and technological progress under the uncertainty of economic policy. Therefore, the future research can study the effectiveness of macro-control policy under uncertainty environment from a broader international level, which can be carried out from both theoretical and empirical perspectives. Another potential extension is to analyze the impact of macro-control policies on green development and inclusive growth under uncertain environment, and deepen the research on sustainable development under uncertain environment.

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