Dean&Francis
ISSN 2959-6130

The Impact of the Issuance of CBDC on Monetary Policy——From the Perspective of Narrow Monetary Multiplier

Fanzhou Wu

Bejing-Dublin International College, Bejing University of Technology, Beijing, China

Corresponding author: m01846206@gmail.com

Abstract:

With the fast development of global financial technology, the central bank digital currency (CBDC) has gradually become a new direction for countries to explore. As a digital shape of legal currency, CBDC not only helps to enhance payment system efficiency, but also brings new changes to engaging in the digital era. China shows the importance of CBDC in the monetary system by introducing digital RMB (e-CNY) and incorporating it into M_0 statistics. However, the appearance of CBDC has generated many impacts to the traditional currency system, especially in terms of money supply mechanism, liquidity management of commercial banks and financial stability. Through theoretical analysis and empirical research, this paper discusses the influence of CBDC on narrow monetary multipliers. This paper found that the increase in the liquidity of CBDC has a certain inhibitory effect on the narrow monetary multiplier, and the market share of digital currency payment has significantly affected the change of the monetary multiplier. In addition, the short-term impact effect is relatively obvious, but it tends to decline in the long term. This paper provides a new perspective for understanding the possible effects of CBDC on monetary policy, and also points out the risks and challenges that need attention in future policy formulation.

Keywords: Central Bank Digital Currency (CBDC); Digital RMB (e-CNY); Narrow monetary multiplier; Monetary Policy; Digital Economy

1. Introduction

In 2023, a spokesman for China's Central People's Bank pointed out at a relevant press conference that the central bank digital currency (CBDC) has now been included in the statistical category of M_0. This shows that in the current stage of development, CBDC has strong liquidity. Meanwhile, policy actions like issuing CBDC could enhance social welfare

by offering benefits that decentralized digital currencies currently do not provide, such as improved security [1]. In addition, some scholars have noted that issuing CBDC can enhance the payment functions of fiat money, alleviate the regulatory burden and pressure on central banks and address challenges faced by modern monetary policy [2]. There are signs which show that the issuance of CBDC is bringing huge changes and optimization space to the traditional monetary system.

At present, it seems that there are differences in the perspectives and methods of research and development of their own legal digital currencies by central banks. Generally speaking, legal digital currencies can be simply classified as wholesale CBDC and retail CBDC. For example, in many developed countries (e.g. France), their central banks are more likely to develop wholesale CBDC, which is mainly used for mutual settlement between financial institutions to reduce systemic risks and improve payment efficiency. In addition, in many developing countries (e.g. China), central banks are more tend to develop retail CBDC for daily payment, which has the potential for universal use.

The e-CNY issued by the People's Bank of China is triggering a new wave of changes in the financial sector. This paper integrates relevant theories to examine the potential effects of CBDC on the current monetary system and monetary multipliers. It also aims to construct an empirical model to analyze factors influencing the narrow monetary multiplier, thereby exploring CBDC's potential impact on it and investigating its implications for current monetary policy. The influence of policy provides new perspectives and relevant thinking. The innovation and contribution of this article is mainly the fact that the data selected in this article comes from the macro data of the last 10 years from the third quarter of 2014 to the second quarter of 2024, which is very timely. In addition, in terms of empirical analysis, in the absence of actual data of CBDC, this paper uses the share of third-party payment to simulate the payment data of CBDC, and builds a VAR model in combination with other relevant indicators, with comprehensively theoretical analysis to explore the possibility of the monetary multiplier with CBDC. The remainder of this paper is organized as follows. In Section 2, this part would summarize some existing researching results and sort out the content. In Section 3, the theoretical analysis related to the impact on the monetary multiplier from CBDC is described. In the following Section 2, the data, their sources, and how they were processed into the measures used for analysis is described. After that, an empirical analysis is given. Finally, some conclusions and corresponding suggestions would be generated.

2. Literature Review

Over the past years, under the continuous integration of the traditional monetary system and digital currency, CBDC is playing an increasingly important role in promoting the traditional monetary system. The appearance of this historic process is attracting wide attentions from scholars in relevant fields.

First of all, the issuance of CBDC has brought a lot of good development space to the traditional monetary system. For instance, the extensive application of CBDC may solve some inherent problems in the traditional monetary system and bring great changes and development opportunities to the traditional monetary system [3]. In addition, in terms of security, it was pointed out that CBDC has an important advantage over privately operated digital payment services, because they are fiat currency [4]. Therefore, theoretically, they would be safer. In terms of environmental protection, CBDC also has many positive implications. For instance, CBDC has led to an increase in the issuance of green bonds within the manufacturing sector and state-owned enterprises [5]. In addition. CBDC reduces SO_2 and NO_X emissions and smokeless emissions, improving land utilization, which is conducive to sustainable development [5]. Another case from China is that e-CNY will alter the structure of money demand, accelerate the circulation of money, and make central bank reserves more controllable [6]. Simultaneously, e-CNY will expand the channels where monetary policy is transmitted, enhance the effectiveness of existing monetary policy tools, and make the intermediate targets of monetary policy more manageable and dependable [6]. The efficient transmission of policy through this currency positively influences the achievement of monetary policy objectives [6]. From the above research results, it can be seen that the issuance of CBDC plays many positive significance in promoting safety, environmental protection and optimizing monetary policy transmission channels. However, the widespread distribution of CBDC has also brought some potential hidden risks.

In terms of financial stability, although CBDC will not represent the separation between the dollar-centered international currency and the financial system [7], it also brings many potential risks, such as lack of regulation [8]. In addition, from the perspective of commercial banks, the substantial rise in central bank reserves might mean that some commercial banks have not adequately prepared for the introduction of CBDC in recent years. Consequently, the issuance of CBDC could have several negative impacts on a banking system that is heavily reliant on deposits, including potential capital issues and

reduced profitability [9]. At the same time, as a relatively recent development, the increase in money supply has led to a rise in central bank issued digital currency. However, there is no consensus on the attributes and design of digital fiat currency [10]. In addition, the design and implementation of CBDC might vary from country to country [11], which also introduces new challenges to the stability of the global financial system. Lastly, from the perspective of government performance, factors such as the inflation rate, economic inequality, and technical literacy significantly influence public perception of CBDC [12]. From this point of view, although the issuance of CBDC has significant potential in improving financial stability and promoting changes in the international monetary system, it still faces many challenges in its implementation process. Especially in the liquidity pressure and the risk of loss of profits that commercial banks may encounter, as well as the differences between countries in the design of CBDC. This shows that in order to ensure the smooth launch and long-term success of CBDC, policymakers and financial institutions are strongly suggested to carefully weigh the advantages and disadvantages, continuously optimize relevant mechanisms to cope with potential adverse effects and achieve the stability and innovative development of the global financial system.

Generally speaking, the current literature has made a detailed study on the impact of the distribution of CBCD in many fields, and has achieved very valuable results, which are also important bases for the research of this article. However, there are still some shortcomings. First of all, since CBDC is a new payment method that has emerged in recent years, there is no good way to collect first-hand accurate relevant materials. In addition, in terms of research methods, most of the surveys conducted by relevant research institutes are based on the questionnaires, and most of the data also comes from the corresponding questionnaires. There may be certain limitations in scope. Besides, some data is unavoidable subjective, so it's difficult to control the data quality. Finally, in terms of the entry angle of the traditional monetary system, the relevant research rarely chooses to conduct a detailed analysis of the indicator of the monetary multiplier. The gaps in these research fields also provide direction and guidance for the work of this paper to a certain extent.

3. Theoretical Analysis

In this part, this article refers to part of the theory in Frederick S.Mishkin's " The Economics of Money, Banking, and Financial Markets" :

$$R=RR+ER \tag{1}$$

The equation (1), will be used as the starting point to derive the money supply model. R represents the total reserve of the banking system, RR represents the legal reserve, and ER represents the excess reserve.

The following relevant parameters are stipulated as below: Currency ratio (c), Excess reserve ratio (e), and Statutory reserve ratio (rr). Here, $c=\frac{C}{D}$, $e=\frac{E}{D}$, $rr=\frac{RR}{D}$, C represents cash.

Besides, for the study of this paper, Yang and Zhou' s research is of great rederence significance [6]. First of all, the monetary multiplier (m) reflects the multiple of the conversion of the base currency (M_B) into money supply (M). That is:

$$m=M/M_B \tag{2}$$

To derive the narrow monetary multiplier m_1, it is necessary to obtain the expressions of M_1 and M_B respectively. It can be seen from the traditional monetary theory that the base currency can be obtained by adding the total reserve to the total currency. That is:

$$M_B=C+R \tag{3}$$

Here, C represents cash and R represents the reserve. According to (1), there is:

$$M_B=C+RR+ER \tag{4}$$

At the same time, money supply M_1 can be given by:

$$M_1=C+D \tag{5}$$

Here, C represents cash and D represents current deposit. Therefore, m_1 can be obtained as:

$$m_1=\frac{C+D}{C+RR+ER} \tag{6}$$

Through sorting, there is:

$$m_1=\frac{1+c}{c+e+rr} \tag{7}$$

On this basis, the introduction of central bank digital currency classified in the M_0 category will have a more direct impact on C. At the same time,according to formula (3) and (5), after the introduction of the central bank's digital currency, there will be:

$$M_1{}^*=C+D+CBDC \tag{8}$$

$$M_B=C+R+CBDC \tag{9}$$

Here, CBDC represents the circulation of central bank digital currency, so at this time:

$$m^*_1=\frac{C+D+CBDC}{C+RR+ER+CBDC} \tag{10}$$

After sorting out, There is:

$$m^*_1 = \frac{c + ed + 1}{c + ed + rr + e} \quad (11)$$

ed is given as $ed = \frac{CBDC}{D}$. In order to study the impact of the introduction of CBDC on the narrow monetary multiplier m_1, now find the partial derivative of *ed* for m^*_1, and there is:

$$\frac{\partial m^*_1}{\partial ed} = \frac{rr + e - 1}{(ed + c + rr + e)^2} \quad (12)$$

Since the range of *ed* is always between 0 and 1, and according to the analysis, the value of the partial derivative of *ed* for m^*_1 in the *ed* range between 0 and 1 is negative, which demonstrates that the increase of *ed* would have an inhibiting effect on m_1. Hence, the value of m^*_1 will gradually decrease in the *ed* range between 0 and 1. There exists:

$$m^*_1 = \frac{c + 2}{c + 1 + rr + e}, \text{ where } ed=0 \quad (13)$$

$$m^*_1 = \frac{c + 1}{c + rr + e}, \text{ where } x=1 \quad (14)$$

From the definition of *rr* and *e*, it is obvious that the sum of *rr* and *e* is less than 1. After analysis, it is easy to found that the value of formula (13) is larger and formula (14), which verifies the conclusion above.

Theoretically speaking, the introduction of CBDC increases the liquidity of money, so there is a certain reduction effect on m_1. In Part 3, this paper analyzed the potential influence of the CBDC on the narrow monetary multiplier from the theoretical perspective, and predicted that CBDC may restrain the growth of the monetary multiplier by increasing liquidity, as it is part of M_0. With the change of money demand structure, the traditional money supply mechanism is also facing challenges. Next, Part 4 will perform an analysis of the impact of CBDC based on empirical data. By using VAR model and time series data, this paper will verify the theoretical conclusions in Part 3 and explore the specific factors affecting the change of narrow monetary multiplier, such as e-CNY payment ratio and reserve ratio.

4. Empirical Analysis

In the absence of legal digital currency actual data, combining narrow monetary multiplier, currency ratio, market share of third-party payment, Ratio of time deposit to current deposit, and bank deposit reserve requirement ratio, this part analyzed the factors of narrow monetary multiplier and discussed legal digital currency issue of the narrow monetary multiplier. This article draws on some existing references of some empirical analysis methods of monetary multiplier [13,14], mainly using the time series model like VAR.

4.1 Data and Variables

4.1.1 Narrow monetary multiplier (m_1)

Although the appearance of electronic money has fuzzed up the level of money to some extent, this impact has not shaken the traditional monetary system. Therefore, this paper will focus on the influence of electronic money on the narrow monetary multiplier, and take the narrow monetary multiplier as the explained variable. The generalized narrow monetary multiplier is given from the money supply formula $m_1 = \frac{1 + c}{c + e + rr}$. The definitions of those variables will be given below.

4.1.2 The proportion of digital RMB payment in the market payment amount (ep)

As a key variable in the development of digital currency, the increase of digital RMB payment in the share of payments is expected to significantly affect the changes in the narrow monetary multiplier. Considering it is difficult to get the relevant data of digital RMB payment, this paper used the proportion of the market share of third-party payment (*ep*) to replace this variable and made relevant research on its influence on the narrow monetary multiplier.

4.1.3 Currency ratio (c)

The currency ratio reflects the relative ratio of cash circulation and current deposit, and is one of the important factors which affect the change of monetary multiplier. This paper used it as one of the explanatory variables to analyze the potential impact of its changes on the narrow monetary multiplier.

4.1.4 Ratio of time deposit to current deposit (t)

Time deposit relative to the ratio of current deposit change, reflects the internal characteristics of the deposit. This factor mainly affects the monetary multiplier through the liquidity in the bank system and amount of loanable capital.

4.1.5 Excess reserve ratio (e) and statutory reserve ratio (rr):

At present, although the digital currency has a small impact on the reserve ratio, reserve ratio still plays an important role in the policy regulation of the central bank.

Through the above mentioned calculation, the initial data which came from Wind generated *ep*, *e* and *rr.* And the data from The People's Bank of China generated m_1, *c*

and *t*. Meanwhile, for the incomplete value of the initial data, it was interpolated using Stata. The above descriptive statistics of the variables is given below in Table 1.

Table 1. Descriptive Statistics of the Variables

	m_1	*e*	*rr*	*c*	*t*	*ep*
Average	3.7679	0.0180	0.1256	0.1718	3.1007	0.0351
Maximum	4.3574	0.0270	0.2000	0.2251	4.4017	0.0489
Minimum	2.7714	0.0120	0.0900	0.1466	2.4230	0.0095
Standard Deviation	0.4163	0.0040	0.0324	0.0210	0.4747	0.0130

4.2 The ADF Unit Root Test for the Variables and the Establishment of VAR Model

This empirical test selects time series data, in order to avoid pseudo regression, it is necessary to test the sequences for stationarity. In this paper, the ADF unit root test was used for the stationarity test. The test results were given in Table 2.

Table 2. Augmented Dickey-Fuller (ADF) Test

Variable	Test Statistic	p	1%	5%	10%	Stationary
m_1	-2.456	0.1266	-3.655	-2.961	-2.613	Non-Stationary
D. (m_1)	-5.983	0.0000	-3.662	-2.964	-2.614	Stationary
ep	-2.292	0.1745	-3.655	-2.961	-2.613	Non-Stationary
D. (*ep*)	-4.920	0.0000	-3.662	-2.964	-2.614	Stationary
c	-1.648	0.4581	-3.655	-2.961	-2.613	Non-Stationary
D. (*c*)	-9.525	0.0000	-3.662	-2.964	-2.614	Stationary
t	0.713	0.9901	-3.655	-2.961	-2.613	Non-Stationary
D. (*t*)	-9.845	0.0000	-3.662	-2.964	-2.614	Stationary
e	-5.235	0.0000	-3.655	-2.961	-2.613	Stationary
D. (*e*)	-12.125	0.0000	-3.662	-2.964	-2.614	Stationary
rr	-2.012	0.2812	-3.655	-2.961	-2.613	Non-Stationary
D. (*rr*)	-6.962	0.0000	-3.662	-2.964	-2.614	Stationary

Note: D. (*) represents the first-order differential calculation of the variables.

Through the ADF unit root test, it is found that all sequences satisfy the integrated of order one. According to the requirements of modeling for sequence stationarity, the VAR model is established after the first order difference of all sequences.

The model used in this paper does not set the exogenous variables, so the mathematical expression of the VAR model is as follows:

$$y_t = \varphi_1 y_{t-1} + ... + \varphi_p y_{t-p} + \epsilon_t \quad (15)$$

In the formula above, y is the column vector of endogenous variables, p is the lag order, t is the number of samples, $\varphi_1,...,\varphi_p$ is the matrix of the coefficient to be estimated and ϵ_t is the disturbance column vector.

4.3 Cointegration Relationship Test and Optimal Lag Order Selection

By estimating the cointegration coefficient using OLS and performing ADF tests on the residue sequence, long-term equilibrium relationships between these unit root variables. Meanwhile, the VAR model needs to choose the optimal lag period for regression, and the result of Lag period number selection is shown in Table 3, showing that the optimal lag order is 4. Considering the AIC index and the internal relationship of the economic system, a six-variable VAR model with lag 4 periods is established.

Table 3. Results of Lag Period Selection

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	604.009				1.5e -22	33.2227	-33.1306	-32.9588
1	792.506	376.99	36	0.000	3.2e -26	-41.6948	-41.05	-39.8473*
2	854.976	124.94	36	0.000	8.9e -27	-43.1654	-41.9679	-39.7344
3	902.508	95.063	36	0.000	7.8e -27	-43.806	-42.0558	-38.7915
4	961.447	117.88*	36	0.000	7.4e -27*	-45.0804*	-42.7775*	-38.4824

4.4 Unit Circle Inspection

The characteristic root test shows that all of the characteristic roots lie inside the unit circle (Fig.1), indicating that the model is relatively stable.

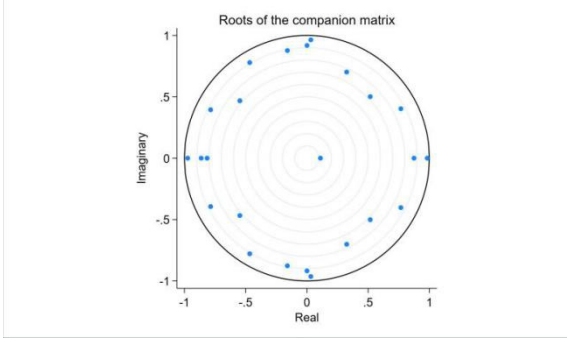

Fig.1 Test results of the unit circle

4.5 Granger Causality Test

To determine whether there is a economic correlation among the sequence of variables, the established VAR model was tested for Granger causality, and the test results are listed in Table 4. As it can be seen from Granger's test results, it is obvious that *ep*, *rr* and *e* have significant predictive ability, especially the influence of *ep* and *e* is relatively significance.

Table 4. Granger Causality Test Result

Null Hypothesis	χ^2 Statistic	Degrees of Freedom	P- value	Conclusion
D. (*ep*) does not Granger cause D. (m_1)	17.8510	4	0.001	Reject
D. (*c*) does not Granger cause D. (m_1)	4.9419	4	0.293	Accept
D. (*t*) does not Granger cause D. (m_1)	2.9313	4	0.569	Accept
D. (*e*) does not Granger cause D. (m_1)	19.9690	4	0.001	Reject
D. (*rr*) does not Granger cause D. (m_1)	9.8318	4	0.043	Reject
All 5 variables do not Granger cause D. (m_1)	60.8870	20	0.000	Reject

4.6 Pulse Response Analysis

Granger Causal test can analyze the static influence relationship between the variables, while the pulse response function could reflect the influence degree of the dynamics of each variable. In this paper, the pulse response is analyzed and the pulse response function image (Fig.2) is made.

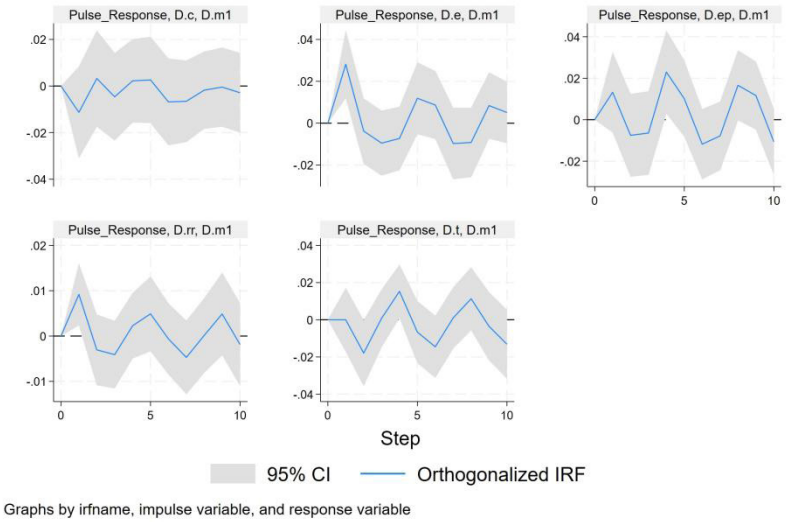

Fig.2 Pulse Response Analysis Results

Take 10 periods as the lag period to investigate the influence of the five elements on the narrow monetary multiplier in the short term. As shown in Fig.2, in the initial response of *ep* effect to m_1, the initial response of m_1 was positive over 0.02, after which it rapidly decays to subzero level and eventually stabilizes. The initial positive response may indicate that during the early promotion and application of CBDC, the monetary system reacts in a relatively positive manner, particularly due to enhanced liquidity and market adjustments. It is important to emphasize that such an initial positive response is often a short-term phenomenon. The impact of short-term residual impact is not necessarily consistent with the long-term equilibrium coefficient [13]. As the market adapts to CBDC and the structure of money demand adjusts, the rate of change in the monetary multiplier may gradually turn negative or stabilize, reaching a more balanced state. As shown in Fig.2, on the whole, near the 10th lag, the response of the group's impact tends to be negative, which is similar to the theoretical analysis results above. However, the initial effect response of m_1 to *c* was relatively drastic, and the initial response was negative. Moreover, the first steps fluctuated greatly, but then the impact gradually decreased, indicating that the long-term effects of the impact may be less significant. Under the influence of *t*, m_1 has a slight negative response, followed by positive and negative alternation, with an amplitude maintained around 0.02. In addition, under the shock of *e*, the initial response of m_1 is negative, and relatively intense. After that, positive and negative behaviors are alternating, and the amplitude reduction trend remains at around 0.01, gradually stabilizing. The response to m_1 at *rr* effects is similar to *e* overall. The difference is that the initial corresponding amplitude of m_1 is smaller and is better for subsequent stability. Overall, the effects of individual variables on m_1 mostly tended to 0 over time, suggesting that the long-term effects of these shocks are limited.

5. Conclusion

With the rapid advancement of financial technology, countries worldwide have accelerated the exploration of central bank digital currency (CBDC). As a digital version of legal currency, CBDC not only has the potential to boost the efficiency of the payment system and enhance the transmission effect of monetary policy, but also provides new opportunities for countries to respond to the rise of the digital economy. Against this background, China did a good job in launching e-CNY and gradually promoted its nationwide pilot application. The People's Bank of China has clearly included the digital e-CNY in the M_0 statistical category, highlighting its important position as a cash substitution. However, the introduction of CBDC has also affected the traditional monetary system, particularly regarding the money supply mechanism, liquidity management in the banking sector, and financial stability. This has caused extensive academic debate and policy concerns. Consequently, examining the impact of CBDC on the traditional monetary system with a particular focus on the monetary multiplier is highly important.

Through an analysis of the relationship between CBDC and the traditional monetary system, this paper has put

forward the following new understandings:

First of all, from a theoretical perspective, the issuance of CBDC not only improves the liquidity of money, but also may change the structure of money demand, which has a direct impact on the traditional monetary multiplier. Through the introduction of CBDC, the issuance and circulation mechanism of money has become more diversified, making the central bank more flexible in controlling the money supply. However, because CBDC is classified as M_0, the increase in liquidity has a certain inhibiting effect on the narrow monetary multiplier, which is significantly different from the traditional money supply mechanism.

Secondly, in empirical analysis, this paper has analyzed the impact of multiple factors including 5 different variables on the narrow monetary multiplier by constructing a VAR model. The research results have shown that the increase in digital currency payments has significantly affected the change of monetary multiplier, especially in the relatively longer term, which has an inhibiting effect on money supply. In addition, pulse response analysis has indicated that although the impact of various variables on the narrow monetary multiplier is relatively obvious in the early stage, its impact would finally weaken over time. This means that although the introduction of CBDC will affect current monetary policy transmission mechanism in the short term, its impact might still be limited in the long run.

The findings of this paper are crucial for understanding the role of CBDC within the monetary system. From a positive perspective, relevant research shows that CBDC can enhance the current payment system and boost the effectiveness of monetary policy, especially in promoting green finance and improving payment security. However, the analysis of this paper has shown that the introduction of CBDC is not absolutely risk-free, and its potential impact on the liquidity pressure, profitability and financial stability of commercial banks still needs further carefully evaluating. In conclusion, the contribution of this article is to link CBDC with the narrow monetary multiplier for the first time, and to explore the potential impact of CBDC on monetary policy by using time series data for modeling and analysis. In future studies, we can further combine a wider range of actual CBDC data and other macroeconomic variables to explore the performance and long term impact of CBDC in different economies. At the same time, the policymakers are supposed to adjust monetary policy tools flexibly based on the scale of CBDC circulation to ensure supply stability and strengthen regulation and support for commercial banks. The introduction of CBDC should be phased to reduce market volatility. Finally, given the differences in CBDC implementation across countries, international cooperation and knowledge sharing are also essential, in order to ensure the stability of the global financial system and the optimization of CBDC policy.

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