

# **China's unconventional monetary policy in response to Covid-19**

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## Abstract

This thesis examines the efficacy of China's unconventional monetary policy (UMP) in alleviating the economic disruption resulting from the Covid-19 pandemic. The study first utilizes a computable general equilibrium (CGE) framework to analyze the pandemic shock, breaking it down into direct, indirect, and interaction effects across various sectors. It identifies small and medium-sized enterprises and service industries as the most susceptible to these impacts.

This study assesses China-specific unconventional monetary policy instruments—targeted liquidity facilities, credit-support measures, and foreign exchange management—through a standard econometric framework. A TVP-SV-VAR model evaluates the transmission effects of specific tools, whereas a DSGE model incorporating policy expectations analyzes the systemic effects of policy combinations.

Results indicate that UMP measures contributed moderately yet significantly to economic recovery, with quantity-based interventions producing quicker short-term benefits but exhibiting diminished long-term effectiveness in the absence of complementary fiscal coordination. The effectiveness of policy relied on achieving a balance between flexibility and predictability while addressing structural frictions in transmission. Data from a high-frequency inflation expectations index, derived from social media, indicates that public sentiment responds more swiftly to real-time information compared to official announcements, highlighting the importance of digital monitoring in monetary policy.

The findings indicate that improving market-oriented reforms, broadening China-specific UMP instruments, and institutionalizing real-time expectation measures may enhance the adaptability and accuracy of monetary policy in addressing

future shocks.

**Keywords:** Monetary policy, Unconventional monetary policy, Central bank, Monetary policy framework, Covid-19 Shock decomposition, Policy Effectiveness, Public expectation.

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# Chapter 1

## Introduction

Monetary policy serves as a fundamental instrument for macroeconomic regulation by the central bank. Since the People's Bank of China resumed its central banking functions in 1984, the framework of China's monetary policy has developed significantly. In the new normal period, China's economic development model has transitioned from high-speed growth to high-quality growth. Concurrently, the flexible mechanisms of credit creation, the evolving financial innovation products, and the deepening economic reforms have introduced new challenges for the macro-control of monetary policy. Currently, China's monetary policy framework is transitioning from a quantity-based to a price-based system, characterized by a hybrid approach to macroeconomic regulation that incorporates both quantity and price elements. To enhance the governance of modern monetary policy and facilitate high-quality economic development, the central bank must optimize the monetary policy target system, diversify the operational instruments of monetary policy, and simultaneously improve the transmission channels of monetary policy. The Covid-19 outbreak has presented significant challenges to the implementation of unconventional monetary policy within the monetary policy framework. This paper will examine the implementation of unconventional monetary policy in response to Covid-19, focusing on the monetary policy framework, including target anchoring, instrument selection, and the transmission and effectiveness of the system for a systematic analysis. This chapter serves as the introduction to the paper, outlining the research background and the significance of the chosen topic. It will also review the current status of related research and subsequently provide a brief overview of the research content, structural arrangement, methodology, and innovations presented in this study.

## **1.1 Background and significance of the study**

### **1.1.1 Background**

In late 2019, a new type of coronavirus, subsequently identified as Covid-19, was detected in individuals in Wuhan, Hubei Province, China. The virus's high transmissibility facilitated a rapid outbreak across the country following the Spring Festival, posing a significant threat to human safety. To prevent large-scale population movements and gatherings, Wuhan instituted a lockdown on 24 January 2020, aligning with control measures aimed at curbing internal proliferation and external importation. Other cities in Hubei also enacted lockdowns in response to similar prevention and control needs.

The Chinese government has implemented a national strategy to address the epidemic through home quarantine measures and an extension of the Chinese New Year holiday. The emergence and dissemination of the epidemic will significantly affect China's economic development, population health, and social stability. During the initial phases of the Covid-19 outbreak, China implemented a stringent lockdown policy and allocated substantial medical resources to mitigate the spread of the epidemic. The epidemic was largely controlled, but the supply and demand chain in China was still significantly impacted. The resurgence of the epidemic internationally has contributed to a persistent decline in China's domestic economy and foreign trade. The ongoing increase and persistence of confirmed Covid-19 cases have concurrently heightened public concerns regarding health security and economic development. As of 31 December 2020, real-time statistics from the World Health Organisation (WHO) indicate that mainland China reported 96,178 confirmed Covid-19 cases, with 4,787 fatalities. Globally, the total number of cases has surpassed 83 million, resulting in

over 1.83 million fatalities. The magnitude of Covid-19 in China significantly surpasses that of the comparable public health crisis, SARS, which reported 5,327 cases and 349 deaths in mainland China. Covid-19 was also represented one of the most significant global public health crises in history, by WHO<sup>1</sup>.

Similar to the financial crisis of 2008 to 2009, governments are currently employing monetary and fiscal policies to mitigate the challenges posed by the ongoing epidemic crisis. In contrast to the financial crisis, the movement restrictions imposed by the Covid-19 outbreak have resulted in an immediate adverse effect on labour supply, transport, and travel, which was not observed during the financial crisis. The Covid-19 outbreak, along with US-China trade tensions, has imposed significant pressures and challenges on Chinese companies and the national economy.

In response to the Covid-19 outbreak, China established a first-level response mechanism for significant public health emergencies in early 2020, focussing on regulating the movement of individuals. Due to China's outbreak prevention and control measures, 68.75% of the provinces postponed the resumption of work for up to 17 days. Hubei Province, the most affected area, delayed work resumption until March 10th, resulting in nearly 50 days of inactivity for companies. The International Monetary Fund (IMF) projected that China's GDP growth in 2020 would decline to between 9.9% and 12% as a result of the shutdown. According to calculations by the China Statistics Bureau, China's GDP in the first quarter of 2020 decreased by 6.8% compared to the previous year, with the primary, secondary, and tertiary sectors declining by 3.2%, 9.6%, and 5.2%, respectively. Initially, some Western authorities expressed optimism regarding the epidemic, positing that, despite potential adverse effects on China's economy, the overall economic impact for the year would be relatively

<sup>1</sup> WHO news conference, 30 January 2020. WHO news conference, 11 March 2020.

minor. Many, however, underestimated the consequences of the epidemic. Initially, following the containment of the outbreak by the Chinese government at the end of April 2020, cautious measures have been maintained due to concerns regarding the spread of imported cases. Concurrently, there has been an active promotion of the resumption of production and labour across the nation. The University of Oxford in the United Kingdom has classified governments' quarantine policies into various levels of stringency, referred to as the Covid-19 Stringency Index (C19SI). Countries like China and Vietnam have implemented stringent measures to eliminate virus transmission, primarily by enforcing complete city lockdown. Simultaneously, the United States and certain European nations implemented mitigation strategies to curb the virus's transmission, primarily through isolation techniques, including the use of masks by residents. Numerous outbreaks were prevented nationwide due to the implementation of suppression measures. Nonetheless, the suppression measures have effectively halted social economic activities in China.

To address the challenges posed by Covid-19 and sustain economic operations, the Chinese government has sequentially enacted a series of fiscal and monetary policies. A range of unconventional monetary policy instruments was incorporated. What is the efficacy of these unconventional monetary policy instruments in managing the Chinese economy? What is the number of targets that have been accomplished? When shall normal operations resume? The enduring impact of Covid-19 on the Chinese economy, coupled with the potential for further intensification as the pandemic progresses, renders these enquiries crucial for China as it confronts the likelihood of further disruptions in the future. In this context, accurately estimating the economic impact of the epidemic amid an increasingly volatile and uncertain environment, as well as selecting appropriate unconventional monetary policies, has emerged as a significant concern for policymakers, academics, and the public.

## 1.1.2 Significance

1) Examining unconventional monetary policy can augment the standard monetary policy framework, deepen the comprehension of novel instruments, and facilitate the successful application of unconventional monetary policy instruments. The examination of monetary policy efficacy is a prevalent subject in economics, and the analysis of unconventional monetary policy effectiveness might enhance the theoretical framework of New Keynesian economics about the non-neutrality of monetary policy. The 2008 global financial crisis significantly influenced the evolution of the monetary policy framework, prompting developed nations to frequently employ unconventional monetary policies for domestic economic recovery, a trend that many developing countries have subsequently adopted. However, the shock induced by Covid-19 markedly differs from the financial crisis, and the domestic and international contexts, along with policy control mechanisms, are also distinct. China's monetary policy system is structurally distinct internationally, blending conventional and unconventional Instruments within its state-influenced framework. Unlike advanced economies relying on interest rates or broad quantitative easing, the PBOC employs targeted structural instruments as core mechanisms. These include direct credit allocation (e.g., PSL loans for infrastructure), hybrid interest rate steering (LPR anchored to policy rates), and macroprudential levers (dynamic RRR/LTV adjustments) tailored by sector or institution. Administrative guidance leverages state-owned banks for granular credit control. Crucially, this system integrates monetary, industrial, and fiscal targets—prioritizing sector-specific stability and development over market neutrality. Capital controls enable instruments impractical elsewhere. Globally, such embedded "unconventional" approaches form a unique institutional alternative to Western models centered on price signals and independent central banking. Consequently, it is challenging for China to draw upon the West's unconventional

monetary policy experiences, and forecasting the policy's effects prior to implementation is equally problematic. This further emphasises the necessity of examining unconventional monetary policy with Chinese attributes. Monetary policy Instruments constitute the operational instruments employed by central banks to regulate money supply, credit conditions, and broader economic activity. Studying China's unconventional monetary framework—characterised by targeted credit allocation (e.g., PSL), hybrid interest rate benchmarks (LPR), and macroprudential levers calibrated to institutional scale—offers instructive perspectives for other economies. Its integration of structural guidance within a state-capitalist context demonstrates: (i) mechanisms for directing credit during market failures, (ii) synergistic deployment of monetary and financial stability instruments under capital controls, and (iii) alternative stimulus approaches for emerging economies facing conventional policy constraints. This institutional innovation enriches global understanding of monetary architecture beyond orthodox market-centric models.

2) Decomposing the Covid-19 impact on China's macroeconomy enables policymakers to accurately identify the economic sectors and operational processes most adversely affected, hence enhancing the targeting and efficacy of unconventional monetary policies. Most contemporary research regarding the effects of Covid-19 on China's economy mostly focus on certain macroeconomic metrics, such as the unemployment rate and output gap, and lack a quantitative and systematic evaluation (Sheng, 2020; Zhu et al., 2020; Liu et al., 2021). By examining the mechanism through which Covid-19 affects the macroeconomic system and analysing its shocks within the framework of China's economy, we can gain a clearer understanding of the various short-term, long-term, and other impacts experienced by both supply and demand, thereby facilitating the formulation of targeted policy recommendations.

3) Examining the function of unconventional monetary policy instruments through time-varying models is more effective in capturing the dynamic aspects of policy implementation impacts. The TVP-SV-VAR model facilitates an independent analysis of the efficacy of unconventional monetary policy instruments employed by China in response to Covid-19, as well as the effectiveness of the transmission channels, thereby enabling a more precise identification of the most suitable instruments and channels for implementation. Consequently, it can offer recommendations for China's central bank to develop unconventional monetary policy portfolios in anticipation of potential future pandemic shocks.

4) The development of unconventional monetary policy portfolio variables utilising the DSGE model enhances the discourse on the optimal selection of policy portfolio types. In China's macroeconomic framework, primary policy shocks are categorised into price and quantity categories. Nonetheless, despite the allusions to the alteration in primary policy types within the reports and presentations of the People's Bank of China and the National Ministry of Finance (NMF), it remains ambiguous which policy type is more suitable for the Chinese economy during a phase of systematic transition to address intricate and sudden shocks like Covid-19. Combined with the discussion of unconventional monetary policy instruments and channels, our research should help policymakers make better choices about policy preferences.

5) Offering a more accurate assessment of the public's inflation expectations. China's methodology for assessing public inflation expectations is excessively protracted and comparatively simplistic. The results are ill-suited for monetary policymaking that integrates public inflation expectations. The primary reason is that the questionnaire survey method employed by the PBOC is conducted solely on a quarterly basis, and the design of the questionnaire is very simplistic, with a restricted sample population.

Furthermore, there exists a two-quarter delay in the publication of the statistical outcomes from the inflation questionnaire. Considering China's advanced level of informatisation and socialisation, the significance and utilisation of social media information could enhance the accuracy of estimating public inflation expectations. The intricate nature of the Chinese language necessitates the optimisation of the entire process of utilising Chinese text, which will also subsequently benefit studies conducted on social media.

## **1.2 Literature review**

### **1.2.1 Definition and characteristics of unconventional monetary policy**

Monetary policy is fundamental to contemporary macroeconomic management, involving the systematic adjustments of monetary conditions by central banks to attain key objectives, including price stability, full employment, and financial stability. The conventional nature is evident in the standardized framework for tool selection, operational mechanisms, and transmission channels, which is based on a consensus framework that integrates New Keynesian and monetarist theories (Clarida et al., 1999).

Conventional monetary policy focuses on short-term policy interest rates as its main operational target, utilizing liquidity management through three established tools. Initially, open market operations, including government bond repurchase agreements, directly control the quantity of reserves within the banking system. Adjusting the reserve requirement ratio modifies the limits of the money multiplier. Third, the establishment of the rediscount rate functions as the cost anchor for emergency

financing provided to commercial banks. The primary role of these tools is to influence interbank overnight interest rates, such as the federal funds rate in the United States or the interbank repo rate in China. This influence subsequently propagates through the interest rate term structure to affect medium- and long-term rates (Taylor, 1993). Their conventional nature is defined by three characteristics. The tools possess an intermediary nature. The operational target, which is short-term interest rates, serves as a means to influence the real economy. This influence occurs through a sequence that begins with the interest rate channel, progresses to the credit channel, and ultimately affects the asset price channel. Lower interest rates decrease corporate financing costs and promote investment expansion (Bernanke & Blinder, 1992). The clarity of regulations is essential. Policy adjustments adhere to established response functions, exemplified by the Taylor rule. The central bank employs communication strategies to facilitate the formation of stable market expectations, thereby mitigating volatility resulting from abrupt policy shifts (Woodford, 2001). The market's autonomy is the third consideration. The central bank establishes only short-term price signals, while financial intermediaries independently allocate resources; the policy does not directly influence specific credit flows or asset price formation (Mishkin, 2007).

This framework presupposes two fundamental premises: the existence of an effective lower bound for the policy interest rate (generally close to zero) and the proper functioning of the financial system's transmission mechanism. Historical evidence indicates that in a typical setting characterized by moderate inflation and financial stability, conventional policies can effectively mitigate economic cycles by adjusting interest rates (Romer & Romer, 2004). The Federal Reserve increased interest rates 17 times consecutively from 2003 to 2006 to control inflation, while the core CPI remained stable at 2%-3%, illustrating the effective regulatory function of interest rate

instruments on aggregate demand.

The effectiveness limits of traditional policies are distinctly determined by their conventional characteristics. In situations where the economy enters a liquidity trap or experiences structural breakdowns, the mechanisms dependent on interest rate transmission and market autonomy encounter significant challenges, requiring the implementation of unconventional tools that diverge from traditional paradigms. However, this limitation does not diminish its essential function as a macroeconomic stabilizer. Bernanke emphasized that monetary policy has normally been the first line of defense against short-term economic instability (Bernanke, 2007).

At present, the definition of the concept of unconventional monetary policy is more or less different in different research literatures, and different scholars have different perceptions and understandings of unconventional monetary policy. In the initial period of the financial crisis, unconventional monetary policy mainly referred to quantitative easing monetary policy. With more countries adopting regulatory instruments different from traditional monetary policy, subsequent studies tend to define such operations different from traditional conventional monetary policy as unconventional monetary policy. Dai (2010) defines it as an unconventional operation aimed at revising market interest rate expectations, reshaping monetary policy transmission channels, and unblocking the monetary policy transmission mechanism when the traditional monetary policy fails, and economic growth faces a prolonged depression. In contrast, IMF (2013) gives a more direct definition, based on the background and targets of unconventional monetary policy, that unconventional monetary policy is a monetary policy operation of the central bank aimed at providing liquidity to the financial market and stimulating economic recovery in the context of the zero interest rate floor. In addition, some scholars choose the unconventional

monetary policy operation of the central bank as a starting point, and define it as the policy measures of the central bank to directly create money supply in order to directly solve the liquidity problem of the main participants in the financial market. Overall, for western researches, compared with the conventional monetary policy, unconventional monetary policy has three main features, the policy commitment to maintain low interest rates, through large-scale asset purchases to expand the supply of base money, direct injection of liquidity into the financial market. Among these, the assumption of low or negative real interest rate levels is more common, and therefore the study of the low interest rate phenomenon should also be included in the discussion of unconventional monetary policy.

## **1.2.2 Unconventional monetary policy effectiveness**

During a period of extremely low interest rates, the impact of conventional loose monetary policy on stimulating the economy may be restricted. Central banks have resorted to unconventional monetary policy instruments to boost the economy. Following the financial crisis of 2008, there has been an increasing adoption of unconventional monetary policy. Consequently, there has been a significant growth in the study exploring the efficacy of such policies, resulting in an important amount of research. The current debates around the efficacy of unconventional monetary policies can be divided into two main categories: the effects on financial variables and the effects on the overall macroeconomy.

### **1) Effectiveness on financial variables**

Existing research mostly focus on analysing the influence of unconventional policy instruments on market yields and market spreads when evaluating the efficacy of unconventional monetary policies in mitigating financial market stress. The initial

discourse about the effectiveness of unconventional monetary measures centred on Japan's strategy of quantitative easing. The majority of pertinent studies have determined that Japan's quantitative easing programme has diminished the long-term yield on financial assets. A study conducted by Okina and Shiratsuka (2004) examined the impact of unconventional policies and concluded that the Bank of Japan's interest rate commitment policy successfully stabilised market expectations regarding short-term interest rate fluctuations. As a result, long-term interest rates and the yield curve were reduced. Using a no-arbitrage VAR model, Bernanke et al. (2004) assessed the term structure of interest rates in Japan. Their results also demonstrated that the Bank of Japan's quantitative easing programme had the effect of lowering the long-term yield of Japanese financial assets. Following the 2008 financial crisis, there has been a notable surge in study regarding the efficacy of unconventional monetary policy instruments employed by central banks in developed countries. Still, the analysis of financial variables primarily centres around market interest rates and market spreads. McAndrews et al. (2008) and Wu (2008) employed the event study methodology to examine the effects of the Federal Reserve's Term Auction Facility (TAF). Their research demonstrates that TAF has a notable impact on reducing the disparity between the 3-month USD Libor and the overnight index swap rate (Libor-OIS spread). Christensen et al. (2009) employed a multifactor no-arbitrage model to examine the influence of TAF on the risk-free rate and market risk rate. Their findings indicate that TAF effectively decreases the risk premium associated with the market risk rate. Nevertheless, Thornton (2010) contends that TAF does not influence market interest rates and liquidity premiums. The contraction of market spreads following the Federal Reserve's announcement of unconventional monetary policy operations was not caused by a decrease in the liquidity risk premium in the interbank market. Instead, it was a result of the market's anticipation of worsening financial crisis, which raised the default risk of financial bonds. Fleming et al. (2010) and Hrungr

and Seligman (2011) employed regression models to examine the effects of the Federal Reserve's Term Securities Lending Facility (TSLF). All of their regression results demonstrate that TSLF has a beneficial impact on decreasing repo spreads. The study conducted by Swanson and William (2012) and Woodford (2012) on forward guidance in the United States demonstrates that it effectively decreases future market interest rate expectations. Additionally, the large-scale asset purchase programme significantly enhances financial market conditions. More precisely, implementing an asset purchase plan of \$600 billion could potentially lower Treasury yields by approximately 0.15-0.2 percent. Darvas (2012) observes that the European Central Bank's OMT operations resulted in a substantial decline in Spanish 2-year Treasury yields and a moderate decrease in long-term Treasury yields. Several other research, employing diverse analytical techniques, have reached relatively comparable findings, including Williams (2011), Krishnamurthy and Vissing-Jorgensen (2011), Hamilton and Wu (2012), Gagnon et al. (2011), Chen, Cumia, and Ferrero (2012), and others.

Furthermore, several academics have employed regression techniques utilising low-frequency data, particularly the VAR approach, to offer supplementary evidence in examining the influence of unconventional monetary policies on asset prices. Due to the lower limit constraint of zero interest rates, short-term interest rates cannot be used as an explanatory variable to gauge the effectiveness of unconventional monetary policy. Therefore, the size of the central bank's balance sheet is usually employed as a proxy variable for this purpose. D'Amico and King (2013) employed panel regression analysis to evaluate the quantitative correlation between long-term US yields and the magnitude of the Fed's asset purchases. Their findings indicate that the Fed's \$300 billion in asset purchases resulted in an average reduction of 30 basis points in bond yields. Greenwood and Vayanos (2014) also conducted a study on the correlation between the size of the Federal Reserve's asset purchases and the extent of the

decrease in long-term interest rates. They discovered that a \$400 billion Treasury bond purchase programme resulted in an average reduction of 40 basis points in long-term interest rates. Balfoussia and Gibson (2016) examined the influence of the European Central Bank's targeted long-term refinancing operations on a financial market index. They achieved it by developing a VAR model based on several data.

Additionally, certain scholars have devised shadow interest rates as a means of evaluating the position and impact of unconventional monetary policies implemented by central banks. This approach draws on the methodology introduced by Black (1995). For instance, Krippner (2014), Wu and Xia (2016) put forward different techniques to calculate the shadow interest rate using long-term interest rate data. They showed that the implementation of quantitative easing decreased the shadow interest rate by analysing a counterfactual scenario using the FA-VAR model. Wright (2012) shows that bond yields are influenced by shocks to unconventional monetary policies, as simulated using an SVAR model, based on the estimation of shadow interest rate variables. However, these effects are temporary and do not last for a long time<sup>2</sup>. Neely (2015) challenges this conclusion, contending that SVAR models may underestimate the enduring impact of policy actions due to their excessive predictability. Several researchers have utilised the availability of government bonds as a metric to gauge the effectiveness and position of unconventional monetary policy. Gagnon et al. (2010) utilise a regression equation to establish a relationship between the 10-year term premium and the supply of government bonds. They conclude that quantitative easing plays a significant role in diminishing term risk. Yellen (2011b) conducted a study utilising data from November 2008 to March 2009 and determined that the Federal Reserve's extensive purchases of securities resulted in a cumulative reduction of approximately 107 basis points in the 10-year Treasury yield. Krishnamurthy and

<sup>2</sup> According to simulations from Wright (2012), the half-life of the effect of unconventional monetary policy on bond yields ranges from 3 to 6 months, i.e. the policy effect decays by half every three to six months.

Vissing-Jorgensen (2011) provide further support for the results obtained through the event-study method by employing a comparable strategy. They show that an increased ratio of government debt to GDP leads to a decrease in the yield differential between corporate bonds and Treasuries. There are several possible issues with analysing debt supply in this manner. One concern is that changes in government bond issuance are influenced by factors other than just central bank asset purchase programmes, making them partly endogenous. Furthermore, the issuance of government bonds is very predictable, making it challenging to examine the relationship with concurrent financial variables through simple regression analysis. This refers to that standard regression models do not sufficiently account for expectations.

## **2) Effectiveness on economic variables**

When examining the effectiveness of unconventional monetary policies on the overall economy, previous research has primarily focused on analysing how unconventional monetary policy instruments affect key variables such as output, employment, and inflation.

The effectiveness of macroeconomy cannot be accurately analysed using event analysis because of the higher level of endogeneity in macroeconomic factors, the presence of omitted variables, and measurement problems. The performed studies primarily employed DSGE stochastic simulation or other types of VAR models as empirical methodologies. The DSGE model can isolate and quantify the specific influence of unconventional monetary policy by simulating the macroeconomic conditions both with and without the policy in place. Chen et al. (2012) employed a calibrated DSGE model to assess the effects of quantitative easing. They specifically focused on the portfolio balance channel and concluded that the purchase of \$600 billion worth of long-term government bonds, along with a four-month commitment to a zero interest rate, would

result in a 0.13% increase in GDP growth and a 3 basis point rise in inflation. They also found that maintaining the zero interest rate commitment had a more substantial effect. Bhattarai et al. (2015) analysed the impact of long-term yields and expected inflation on the economy by incorporating changes in the size and maturity of the Federal Reserve's bond holdings. They found that the second round of quantitative easing had a greater stimulating effect on output compared to the combined effect of the third round of quantitative easing and Operation Twist. Del Negro et al. (2017) incorporate financial obstacles into a dynamic stochastic general equilibrium (DSGE) model and assess the overall economic consequences of unconventional monetary policies. They discover that exchanging liquid and illiquid assets between central banks can effectively mitigate the risk of economic contraction and deflation, and this approach continues to be effective even when interest rates reach their lower limit of zero. Ma et al. (2013) examined the effect of the European Central Bank's OMT policy by using a three-way game model. The findings of this study indicate that OMT operations effectively mitigate liquidity constraints and deflation in the euro market, hence facilitating the revival of long-term investment.

While the DSGE model is capable of simulating the intended policy effects through predetermined transmission channels, it still lacks statistical significance and persuasive power. VAR models, in contrast, offer a substantial empirical foundation for DSGE modelling and simulation by utilising a vast quantity of economic and financial data. The VAR approach, although it assumes less about the conduct of consumers and enterprises, need an appropriate mechanism for recognising policy shocks. The current research primarily utilises three instruments, specifically central bank asset size, interest rate indicator, and spread, as the policy variables in the study. A significant number of research have utilised central bank asset size as an explanatory variable, with a particular emphasis on Japan's quantitative easing strategy in the early studies.

For instance, Watzka & Schenkelberg (2011) developed a SVAR model with sign constraints. They used the total asset size of the Bank of Japan as the main endogenous variable. Their findings indicated that Japan's quantitative easing policy successfully increased domestic output without leading to excessive inflationary pressures. They also argued that this conclusion can be extended to other advanced economies facing the constraint of zero interest rates. According to Harada & Masuima (2009), Japan's quantitative easing strategy increased the amount of base money, which helped stimulate the expansion of aggregate output and alleviate the long-lasting recession in the Japanese economy. However, Bernanke et al. (2004) conducted an evaluation of Japan's quantitative easing programme prior to 2004 using the VAR model. They determined that this policy did not have a substantial impact on the economic recovery or the improvement of aggregate demand. In the words of Ugai's (2007) research, Japan's quantitative easing programme successfully steadied the financial sector but did not have a significant impact on the economic recovery. Cui (2014) employed a VAR model to assess the impact of Japan's unconventional monetary policy on the country's economic recovery and price improvement. The findings indicated that while the policy did have some influence, its significance was limited.

Due to the extensive use of unconventional monetary policy in major advanced economies, the VAR empirical research approach has also been employed to assess the impacts of unconventional monetary policy in other nations. Gambacorta et al. (2014) conducted a study where they used a VAR model with sign constraints to analyse central bank assets and macroeconomic data from eight countries, including the United States, the United Kingdom, and Canada. They discovered that when there is an external increase in central bank assets, it leads to a temporary boost in both output and the price level. Furthermore, empirical evidence demonstrates that unconventional

monetary policy exerts a more significant influence on output while having a lesser effect on prices compared to conventional monetary policy. In their study, Darracq-Paries & De Santis (2015) examined the impact of the European Central Bank's long-term refinancing operations on the macroeconomy. They used a panel vector autoregressive model with sign constraints and concluded that this approach successfully mitigated the credit crunch in the euro market. Bhattarai et al. (2015) used a Bayesian SVAR model to estimate the effects of quantitative easing. They measured changes in monetary policy using the Federal Reserve's asset size. The study found that quantitative easing in the United States has a substantial impact on both the U.S. economy and finance. Additionally, it has significant spillover effects on the financial systems of emerging market countries. Weale & Wieladek (2016) employed the ratio of cumulative central bank asset purchases to total output as a measure of monetary policy and evaluated the impacts of the asset purchase programmes of the Federal Reserve and the Bank of England by creating Bayesian VAR models. It was revealed that a 1 percent expansion in the scale of asset acquisitions by the Federal Reserve and the Bank of England results in a 0.58 percent and 0.25 percent boost in domestic output, and a 0.62 percent and 0.32 percent increase in the consumer price level, respectively. This approach effectively captures the characteristics and emphasis of unconventional monetary policy following the crisis. However, the assumption that the size of central bank assets is solely determined by monetary policy decisions is overly rigid, and this indicator is somewhat too broad in representing the various unconventional monetary policy instruments.

Some claim that several spread indicators offer a more accurate assessment of the effectiveness of a specific form of unconventional monetary policy compared to the size of the balance sheet. According to Walentin (2014), the extent of the Federal Reserve's unconventional monetary policy may be determined by comparing mortgage rates and

Treasury yields. Walentin's study shows that a decrease in this disparity will boost economic output, consumption, and real estate investment, as demonstrated by an SVAR model. Baumeister & Benati (2010) employed a comparable methodology to assess and contrast the impacts of the asset purchase programmes of the Federal Reserve and the Bank of England. They achieved this by developing a VAR model that incorporates a spread indicator that measures the 10-year term premium. It was discovered that the unconventional monetary strategies implemented by the Federal Reserve and the Bank of England were successful in mitigating the occurrence of a severe decline in economic output and a decrease in prices, when compared to the Great Depression of the 1930s.

Prior studies have employed a solitary interest rate variable to symbolise the monetary policy position of central banks. For instance, Fuhrer & Olivei (2011) isolate the influence of the Federal Reserve's second round of quantitative easing on the economy by examining the decrease in long-term interest rates. They then used a vector autoregressive model to evaluate the resulting macroeconomic effects. Evidence demonstrates that the implementation of the second wave of quantitative easing resulted in a 0.6 to 0.9 percent increase in actual production in the United States during the two years that followed. Gilchrist et al. (2015) employed the 2-year Treasury bill as an instrumental variable for monetary policy. They discover that the fluctuation in this indicator during the announcement of unconventional monetary policy effectively represents the trend in long-term yields. Wu & Xia (2016) utilised their calculated shadow interest rate indicator to construct an FAVAR model and discover that the impacts produced by unconventional monetary policy closely resemble the impacts of conventional monetary policy instruments prior to the crisis.

### 1.2.3 Impact of Covid-19

Numerous scientists have examined the economic implications of epidemics, including Covid-19, from a macroeconomic standpoint. Despite China's substantial reduction in infections and fatalities via stringent lockdowns and public health measures (Qiu et al., 2020), the extensive work stoppages resulting from the epidemic have nonetheless inflicted a considerable economic impact on the Chinese economy (Liu et al., 2020; Hong et al., 2022). Barro et al. (2020) contended that the Covid-19 would result in a decrease in the nation's GDP, consumption, and real stock returns. Mandel and Veetil (2020) report that at the onset of the outbreak, when only China was in lockdown, global output decreased by 7%. Conversely, during the height of the outbreak, numerous countries implemented lockdowns, resulting in a 23% decline in worldwide output. Viruses proliferate more rapidly during economic booms (Adda, 2016), and a positive association exists between employment and influenza incidence (Markowitz et al., 2019). The reduction in consumer expenditure and factory production due to the Covid-19 precipitated several issues. The adverse effect of the Covid-19 shock on residents' consumption is more pronounced (He et al., 2020; Liu et al., 2020; Yang et al., 2020).

The Covid-19's proliferation induced a sequence of adverse impacts from a supply and demand standpoint. Factors include labour and capital underutilisation and increasing international trade expenses resulted in a 2% reduction in global GDP (Maliszewska, 2020). A significant portion of the decrease in U.S. GDP during the first and second quarters of 2020 is ascribed to adverse shocks to aggregate demand and aggregate supply (Bekaert, 2020). Guerrieri et al. (2020) examined the Covid-19 outbreak through a Keynesian supply and demand lens, emphasising various reasons that induce supply shocks. Their findings indicate that triggering variables, such as closures and layoffs in

actual industries, induce changes in aggregate demand that exceed the magnitude of the shocks themselves. The Covid-19 caused supply chain interruptions, resulting in pessimism and a demand-driven decline (Fornaro and Wolf, 2020). Several companies have diminished their sales, order, and investment projections due to financing limitations, resulting in a more rapid increase in product costs. Structural shocks induced by supply and demand fluctuations in oil will also result in volatility in global agricultural and metal commodity prices (Ezeaku et al. 2021). The supply shocks from the Covid-19 will lead to significant welfare losses when assessed through global value chains (GVCs) (Eppinger et al., 2020).

China is contending with domestic economic pressures as well as a challenging foreign trade landscape. Due to Covid-19, the global goods trade market continues to contract in mid-2020. In the first quarter of 2019, China's foreign trade imports and exports declined by 1.5%<sup>3</sup> compared to the previous year. The declining trade benefits of WTO admission in recent years, along with the trade tensions between China and the U.S., have undoubtedly exacerbated the impact of the epidemic on China's overseas trade. The Covid-19 has significantly affected China's overseas trade and jobs, along with the worldwide industrial and supply chains (Shen, 2020). The decline of foreign trade due to Covid-19 significantly impacts China's job landscape. Statistics indicate that any 1% variation in China's foreign trade exports will impact between 480,000 and 500,000 employment (Chen, 2018). The fundamental issue that policymakers must solve is how to successfully manage such a catastrophic scenario.

Several researchers have examined the efficacy of monetary and fiscal policy execution during the Covid-19 crisis, yielding divergent conclusions. Tian (2020) contends that fiscal policy contributed to alleviating the epidemic's economic burden. Nonetheless,

<sup>3</sup> Information Office of the State Council of the People's Republic of China, Press Conference on Import and Export Situation in the First Quarter of 2019, Graphic Transcript, April 12, 2019

several researchers contend that conventional fiscal policy stimulus may be less successful during a recession induced by an epidemic, as the closure of some firms diminishes the impact of the Keynesian multiplier. In numerous developing nations characterised by feeble monetary transmission and limited fiscal multipliers, the efficacy of the stimulus may be diminished (Loayza and Pennings, 2020). Conversely, monetary policy may exert an amplifying influence by inhibiting firms from departing the market (Mandel and Veetil, 2020). Chao (2019) contends that monetary policy serves as a much superior safeguard against disaster risk compared to the absence of policy and fiscal policy considerations. A hybrid monetary strategy that integrates a suboptimal mix of quantity and price is deemed the most effective approach to address epidemic shocks (Guo, 2020). Consequently, governments must promptly enact swift and effective monetary policies and timely employ unconventional monetary measures when conventional policies become ineffectual. The People's Bank of China instituted a novel form of unconventional monetary policy to alleviate the epidemic's effects on the Chinese economy, hence ensuring liquidity access and credit availability (Funke and Tsang, 2020).

The Covid-19 shock has been so substantial for financial markets that the term "Covid-19 virus shock" has been officially recognised in financial academia (Caballero and Simsek, 2021). In light of the global outbreak, researchers have examined its effects on financial markets from multiple viewpoints (Gu et al., 2020; Heyden and Heyden, 2020; Liu et al., 2021; Apostolakis et al., 2021; Nigmonov and Shams, 2021). Research indicates that the aggregate number of confirmed cases and fatalities adversely affects stock market returns (Al-Awadhi et al., 2020; Ashraf, 2020a; Zhang et al., 2021) and will exert a substantial long-term influence on the countries most impacted (Sharma et al., 2021). Nonetheless, research suggests that this effect is transient in the Chinese stock market as government regulations are enacted (Hu et al.,

2020; Xu and Pu, 2021). Liu et al. (2021) assert that the Shanghai Composite Index is the sole stock index that has not undergone a notable rise in volatility.

A prolonged downturn in global markets will result in financial risk spillovers, and the rise in adverse returns, uncertainty, and volatility linked to this spillover will jeopardise the entire financial system (Ashraf, 2020b; Goodell, 2020; Sharif et al., 2020; Li et al., 2021; Yang, 2021). Yuan and Hu (2021) identify European countries as the primary regions for risk spillovers from the global stock market, with China serving as the recipient of risk during the Covid-19 pandemic. Certain researchers have examined spillovers during the Covid-19 pandemic, encompassing spillovers between fintech equities and other financial instruments (Lan et al., 2021), as well as volatility spillovers among European stock markets (Aslam et al., 2021; Youssef et al., 2021). Cross-market links resulting from financial transmission effects may markedly intensify following shocks or financial crises in several nations (Forbes and Rigobon, 2010). Yang et al. (2020) examined the primary sources and spillover mechanisms of international financial risk transmission during the epidemic and contended that stabilising currency rates in the foreign exchange market is essential.

In financial markets, the instability of the market, together with alterations in the conduct of market participants, are significant elements that have been profoundly impacted. Investor sentiment is the primary focus of numerous scholars. Investor sentiment significantly influences stock price volatility, particularly fluctuations in confidence related to alterations in economic fundamentals and policy (Wang and Jia, 2019). Shan (2008) contends that adverse investor mood significantly influences stock returns. The analysis revealed that following the Wenchuan earthquake, the stock returns of publicly traded companies situated nearer to the earthquake's epicentre were markedly adversely affected. Wang and Jia (2019) contend that the influence of

adverse investor sentiment on the stock market much surpasses the detrimental effect of actual economic losses on the stock market.

Simultaneously, the excessive response of investors in the optimistic stock market results in the manifestation of positive volatility asymmetry (Gu and Jin, 2013). Concerns regarding the contagion effect of Covid-19 outbreaks may result in increased risk aversion in the stock market, even though certain countries and regions have observed a positive impact of Covid-19 outbreaks on stock returns (Brueckner and Vespignani, 2020; Rabhi, 2020; Nwokolo et al.). Ma et al. (2020) determined through empirical analysis of Chinese stock market data that the enhancement of pricing model efficacy is contingent upon the incorporation of the investor sentiment variable. Theoretically, the Covid-19 pandemic may lead investors to overreact and adopt a conservative stance in their investing decisions (Shear et al., 2020; Aslam et al., 2021; Gan et al., 2020; Zhang et al., 2021). The Covid-19 outbreak had a more significant influence on overseas investor confidence than on local investor confidence because to the variability of the shock's effects (Zhang et al., 2021). Huber et al. (2021) demonstrate that even when the experimental assets exhibit lower risk, investment diminishes in the presence of heightened risk aversion during the pandemic. Angrisani et al. (2020) contend that the rise in the risk premium during an epidemic is attributable to a shift in beliefs rather than a modification in the risk appetite of market players. The Covid-19 pandemic has resulted in a prolonged global economic downturn, prompting certain scholars to examine the influence of psychological panic and develop a global fear index related to the pandemic as a metric for investment decisions (Haroon and Rizvi, 2020; Papadamou et al., 2020; Salisu and Akanni, 2020). Nevertheless, metrics pertinent to Chinese investors have not been reliably computed and disseminated, leading many Chinese academics to rely on public responses to interest rates and inflation, along with expectations, as reference indicators for

analysing market participant behaviour (Huang and Feng, 2021; Chen et al., 2022; Zhuang and Kuang, 2023).

Covid-19 has induced disruptions across several industries and smaller enterprises (Tisdell, 2020; Zaremba et al., 2020; Sharma et al., 2021; Wang and Gao, 2020; Liu, 2020). These shocks are typically accompanied by adverse shocks, such capital underutilisation, decreasing manufacturing output, rising production costs, and diminishing demand for services. The epidemic's impact has led to a substantial decline in sales across numerous industries, causing enterprises to struggle with maintaining standard procedures regarding the supply of goods and the demand for resources. Numerous analysts contend that the industry will struggle to attain a complete recovery of production in a brief timeframe, emphasising the government's budgetary constraints and the significant adverse effects on export volumes. In light of this context, it is essential to analyse the epidemic's effects on China's industry to develop specific strategies to address the epidemic. The economic impact of Covid-19 paralleled that of the SARS epidemic in 2003. However, the magnitude of the impact as a public health emergency has significantly altered due to the changes in China's economic environment since then (Liu, 2020). Mo et al. (2020) examined employment during the epidemic, contrasting the three significant crises: the SARS epidemic, the financial crisis, and Covid-19. Finally they concluded that while SARS adversely affected certain industries and regions more severely, recovery occurred within a brief timeframe. Conversely, Covid-19 will exert a more significant influence on the economy, marked by profound effects and extensive repercussions throughout Chinese industries. Furthermore, the outbreak transpired during the Chinese New Year, impacting numerous people resuming their employment. Alongside the unavoidable growth in unemployment and other challenges, the scenario presents significant structural contradictions, suggesting that the jobless rate may peak among the three crises. He et

al. (2020) examined the effects of Covid-19 on various economic indicators in China following the outbreak, employing retrospective research methods, comparative static analysis, and additional methodologies for prediction. The findings indicated that the epidemic significantly affected the development of China's national economy, resulting in substantial losses in indicators such as total output, household consumption, manufacturers' investment, and foreign trade, while also impacting the investment and financing environment within the capital market of the financial sector. Li and Sheng (2020) examined the effects of the epidemic on China's economy through the lens of the three primary industries, with particular emphasis on the tertiary sector, which includes high-density gathering industries such as catering and transportation. They concluded that these industries were the most adversely impacted by the epidemic.

The timing and intensity of the Covid-19 outbreak have significantly impacted the development of the electricity sector. Electricity is essential for evaluating the pertinent departments to guarantee the ongoing operation of such industries. Consequently, several academics have proposed that the epidemic will influence the production and operations of electricity firms via multiple pathways (Nie et al., 2020). An analysis of the industry's economic performance in recent years indicates a substantial increase in Covid-19-related consumption within healthcare organisations, whereas power consumption for commercial purposes is projected to decline. Luo (2020) examines the effects of the epidemic on China's macroeconomy through the lenses of economic development, capital market functioning, and national governance. The findings indicate that economic indices suggest a decline in consumption, investment, and exports, while the populace confronts the dual challenges of unemployment and rising prices. Certain researchers have noted adverse tendencies in supply and labour demand, which would detrimentally affect the service industry; thus, there is a necessity to further elaborate on preventive measures for epidemic security and

unemployment across all sectors (Ceylan et al., 2020).

Likewise, some scholars have investigated the medium- and long-term effects of Covid-19. Zhi and Luo (2020) contend that the effects of the epidemic should not be assessed from a singular viewpoint. They contend that, if the epidemic's short-term duration is either one quarter or one year, it will hinder economic growth. In the long term, Covid-19 may induce alterations in the industrial framework of the Chinese economy, fostering prospects for industrial enhancement in some industries. Li (2020) employs the resilient economy theory to forecast the varying effects of Covid-19 on the economy in both the short and long term, asserting that China will undergo a temporary rebound followed by a downward adjustment in the short term, while the long-term economic development trajectory will be more favourable. Lou (2020) forecasts the prolonged persistence of Covid-19 and examines the reactions of the economic and financial sectors in relation to the epidemic. Liu (2020) contends that, by analysing the similarities and differences in the effects of the 2003 SARS epidemic and the Covid-19 pandemic on China's economy, the SARS epidemic had a discernible short-term impact on economic development, but its long-term effects were not significant. The magnitude of this epidemic's impact surpasses that of SARS, with immediate economic repercussions already evident; nevertheless, the long-term effects on the development of numerous businesses in China remain uncertain. Luo (2020) analyses the effects of the epidemic on China's economy, stock markets, and national governance policies. He stated that the rapid onset of the epidemic will pose a significant threat to our lives and production activities, exerting considerable pressure on the entire functioning of the Chinese macroeconomy. Nonetheless, following the government's strategies to address the outbreak, it will be effectively alleviated in the long term. This assistance should be dedicated to both the supply and demand aspects of the economy. Collectively, it is anticipated that Covid-19 will impact the short-term

development of China's sector. But in the long term, it is expected to enhance the economy's operation positively. Consequently, the majority of experts think that the epidemic is cyclical, exhibiting a short-term decline in its effects on the Chinese economy, although opinions diverge about its long-term implications for economic development.

For the monetary policy system, the Covid-19 pandemic has significantly altered the synergistic dynamics of China's monetary policy target framework and instrument framework. The pandemic shock has compelled a shift in monetary policy at the target framework level from the traditional dual targets of stabilizing growth and controlling inflation to a multi-target dynamic balance. This balance includes ensuring reasonable and adequate liquidity while incorporating structural targets such as protecting market entities, stabilizing the employment chain, and preventing systemic risks. In 2020, the People's Bank of China prioritized targeted support for industries and groups significantly impacted by the pandemic. This included reducing the actual financing costs for key medical enterprises to below 1.6% through a combination of special re-lending and fiscal subsidies (PBOC, 2020). This internalized public health crisis response as a monetary policy target, surpassing the limits of conventional macroeconomic policy.

At the instrument framework level, traditional aggregate instruments proved ineffective due to the failure of transmission mechanisms. The decline in bank risk preferences has impaired the transmission of interest rate effects; for instance, following a 10 basis point reduction in the MLF rate in 2020, the actual loan rate for small and medium-sized enterprises decreased by only 5 basis points. Concurrently, economic entities have entered a quasi-liquidity trap, as evidenced by a household savings rate that surged to 37%, thereby hindering the capacity of monetary expansion

to stimulate effective demand. This prompted the PBOC to develop a combination of three structural instruments. Initially, targeted liquidity instruments such as the Standing Lending Facility (SLF), Medium-term Lending Facility (MLF), and Pledged Supplementary Lending (PSL) were employed to inject medium-term liquidity into primary dealers through the MLF, which saw an injection of 4.3 trillion yuan in 2020. The SLF functioned as the upper limit of the interest rate corridor at 3.4%, effectively mitigating the transmission of fluctuations in the monetary market. Concurrently, the PSL provided focused support for medical infrastructure aimed at repairing supply chains, exemplified by the power supply system of Leishenshan Hospital. Secondly, credit-targeting instruments executed specific reserve requirement reductions, which released 550 billion yuan in 2020, and stipulated that these funds be allocated for small and micro loans. Additionally, a re-lending quota of 1.8 trillion yuan was established to provide zero-interest funds to enterprises engaged in epidemic prevention. Third, regulatory incentive instruments, including the policy to defer principal and interest payments (with a deferral rate of 35% in the first quarter of 2020) and the inclusive small and micro credit loan support program, effectively distribute risks by having the central bank cover 40% of the loan share (Wei et al., 2025).

#### **1.2.4 Literature description and review**

Examination of the current literature reveals that numerous researchers have employed a diverse array of research methodologies to investigate unconventional monetary policy, which holds significant reference value. Nevertheless, the current research exhibit the following shortcomings.

- 1) The selected factors for the study were not representative. In the study of China's unconventional monetary policy, the majority of experts have directly employed the

instruments and mechanisms utilised in Western nations. However, China's economic system and market mechanism are distinctly unique. For instance, asset purchases, frequently employed by the Federal Reserve, are nonexistent in China. The balance sheet channel, prevalent in Western research, lacks official acknowledgement in the Chinese economy and is just referenced by numerous Chinese experts in diverse forums and speeches. Consequently, we delineate the attributes of China's monetary policy framework, its target system, and mechanisms, informed by the progression of China's monetary policy throughout the Covid-19 pandemic. Simultaneously, we examine the unconventional monetary policy instruments actual employed by China. Consequently, the empirical segment of our research is anticipated to produce more authentic and representative conclusions regarding China.

2) The analysis of China's unconventional monetary policy lacks comprehensiveness and depth. Similar to most nations, China's unconventional monetary policy has been executed through a synthesis of many policy kinds and instruments that function in concert. In the majority of studies, researchers have examined either specific instruments or categories of policies. Certain scholars examining the amalgamation of the two have also concentrated on significant Western economies, like the United States. Nonetheless, China's unconventional monetary policy is more unique and intricate than that of Western nations. The targeted standing lending facility, established in 2017, has been further divided into smaller components, including general lending. However, limited research has addressed which of these were special utilised in response to Covid-19. Consequently, we concurrently differentiate between instruments and categories of unconventional monetary policy enacted in China. Furthermore, we further disaggregate China-specific policy measures to ascertain the portion that was utilised in response to Covid-19.

3) The discussion of unconventional monetary policy instruments with Chinese characteristics lacks foundation. Among the limited studies that have analysed the unconventional monetary policy instruments employed in China in depth, few academics have empirically substantiated their rationale for targeting specific sectors of the economy. Nearly all scholars pinpoint particular targets for intervention based on declarations from the Chinese government and central bank, neglecting to analyse the underlying motivations for these actions. Consequently, we present a systematic empirical analysis and discourse on the Covid-19 impact on the Chinese economy, substantiating the rationale behind the PBOC's focus on unconventional monetary policy directed at the tertiary sector, and further affirming that the primary supportive sector of this policy should be the Small and Medium Enterprises (SMEs).

## **1.3 Research Philosophy, Structure and Methodology**

### **1.3.1 Research philosophy**

This paper's logical framework centres on China's unconventional monetary policy in response to Covid-19, structured as follows: theoretical foundation, theoretical modelling, empirical analysis, and conclusion with recommendations. Detailed research flowchart as Figure 1.1.

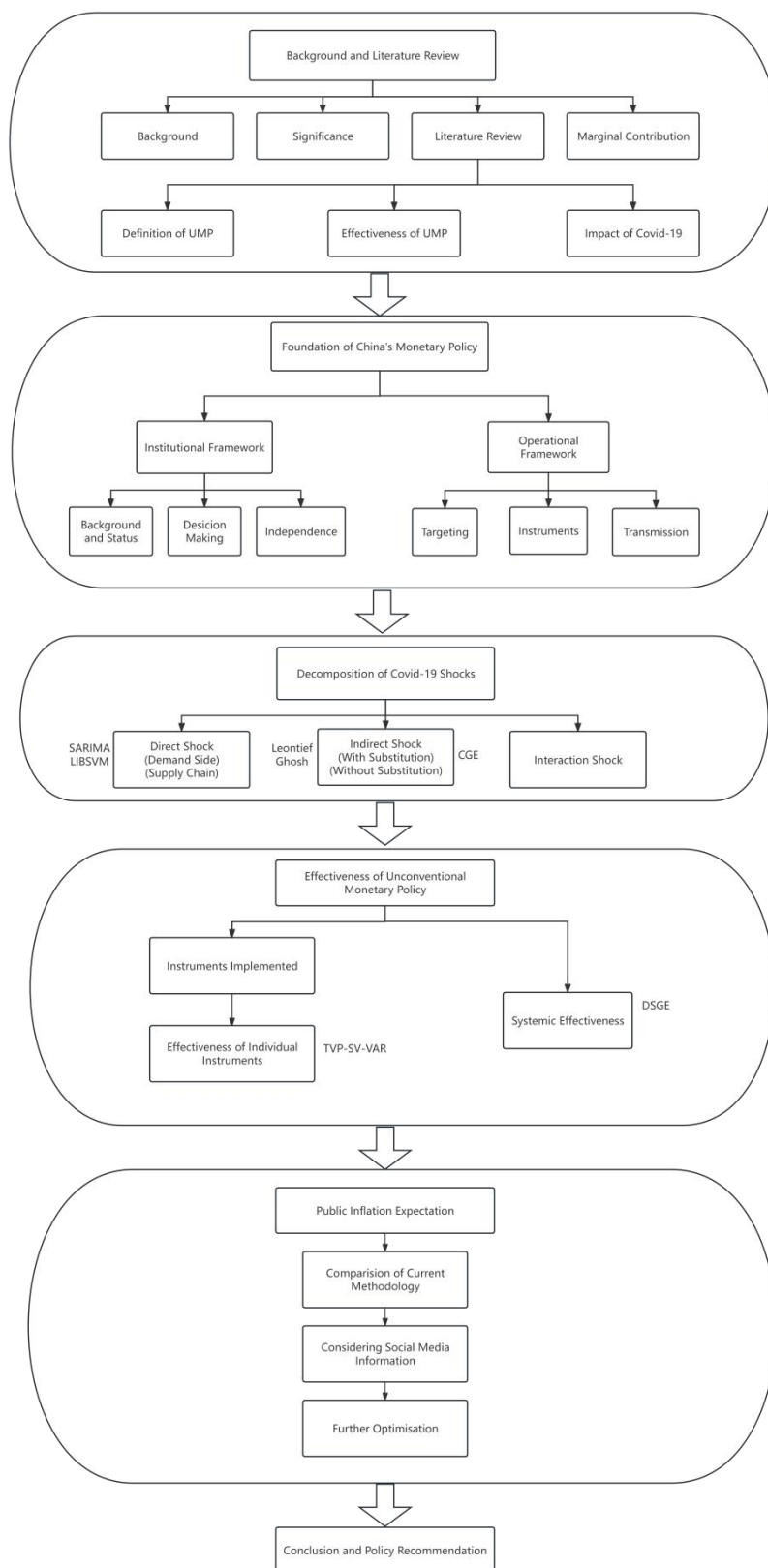


Figure 1.1: Basic research flowchart of this paper

### **1.3.2 Research structure**

The specifics of each chapter of this paper are listed below based on the flowchart:

Chapter 1 is an introduction. This chapter presents the study's background and significance, reviews pertinent literature, and finishes with a succinct overview of the central concept and structure.

Chapter 2 delineates the theoretical underpinnings of China's monetary policy. This chapter offers a comprehensive examination of the evolution of monetary policy in China. It encompasses the comprehensive monetary policy framework, the policy target system, the transmission mechanism and channels for monetary policy. This chapter will establish the theoretical framework for the following empirical analysis about the effectiveness of unconventional monetary policy in China.

Chapter 3 provides a decomposition of the impact of the Covid-19 epidemic on the Chinese economy. This chapter employs a systematic analytical framework to examine several types of shocks, including direct, indirect, interaction, and comprehensive shocks, utilising diverse models. This chapter's findings pinpoint the economic sectors within the Chinese economy that were most adversely affected by the Covid-19 pandemic and require significant policy assistance, hence facilitating the following formulation of unconventional monetary policy instruments tailored to Chinese features.

Chapter 4 examines the effectiveness of China's unconventional monetary policy in response to Covid-19. The chapter utilises the TVP-SV-VAR model to analyse the efficacy of independent unconventional monetary policy instruments and

the transmission channels, while employing the DSGE model with policy expectations to evaluate the effectiveness of the policy combinations.

Chapter 5 introduces a novel methodology for assessing public inflation expectations in China. Given the significant role of public inflation expectations in international theoretical research, the formulation of our model, and the evaluation of exit strategies, an improved estimating approach is essential. Due to the present primitive and imprecise measurement of public inflation predictions in China, we have created a higher-frequency and more accurate estimate utilising social media data.

Chapter 6 presents conclusions and recommendations. This chapter consolidates the findings from the theoretical simulations and empirical testing presented in the preceding part, from which the relevant policy recommendations are derived.

### **1.3.3 Research methodology**

**Literature Analysis.** The literature analysis approach primarily gathers, identifies, and organises literature to elucidate the research lineage within a specific topic by conducting comparative analyses, so establishing a systematic comprehension of classical facts and theoretical science. Through the examination, organisation, and synthesis of the existing literature, we can comprehensively grasp the research frontiers in unconventional monetary policy and elucidate the current status and deficiencies of the research based on a substantial body of existing studies on related issues. This paper's research aims to innovate based on the theory and empirical data of unconventional monetary policy.

**Theoretical Analysis.** Analyse the principal theories on the evolution of China's

monetary policy, along with its transmission and mechanisms. A theoretical model is concurrently developed to analyse China's monetary policy instruments and transmission channels in response to Covid-19, offering theoretical support for the empirical model's establishment.

**Empirical Analysis.** Empirical analysis derives consistent findings by examining economic occurrences, behaviours, or activities and their developmental tendencies. This research uses the TVP-SV-VAR model, characterised by time-varying properties, to examine the instrumental and channel efficacy, as well as the spillover effects, of unconventional monetary policy. Utilising a DSGE model to evaluate the comprehensive efficacy of unconventional monetary policy. The outcomes of empirical analysis serve as a crucial foundation for the article's conclusions, and accurate interpretation of these data enhances the current research conclusions to facilitate theoretical innovation.

## **1.4 Marginal contributions**

First, we concentrated on China's unconventional monetary policy operations, identifying additional China-specific targeted policy instruments alongside standard unconventional monetary policy instruments, and developed a measurement methodology to examine the relevant instruments within the foreign exchange channel. The current literature on China's unconventional monetary policy instruments predominantly draws on the research experiences of Western nations, neglecting China's unique economic traits and policy attributes. This article differentiates between the targeted component of generalised targeted lending that emerged post-Covid-19 and the component that existed before the pandemic, thereby enabling the central bank to more accurately regulate the trajectory of unconventional policies.

This paper's assessment of unconventional monetary policy instruments within the foreign exchange channel will also guide future studies.

Secondly, we offer a reference technique for the analysis of economic shock decomposition. In response to intricate and extensive shocks like Covid-19, we analyse its effects on China's economy and develop a two-dimensional decomposition approach by integrating many models. Initially, we differentiate between the two effects of the epidemic on supply-side and demand-side shocks to the economic system. Also, we ascertain the industrial chain effect, the comprehensive effect, and the interaction effect of the epidemic on the supply and demand aspects of the economic system in light of the epidemic's impact.

Third, we present a DSGE model that incorporates policy expectations to more accurately reflect the actual economic characteristics of China. The Chinese economy exhibits a disparity between the autonomy of the central bank and market flexibility relative to western economies, with the Chinese government exerting considerably greater policy direction and influence. Consequently, we modify the government sector and private household sector in our DSGE model by diminishing the central bank's independence assumption and amplifying the impact of policy expectations, respectively. The DSGE model we developed can serve as a reference for scholars conducting further study on the Chinese economy.

Fourth, we assess public inflation forecasts in China utilising data from social media. Public inflation expectations are a crucial signal that monetary policymakers must examine. Nonetheless, the study of public inflation expectations in China remains reliant on quarterly questionnaires, and the sample size is markedly inadequate, with merely 50,000 questionnaires disseminated each quarter. The respondent demographic

is restricted to individuals who utilise offline bank branches for transactions. Our social media-derived metric of public inflation expectations demonstrates superior alignment with actual inflation and offers greater frequency, facilitating prompt assessment and response by policymakers to economic challenges.

# Chapter 2

## Foundations of China's monetary policy

China, as the world's second-largest economy, has gained significant prominence in the global financial system. Nevertheless, in relation to the magnitude of its economy, the transparency and comprehension of China's monetary policy framework require enhancement. In recent years, with the acceleration of financial market deepening and external opening, the People's Bank of China (PBOC) has been refining its monetary policy system, operational framework, and communication mechanism, gradually shifting towards a price-based regulatory mechanism. Nevertheless, China's monetary policy framework demonstrates distinctive characteristics that markedly diverge from those of advanced economies, reflecting both variations in institutional context and the diverse stages of growth and policy aims. Consequently, whether examining China's unconventional monetary policy in response to Covid-19 from a domestic viewpoint or evaluating the structure and efficacy of this policy from the standpoint of other economies, a comprehensive analysis of China's monetary policy framework is an essential preliminary investigation.

This chapter examines the development of China's monetary policy system, emphasizing its institutional framework, operational framework, and transmission channels, while assessing its distinctiveness and potential reform trajectory through international comparisons. The People's Bank of China implements monetary policy under the guidance of the State Council, utilizing a multi-target framework that includes price stability, economic growth, employment, and balance of payments, while

employing both quantitative and price-based instruments comprehensively. Essential policy instruments comprise open market operations (OMO) for short-term liquidity regulation, the reserve requirement ratio (RRR) for medium- and long-term fund management within the banking sector, the medium-term lending facility (MLF) and standing lending facility (SLF) for targeted liquidity provision, and the loan prime rate (LPR) serving as a benchmark for market interest rate determination. Policy intentions are conveyed to the real economy via the banking system and financial markets. China's monetary policy exhibits notable differences when contrasted with that of developed countries. Initially, regarding targets, China prioritizes the coordination of various goals, including structural adjustments, whereas developed economies, such as the US and Europe, generally concentrate on inflation targeting. Secondly, regarding instrument selection, China predominantly utilizes quantitative instruments, including adjustments to the reserve requirement ratio, and innovatively implements structural measures like targeted re-lending. In contrast, developed countries primarily depend on policy interest rates, such as the federal funds rate and the main refinancing rate, for price-based regulation, with more advanced quantitative easing (QE) operations. The efficiency of transmission is limited by the advancement of interest rate liberalization and financial structural factors, resulting in certain frictions for China. In contrast, developed countries benefit from established financial markets, which facilitate relatively smooth interest rate transmission channels. The People's Bank of China exhibits reduced policy autonomy in comparison to institutions such as the Federal Reserve and the European Central Bank. Furthermore, China prioritizes the coordinated execution of monetary policy alongside fiscal policy and macroprudential management to establish a synergistic approach across departments. China's monetary policy is transitioning from direct regulation to market-based price regulation, influenced by multi-target constraints and its institutional environment, which shapes a distinct operational logic. As a conclusion, China's monetary policy

system resembles that of Western economies, with a significant distinction: China's system, dominated by state-owned banks, permits administrative intervention, while Western central banks predominantly utilize market-based instruments.

## **2.1 Institutional framework**

The monetary policy system of China is best described as exhibiting a significant level of policy coordination. The Law of the People's Republic of China regarding the People's Bank of China stipulates that the central bank's primary mission is to 'preserve the stability of the currency's value and so foster economic growth.' Although this target resembles that of numerous modern countries in conception, the Chinese central bank lacks full independence regarding policy instruments.

Significant monetary policy modifications by the central bank, such as the benchmark interest rate, reserve requirement ratio, and annual money supply target, require approval from the State Council. The central bank possesses limited autonomy solely at the operational level, specifically in domains such as Open Market Operations (OMO), Medium-term Lending Facility (MLF), and Standing Lending Facility (SLF). This institutional framework integrates monetary policy into the coordination of the nation's comprehensive economic strategy rather than treating it as a wholly autonomous technical regulatory action.

The Monetary Policy Committee of the central bank functions as an advising entity rather than a decision-making authority, hence constraining the central bank's preeminent role in monetary policy formulation. This arrangement maintains policy continuity but restricts the central bank's flexibility in addressing short-term shocks.

Overall, the People's Bank of China implements monetary policy under the guidance of the State Council, utilizing a multi-target framework that includes price stability, economic growth, employment, and balance of payments, while employing both quantitative and price-based instruments comprehensively. Essential policy instruments comprise open market operations (OMO) for short-term liquidity regulation, the reserve requirement ratio (RRR) for medium- and long-term fund management within the banking sector, the medium-term lending facility (MLF) and standing lending facility (SLF) for targeted liquidity provision, and the loan prime rate (LPR) serving as a benchmark for market interest rate determination. Policy intentions are conveyed to the real economy via the banking system and financial markets.

China's monetary policy exhibits notable differences when contrasted with that of developed countries. Initially, regarding targets, China prioritizes the coordination of various goals, including structural adjustments, whereas developed economies, such as the US and Europe, generally concentrate on inflation targeting. Secondly, regarding instrument selection, China predominantly utilizes quantitative instruments, including adjustments to the reserve requirement ratio, and innovatively implements structural measures like targeted re-lending. In contrast, developed countries primarily depend on policy interest rates, such as the federal funds rate and the main refinancing rate, for price-based regulation, with more advanced quantitative easing (QE) operations. The efficiency of transmission is limited by the advancement of interest rate liberalization and financial structural factors, resulting in certain frictions for China. In contrast, developed countries benefit from established financial markets, which facilitate relatively smooth interest rate transmission channels. The People's Bank of China exhibits reduced policy autonomy in comparison to institutions such as the Federal Reserve and the European Central Bank. Furthermore, China

prioritizes the coordinated execution of monetary policy alongside fiscal policy and macroprudential management to establish a synergistic approach across departments. China's monetary policy is transitioning from direct regulation to market-based price regulation, influenced by multi-target constraints and its institutional environment, which shapes a distinct operational logic.

### **2.1.1 Institutional background and establishment of central bank status**

The People's Bank of China (PBOC) was founded in 1948, initially amalgamating the roles of a central bank and a commercial bank. The separation of the central bank's functions from commercial banking commenced only with the initiation of reform and opening-up in 1978. In 1995, the Central Bank Law of the People's Republic of China explicitly designated PBOC as the nation's central bank, responsible for formulating and implementing monetary policy and ensuring financial stability in accordance with the law. This signified the official recognition of the PBOC's legal standing as a contemporary central bank.

The fundamental tasks of the PBOC, as delineated by the Central Bank Law, encompass the formulation and execution of monetary policy, the issuance of CNY, the management of the financial market and payment clearing system, as well as the holding and administration of foreign exchange reserves. In contrast to the more autonomous central banking systems in Europe and the United States, China's central bank has been intricately integrated into the nation's comprehensive economic management framework since its inception, with its decision-making and implementation authority straight directed and overseen by the State Council. This institutional framework has significantly influenced the development and execution of

China's monetary policy.

### **2.1.2 Decision-making mechanisms**

The decision-making process of China's monetary policy adheres to the fundamental principle, which is centralized leadership by the State Council with detailed execution by the central bank. Article 5 of the Central Bank Law mandates that the central bank obtain prior approval from the State Council for significant issues concerning the money supply, interest rates, exchange rates, and related topics. This decision-making framework is mostly evident in three facets.

First, Significant monetary policy modifications require approval from the State Council. The establishment and modification of essential variables, including the benchmark deposit and lending rates, the reserve requirement ratio (RRR), and the yearly money supply target (M2 growth rate), necessitate the approval of the State Council. The PBOC possesses the authority to propose policy suggestions, although lacks the power to make the final choice. This institutional framework guarantees the alignment of monetary policy with the nation's comprehensive macroeconomic control approach, encompassing fiscal and industrial policies, among others.

Second, Monetary Policy Committee (MPC) functioning as an advisory entity. A MPC was constituted within PBOC, established in 2000, chaired by the central bank's governor and including top officials from the Ministry of Finance, the National Development and Reform Commission (NDRC), other ministries, and experts and scholars. The committee's function is to offer counsel on monetary policy formulation, rather than serving as a decision-making body. The central bank must issue the final policy following deliberation and approval by the State Council.

Third, Characteristics of coordinated decision-making across multiple sectors. China's macro-control exemplifies the attributes of multi-sectoral coordination in fiscal, monetary, industrial, and financial regulation. The State Council's executive meeting incorporates monetary policy as a component of macroeconomic regulation, coordinating it with fiscal expansion, investment stimulation, and foreign trade strategies. This horizontal coordination mechanism has preserved the coherence and efficacy of macroeconomic regulation; nevertheless, it has also constrained the central bank's capacity to autonomously modify policy instruments according to its own assessment.

### **2.1.3 Target and instrument independence**

In the theory of international monetary policy, central bank independence is typically categorized into target independence and instrument independence. Target independence refers to the ability of a central bank to determine its primary targets for monetary policy, such as the inflation rate or employment level. Instrument independence denotes the central bank's authority to select the instruments it deems appropriate for achieving these targets.

Within the context of China, the target independence is limited. The policy target of the PBOC, as established by the Central Bank Law, is to maintain currency stability and promote economic growth. In practice, it must also consider various additional targets, including employment, financial stability, and balance of payments. Unlike the Federal Reserve's dual targets of inflation and employment, the Chinese central bank pursues a broader range of targets that align with the nation's economic and social development strategy, with the target-setting process being significantly influenced by political

considerations.

Moreover, the instrument independence is restricted. The PBOC has the flexibility to employ technical instruments, within specified limits. However, the utilization of core policy instruments, such as the benchmark interest rate and the reserve requirement ratio, requires approval from the State Council. This arrangement has granted China's central bank a degree of autonomy in daily regulation and control. However, it must await the State Council's decision-making process when addressing significant economic period fluctuations, thereby diminishing the speed and flexibility of its responses.

Table 2.1 presents a comparative analysis of the independence of the central banks of China and the United States, using the Federal Reserve as a case study.

Table 2.1: Comparison of Central Bank Independence

Perspective	Fed	PBOC
Target-setting	Congressional mandate (explicit dual targets)	Legal mandate (broad targets, actually more guided by government)
Instrument Use	Independence (FOMC decision)	State Department approval required for major matters

Clearly, the institutional design of China's central bank markedly contrasts with the framework of Western central banks, which prioritizes independence.

## 2.2 Operational framework

Since China's reform and opening up, the progression of China's monetary policy

operation can be categorised into two distinct phases. That is, from the initial phase of the subsequent phase of indirect regulation focused on quantity-based policies, and ultimately to the current transitional period of regulation dominated by price-based policies.

### **2.2.1 Historical background of the operational framework**

The operational framework of China's monetary policy has significantly shifted from administrative management within a planned system to price-driven management in a market-oriented system. During the initial phase of the reform and opening-up period, characterized by a highly decentralized financial system and the absence of a formal financial market, monetary policy focused on managing base money injection and credit scale. It primarily utilized window guidance and a credit quota system for macroeconomic control.

Following 1998, the central bank progressively established a regulatory framework for the money market, utilizing money supply (M2) as the intermediary target. The monetary policy target at this stage was to indirectly regulate economic growth and inflation through the control of the money supply growth rate. The central bank affected banking system liquidity through the adjustment of quantitative instruments, including the reserve requirement ratio, issuance of central bank bills, and refinancing operations. Nonetheless, due to the ongoing innovation in financial markets and the growing complexity of monetary accounting, the relationship between monetary aggregates and the real economy has progressively diminished. Following the 2008 financial crisis, numerous scholars have indicated a diminished correlation between the M2 indicator and macroeconomic indicators, resulting in a significant weakening of

monetary policy's efficacy in regulating the macroeconomy when utilising it as an intermediate target (Yang, 2018; Pan and Li, 2018)(see Figure 2.1).

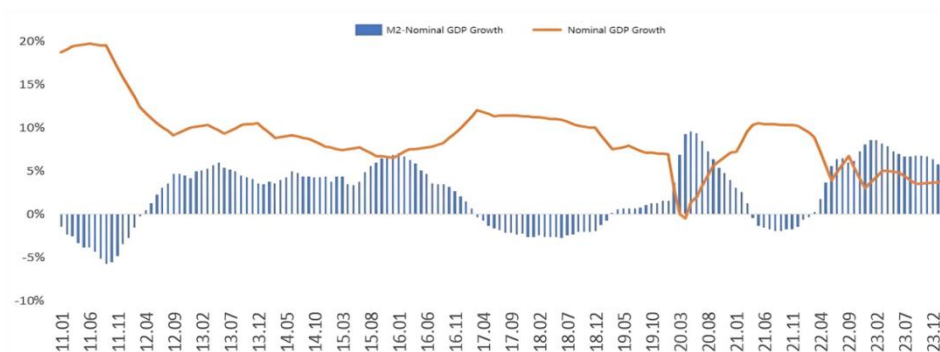


Figure 2.1: Correlation between M2 and GDP growth<sup>4</sup>

Consequently, central banks commenced the pursuit of novel intermediary indicators. It continues to investigate more appropriate indicators among quantitative methods to address the deficiencies of M2. In 2011, PBOC developed a novel monetary statistics indicator, the social financing scale, to represent the robustness of financial assistance to the actual economy. This facilitates a thorough understanding of social financing, elucidates economic trends, and enhances finance's capacity to support the real economy. Conversely, it has actively advanced the reform of interest rate marketisation and endeavoured to enhance the price-based regulatory framework. Since 2013, PBOC has developed various interest rate regulation instruments, including the Standing Lending Facility (SLF) and Medium-term Lending Facility (MLF), abolished the cap on deposit interest rates in 2015, and implemented the reform of the Loan Market Quotation Rate (LPR) in 2019, thereby establishing a foundation for facilitating interest rate transmission channels and achieving price-based monetary policy regulation. Nevertheless, the PBOC has yet to publicly announce an update to the intermediate target.

<sup>4</sup> Data source: China Merchants Bank, First Quarter 2024, Macroeconomic Research Report.

## 2.2.2 Recent operational framework

Prior to 2014, the People's Bank of China's monetary policy operational framework focused on addressing structural liquidity shortages (People's Bank of China, 2014). However, quantitative intermediate variables encounter challenges related to diminished measurability, controllability, and relevance (Reuters, 2024a). Before 2014, foreign exchange account holdings were utilized alongside central bank bills for liquidity injections and withdrawals, representing a passive implementation framework (People's Bank of China, 2014).

Subsequent to 2014, the PBOC developed an operational framework focused on structural liquidity shortage (see Figure 2.2) (Guo, 2022). Within this framework, the primary strategy of the PBOC is to address the conflicting relationship between anticipated reserve demand and supply, aiming to establish a situation where anticipated reserve demand surpasses supply. This strategy results in a structural liquidity shortage in the market, positioning the PBOC advantageously as a lender and enabling it to exert control over liquidity. The statutory reserve system facilitates a natural increase in financial institutions' demand for reserves in correlation with deposit growth, thereby offering institutional support for the operational framework employed by the PBOC in this strategy. Within this operational framework, the PBOC injects short-term liquidity into the market via open market operations to address short-term liquidity shortages in the financial system, while also providing long-term liquidity to bridge liquidity gaps or substitute for short-term liquidity through interest rate reductions (Ma & McCauley, 2023). The PBOC has implemented numerous reforms within the price-based framework; however, the overall system remains predominantly quantity-based. The primary intermediate variable currently monitored by the PBOC remains the money supply (M2) (Reuters, 2024b). In recent years, issues

related to money supply as an intermediate variable have intensified, primarily encompassing three aspects. Financial innovations have obscured the hierarchical boundaries of money, consequently impacting the measurability of the money supply. The money multiplier has increased significantly and exhibited greater volatility, thereby diminishing the controllability of M2 as an intermediary target. The recent phase of economic development has resulted in a notable reduction in the correlation between quantitative indicators and growth (Reuters, 2024a). The aforementioned changes have resulted in a transition in the PBOC's monetary policy operating framework from a quantity-based approach to a price-based one.

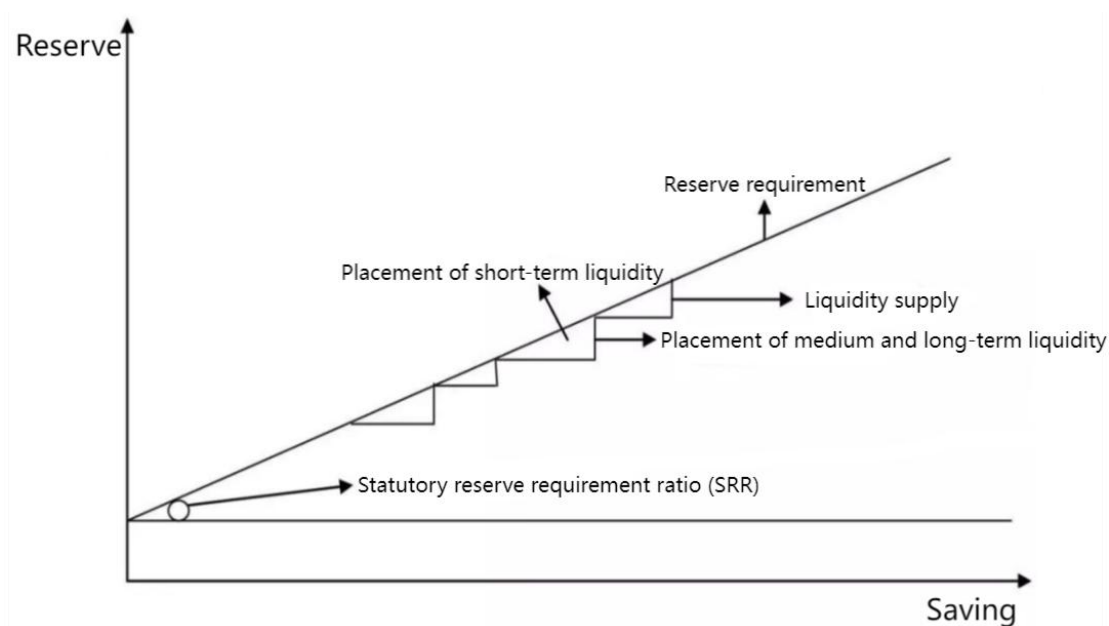


Figure 2.2: Schematic of the liquidity management framework for liquidity shortages

The address by central bank governor Yi Gang at the Lujiazui Financial Forum on 19 June 2024 clarified the overarching trajectory of the central bank's policy operational framework shift (CGTN, 2024). The speech encompasses several key points. Initially, it is essential to optimize the intermediate variables of monetary policy regulation, progressively reducing the emphasis on quantitative targets while increasing the focus

on price indicators. The central bank previously aimed to develop DR007 as a market interest rate benchmark aligned with the policy rate, and it is now recognized that DR007 fulfills this role (Reuters, 2024b). Secondly, enhance the mechanism for controlling market-based interest rates. This decision entails optimizing the transmission mechanism from the central bank's policy rate to the market benchmark rate and subsequently to various financial market interest rates, emphasizing the enhancement of LPR quotes to achieve a more accurate representation of interest rates in the lending market (Reuters, 2024b). The width of the interest rate corridor was moderately narrowed by establishing a temporary overnight positive reverse repo, alongside a 20 basis point reduction and a 50 basis point increase in the 7-day reverse repo rate, respectively (MarketWatch, 2024). Third, the gradual inclusion of treasury bond transactions in the secondary market into the monetary policy framework aims to enhance and diversify the methods of base money injection. A robust framework of precise and suitable structural monetary policy instruments will be established to direct financial institutions in optimizing their credit structures in a market-oriented fashion through incentive mechanisms, with a focus on mitigating moral hazards. This speech supported the PBOC's targets and actions concerning the transformation of the monetary policy operating system, specifically a transition to a price-based framework and the improvement of interest rate instrument effectiveness (Guo, 2022).

### **2.2.3 Targeting framework**

The operational instruments of a central bank are typically structured around a targeting system, with the operational framework serving as the theoretical foundation for the development of these instruments. Thus the targeting system holds a crucial central role in the operational framework, making its study and discussion essential.

We aim to examine China's unconventional monetary policy in response to Covid-19. It is essential to first analyze any changes in China's monetary policy target framework before addressing the target framework.

The framework of China's monetary policy targets has been reinforced in its structural orientation and multi-target coordination following Covid-19, largely in response to new challenges posed by the pandemic, including inadequate domestic demand, low inflation, and heightened risks. This necessitates the application of structural instruments to deliver focused assistance for vulnerable sectors, including technological innovation, consumption, and small and medium-sized enterprises, while concurrently tackling phased targets such as mitigating local government debt risks (e.g., finalizing the restructuring of financing platforms by 2027). The core framework persists in adopting a moderate easing stance while balancing multiple targets. It facilitates sufficient liquidity and reduces social financing costs to uphold traditional goals, including stable growth and employment. Conversely, it supports a combination of proactive fiscal policy and accommodative monetary policy, utilizing anticipated reductions in reserve requirement ratios and interest rates, along with fiscal coordination, to stabilize aggregate demand. This approach reflects the dual targets of policy during the transition period, addressing both aggregate balance and structural optimization. The rationale for these changes and continuities is that short-term instrument innovations, like enhancing structural support, serve as adaptive responses to cyclical pressures and structural deficiencies. In contrast, multi-target balancing—encompassing growth, price stability, and debt resolution—and institutional coordination, which emphasizes consistency in macroeconomic policy orientation, are fundamentally linked to China's long-term internal constraints and the requirements for transformation in economic governance. Therefore, this chapter will examine China's monetary policy target framework following the Covid-19

outbreak.

### **1) Primary target**

Covid-19, which emerged at the close of 2019, is unequivocally the public health event with the most significant influence on the global economy in this century. As the initial economy to experience and respond to the Covid-19 shock, China's central bank implemented various monetary policy measures. Scholars typically categorise China's monetary policy aims post-Covid-19 into two distinct classifications: short-term and long-term.

In the immediate term, China's monetary policy aims were to stabilise growth and stabilise employment, whereas the Covid-19 outbreak in China had notable regional peculiarities. The Covid-19 outbreak in China originated in Hubei and disseminated across the nation. Provincial governments have implemented rigorous anti-epidemic measures that will suppress consumption, investment, and trade activity in the short run. Secondly, the Covid-19 outbreak coincided with the Chinese New Year, which, along with the prolonged incubation period and the disease's high contagion rate in its initial phases, resulted in stringent travel restrictions for residents, thereby severely affecting the tertiary sector. The Chinese New Year marks the apex of labour migration, and the government's swift implementation of extended holidays and restrictions on interprovincial movement postponed the recommencement of large-scale employment and startups post-holiday, leading to labour shortages in certain regions and industries, significantly affecting the secondary sector.

The abrupt emergence of the pandemic exacerbated the challenges faced by small and medium-sized firms (SMEs), which were already struggling during the economic recession. During the epidemic outbreak, firms were unable to conduct regular

manufacturing, sales, and other economic activities, yet were still obligated to pay rent, employee wages, loan principle and interest, and other expenses punctually, while existing raw supplies and orders potentially incurred losses. In February 2020, a brief online survey conducted by China's National Bureau of Statistics revealed that over 80% of SMEs possess financial reserves sufficient to sustain their operations for only 1 to 3 months. As Covid-19 persists, numerous SMEs are facing the ongoing issue of disrupted cash flows, particularly in service sectors such as housing and catering, transport, culture and entertainment, and wholesale and retail, which have been severely affected by the pandemic.

The predicament of SMEs pertains to employment, the economy, and, most significantly, the sustenance of individuals. The 2019 China Economic Yearbook indicates that China's SMEs exhibit the defining features of '56789'. They account for over 50% of the nation's tax income, over 60% of GDP, surpassing 70% of technological innovation, comprising over 80% of urban labour employment, and representing more than 90% of firms. These statistics indicate that SMEs are fundamental to China's economic framework. Consequently, PBOC has established the principal short-term monetary policy target as stabilising growth and protecting employment.

In the long term, China's principal target of monetary policy in response to Covid-19 is to stabilise the CNY exchange rate and expedite the internationalisation of the CNY. Yi Gang, former governor of the People's Bank of China, addressed all facets of China's economic landscape and monetary policy during the Macro Week 2023 event. He stated that China's principal long-term target following the Covid-19 epidemic was to advance the internationalisation of the CNY, enhance its standing in the global monetary system, and ensure the relative stability of its exchange rate. Numerous scholarly studies endorse the PBOC's prioritisation of addressing the CNY exchange rate as a

principal target following the crisis. Banerjee and Goyal (2021) identified that the CNY was overvalued prior to the 2008 global financial crisis and then became undervalued post-crisis. Guo (2023) confirms that post-Covid-19, the CNY exchange rate increased, indicating an undervalued condition. Tian (2019) illustrates that the real effective exchange rate of the CNY has fluctuated between overvaluation and undervaluation since the 1990s, with no significant imbalances occurring except in 2008 and 2009. Based on Guo (2023), an escalation in the temporary degree of exchange rate imbalance inhibits short-term capital flows, with the most pronounced suppression occurring in the short term, diminishing in the medium term, and approaching negligible effects in the long run. As China progresses in liberalising its capital account, attracting foreign capital inflows, and enhancing capital mobility to manage the balance of payments, foreign investors may exhibit reluctance to invest in China due to risk aversion, particularly in scenarios of severe exchange rate instability and significant short-term imbalances. This will adversely affect short-term capital flows and hinder domestic investment initiatives and economic growth. Consequently, it is crucial for PBOC to execute monetary policy to rectify the transient imbalance of the the exchange rate and uphold the stability of it.

It is noteworthy that, in contrast to Western economies characterized by more open capital markets, China's capital account is comparatively closed. The closed nature of China's capital account during the Covid-19 pandemic notably strengthened the autonomy of monetary policy in both the pandemic and post-pandemic periods (2020–2025). Capital controls successfully prevented the transmission of external financial cycle shocks, allowing the People's Bank of China to independently reduce policy interest rates, including the Medium-term Lending Facility (MLF), and reserve requirement ratios during the Federal Reserve's aggressive rate-hiking cycle (2023–2025). This approach facilitated a loose monetary policy stance aimed at

supporting economic recovery (Zhang, 2022). This has diminished the limitations of the trilemma, enabling monetary policy to focus on the dual goals of stabilizing growth and mitigating domestic risks (State Administration of Foreign Exchange, 2025). The closed capital account has facilitated institutional buffers for the transition to price-based regulation. Restrictions on cross-border capital flows have diminished the influence of arbitrage transactions on the interest rate corridor, allowing the central bank to progressively enhance the transmission mechanism from the MLF rate to the LPR and subsequently to loan rates (Wei et al., 2025). Quantitative instruments, including the reserve requirement ratio, continue to play a structural adjustment role, especially within the credit sector of small and medium-sized banks where interest rate transmission is ineffective. However, this mechanism also involves structural costs. The inefficiency of cross-border financing has compelled enterprises to depend on policy alternatives like integrated CNY and foreign currency funding pools, thereby heightening operational complexity (Zhang, 2022). Long-term capital account management must be enhanced alongside interest rate and exchange rate reforms to meet the requirements of CNY internationalization (Wei et al., 2025).

Overall, China's recent monetary policy targets framework is multi-dimensional, comprising four primary priorities. First, price stability. Ensuring that CPI inflation stays within a reasonable range is a fundamental target, particularly due to the socio-political implications of food and housing costs. Second, economic growth and employment. Monetary policy is essential for achieving broader economic targets established by the government, especially during cyclical downturns or external shocks, such as the Covid-19 pandemic and trade tensions. Third, financial stability. Following the 2015 stock market crisis and the 2017 deleveraging campaign, PBOC has explicitly associated monetary policy with macroprudential targets. This involves limiting excessive credit expansion, averting asset bubbles, and overseeing systemic risk

management. Finally, stability of exchange rates. China has officially adopted a managed floating exchange rate regime. However, in practice, the targets related to the exchange rate continue to limit the autonomy of monetary policy due to existing capital controls and pressures from international trade.

This multi-target framework presents inherent challenges. For instance, policies aimed at supporting growth may conflict with inflation control, while measures for financial stability, such as credit tightening, may counteract accommodative impulses. This contradiction is generally substantiated by the Tinbergen rule. The Tinbergen rule posits that a single policy instrument cannot simultaneously attain both price and quantity targets (Tinbergen, 1952). China's institutional innovations have established a dual-track system via structural isolation mechanisms (Zhou, 2018). The selection between interest rate targets and quantity targets is largely contingent upon the efficiency of financial market transmission and the stability of the economic environment. When interest rate transmission channels are efficient, characterized by ample interbank market liquidity and an effective LPR quotation mechanism post-2019 reform, the central bank focuses on adjusting price instruments, such as the MLF rate, to influence financing costs and bolster the real economy (Yi, 2020). An illustrative case is the initial phase of the Covid-19 pandemic during 2020–2021, characterized by moderate inflation and stable capital flows, which established a conducive environment for an interest rate-dominated framework.

In contrast, during instances of market failures or systemic shocks, quantity targets serve as the primary regulatory instrument. This is primarily evident in three scenarios. Structural blockages in interest rate transmission, including rigid liability costs for small and medium-sized banks, compel the central bank to depend on reserve requirement ratios to manage liquidity supply (Ma et al., 2021). Secondly, the necessity

for crisis response becomes evident, as illustrated by the 2022 real estate debt risk, during which the central bank established a 200 billion CNY re-lending quota to regulate credit flows (PBOC, 2022). Third, external shocks can disrupt the monetary base, as observed during the rapid growth of foreign exchange reserves prior to 2014, necessitating the adjustment of the reserve requirement ratio to counteract excess liquidity (Gao, 2015).

China's advancement in theoretical constraints is attributed to two distinct types of institutional designs. Structural instruments, including targeted re-lending, segment the liquidity market to prevent total control from distorting interest rate signals (He et al., 2020). Secondly, the Macroprudential Assessment (MPA) incorporates constraints on credit scale, merging quantitative controls with regulatory indicators (Sun, 2023). This hybrid framework represents an adaptive innovation during the transition period, with its sustainability contingent upon the extent of interest rate liberalization. With the maturation of the government bond yield curve and the advancement of financial reforms, the significance of price-based controls is expected to rise gradually (Yi Gang, 2023).

## **2) Intermediary target**

Generally speaking, policy instruments typically cannot be directly implemented on the ultimate target and must undergo an extended transmission procedure. Consequently, the central bank typically identifies specific intermediate economic indicators that are closely associated with the ultimate target as intermediary targets, thereby minimising the time lag in the transmission of monetary policy and improving the adaptability and promptness of macroeconomic regulation. Intermediate targets of monetary policy are often classified into two categories: quantity-based intermediary targets and price-based intermediary targets. The former is primarily shown by the

money supply and credit scale, while the latter is predominantly reflected by the interest rate. The selection of an intermediate target must be examined within the framework of particular historical developmental phases and economic operational circumstances. Consequently, intermediate targets of monetary policy differ among nations and are always subject to ongoing examination and modification.

According to this framework, the intermediary targets of China's monetary policy can also be categorized into quantitative and price-based classifications. Quantitative intermediary targets primarily pertain to M2 and the volume of social financing, whereas price-based intermediary targets of monetary policy are primarily associated with various interest rate indicators across different maturities in the money, credit, and bond markets. However, the promotion of interest rate marketisation and the enhancement of the transmission mechanism have led to a heightened significance of the operational target, while the intermediary target has diminished in importance. Furthermore, the operational target can serve as a 'wind vane' for the intermediary target (Li, 2019). At this stage, China's central bank focuses on fluctuations in liquidity levels and the market benchmark interest rate, as these factors are directly linked to the implementation of monetary policy and serve as indicators for assessing its effectiveness.

Taken together, for the period before Covid-19, the evolution of China's monetary policy intermediate target exhibits distinct patterns. Initially, in determining the intermediate targets of monetary policy, PBOC has consistently emphasised the interaction between the indicators on the liabilities side of financial institutions (e.g., money supply) and those on the assets side (e.g. the volume of credit and social financing). Secondly, the rapid innovation of financial products and financing methods has broadened the statistical scope of quantitative monetary intermediate targets. The

regulation has progressively evolved from the initial control of base money (M0) injection to the management of narrow money supply (M1), and subsequently to the oversight of broad money supply (M2). Third, as interest rate market reform progresses, price-based policy instruments are increasingly playing a significant role in macroeconomic management, indicating a shift in monetary policy from quantitative to price-based approaches. The transition of monetary policy is not an instantaneous process, and currently, price-based monetary policies alone lack the capacity to govern the macroeconomy. Therefore, the reliance on quantitative regulatory instruments remains necessary for the foreseeable future (Zhou and Ye, 2019; Zhang and Jiang, 2020).

Following the commencement of Covid-19, there was a more pronounced escalation in the PBOC's articulation of intermediate targets. At the announcement of first quarter of 2020, PBOC explicitly stated<sup>5</sup> that, in response to Covid-19, it would enhance its efforts regarding the price channel and the exchange rate channel. However, the selection of the intermediate target was not clearly stated in that announcement. In the fourth quarter of 2020, the PBOC spokesperson commented on the assessment of international trade dynamics in relation to real exchange rates. The spokesman simultaneously referenced the policy of regulating the Shanghai Interbank Offered Rate (SHIBOR) to stabilise financial markets and rejuvenate output. However, it remained ambiguous if it would serve as a primary indication for the interest rate channel. We therefore believe that the price and exchange rate channels have in fact been applied by the PBOC to counteract the effects of Covid-19, just without explicitly stating the corresponding intermediate targets.

In summary, the intermediary target within China's monetary policy framework is

<sup>5</sup> People's Bank of China, Third Briefing, Economic Operations to Combat the Coronavirus Epidemic, March 2020.

currently transitioning from a quantity-based approach, such as M2 and total social financing, to a price-based approach, exemplified by SHIBOR. When analyzing the PBOC's response to Covid-19, it is essential to consider both categories of intermediary targets.

## **2.2.4 Instruments framework**

In comparison to Western economies, China's monetary policy instrument framework is china-specific, featuring a combination of quantitative policy instruments, price-based policy instruments, and a blend of both types during the transition of monetary policy from quantitative to price-based approaches. The PBOC has advanced monetary policy innovation in recent years, introducing not only aggregate-type instruments but also a series of structural-type instruments. This expansion innovatively extends the aggregate demand management function of monetary policy to encompass supply management and economic restructuring. Table 2.2 presents a summary of the classification of China's monetary policy instruments at this stage.

Table 2.2: Instrument framework of PBOC

Category	Quantitative	Price-based	Combined
Aggregate	Refinancing and rediscounting	Deposit and loan	Open Market Operation
	Statutory reserve ratio (Board)	benchmark	Standing Lending Facility
		rates	Medium-term Lending Facility
Structural	Credit quotas and window guidance		Pledged Supplementary Lending
	Statutory reserve ratio (Targeted)	-	Specialised Refinancing

China primarily employs quantitative and hybrid policy instruments, with the latter assuming a more significant role. The central bank employs quantitative instruments by providing funds to financial institutions via refinancing and rediscounting, or by releasing aggregate liquidity through a comprehensive quota reduction, classifying these actions as aggregate-type instruments. The PBOC can release liquidity to enhance financing growth in critical sectors, such as small and micro enterprises, through targeted reductions. Additionally, it can offer specific financial support in exceptional situations via conventional credit quotas and window guidance, which are classified as structural instruments. Among price-based instruments, the conventional adjustment of the benchmark interest rate for deposits and loans is the sole example of pure price-based instruments. With the advancement of interest rate marketisation reform, the benchmark lending rate has been abolished, while the benchmark deposit rate remains in place. Adjustments to the benchmark deposit rate significantly affect the cost of liabilities for commercial banks. Regarding hybrid instruments, PBOC injects liquidity into the market via Open Market Operation (OMO), Standing Lending Facility (SLF), and Medium-term Lending Facility (MLF) operations, which can be characterized as a quantitative function. The bidding rate of the aforementioned

instruments serves as a significant policy rate of the central bank, reflecting its pricing function. Additionally, the MLF interest rate acts as the anchor for LPR pricing, representing an even more critical central bank policy rate. The aforementioned instruments are classified as aggregate-type instruments. The PBOC can simultaneously provide targeted liquidity using structural instruments, including Pledged Supplementary Lending (PSL), specialised refinancing, and specialised support instruments, with the interest rates of these instruments complementing the central bank's policy rate. The interest rates associated with special refinancing and support instruments can effectively lower the financing costs in critical sectors of the real economy. PSL is primarily allocated to agriculture, while other specialised refinancing and support instruments are designated for various fields, including manufacturing, small and micro-enterprises, agriculture, scientific and technological innovation, and transport and logistics. It is worth noting that the reserve requirement ratio (RRR) is considered as a fundamental instrument within China's monetary policy framework. The People's Bank of China regulates the credit expansion capacity of the banking system by frequently adjusting the reserve requirement ratio for commercial banks, exemplified by the two RRR cuts in 2023 that released over one trillion yuan in liquidity. This approach integrates both aggregate and structural functions, including targeted RRR cuts aimed at supporting small and medium-sized enterprises. This operational model resembles that of developing countries, such as India and Brazil, yet it diverges considerably from that of major developed economies. The Federal Reserve has kept a statutory reserve ratio close to zero since the 2008 financial crisis, the European Central Bank eliminated the statutory lower limit in 2012, and the Bank of Japan employs a three-tier reserve system while primarily depending on interest rate corridor controls. The primary factor contributing to the diminished role of the RRR in developed economies is the presence of established interest rate transmission mechanisms, wherein central banks exert direct influence on market interest rates via

policy rates, such as the federal funds rate. In China, interest rate liberalisation remains in an optimisation phase, requiring ongoing dependence on quantitative instruments such as the RRR to enhance liquidity management. Furthermore, China has combined the RRR with the Macroprudential Assessment (MPA), granting it a dual role in mitigating systemic risks. This method integrates quantity and price controls while optimizing structural design, illustrating the distinct features of monetary policy in a transitioning economy.

It should be further noted that the PBOC has so far not made a distinction between so-called conventional and unconventional monetary policy instruments. Therefore, we first need to clarify the choice of unconventional monetary policy instruments in PBOC's monetary policy framework.

Conventional monetary policy operations are defined as the methods employed by central banks to influence money supply and interest rates. These methods include interest rate adjustments and open market operations, aimed at stabilizing economic growth and controlling inflation. Unconventional monetary policy operations denote specific measures implemented by the central bank to promote economic recovery and rebuild confidence during periods of significant economic distress. There are approximately three differing perspectives between the two as outlined below.

The targets of the two are distinct. The primary targets of conventional monetary policy typically include sustaining economic growth and regulating inflation. The aim of unconventional monetary policy is to promote economic recovery and rebuild confidence through specific measures during periods of significant economic distress. Furthermore, the instruments and effects of the two differ. The instruments of conventional monetary policy primarily include widely used and frequent measures,

such as open market operations, which influence economic activity by altering the money supply and interest rates. Unconventional monetary policy instruments encompass quantitative easing, which involves large-scale purchases of treasury bonds and other assets, negative interest rate policies, and atypical measures like direct liquidity support to banks. These instruments aim to enhance credit supply and stimulate investment. The risks and side effects of the two are distinct. Conventional monetary policy operations exhibit greater robustness. However, there exists a risk of them being either excessively tight or excessively loose, potentially leading to negative economic consequences. Unconventional monetary policy operations entail greater risks and may result in issues such as financial market instability, asset price bubbles, and challenges in exiting these policies.

While PBOC did not specify the status of unconventional monetary policy implementation in China in its statements, however, the status of innovative monetary policy implementation was clearly articulated in the Monetary Policy Yearbook. China's innovative monetary policy first appeared in the PBOC's 2013 Monetary Policy Yearbook, released in 2014.

Innovative monetary policy originated from the reevaluation and advancement of conventional monetary policy instruments globally following the 2008 financial crisis. The 2008 subprime mortgage crisis in the United States had far-reaching effects, resulting in a global financial crisis that adversely affected the balance sheets of financial institutions and enterprises in both Europe and the United States, culminating in a market credit crunch. Despite central banks injecting substantial liquidity into the market via conventional monetary policy instruments, the overly cautious lending behavior of financial institutions and the declining financing environment resulted in an overall sufficiency of liquidity, while a structural liquidity

gap developed in the real sector. In response to this situation, central banks have sought to enhance and innovate their monetary policy instruments to better align with market conditions and improve the effectiveness of regulatory measures.

Prior to 2012, the foreign exchange account served as the primary mechanism for PBOC to inject base money. The primary reason for this is that, following its accession to the World Trade Organisation (WTO), China's balance of payments has consistently exhibited a double surplus. The PBOC opted to inject a significant amount of base currency through foreign exchange purchases to maintain stability in the CNY exchange rate. Nonetheless, this situation underwent a transformation in 2012. In the latter half of 2012, China's foreign exchange account growth rate experienced a notable decline, subsequently leading to a reduction in base money injection. To address this issue and ensure sufficient market liquidity, the PBOC initiated the development of innovative monetary policy instruments derived from conventional monetary policy frameworks. This leads to the derivation of innovative monetary instruments that are distinct from conventional monetary policy instruments.

In conclusion, refer to the official yearbook<sup>6</sup> from the PBOC outlines the innovative monetary policy instruments implemented, we believe which consist of following categories: Short-term Liquidity Operation (SLO), Standing Lending Facility (SLF), Medium-term Lending Facility (MLF), Pledged Supplementary Lending (PSL), and Targeted Lending<sup>7</sup> (TL). Furthermore, there exists an additional innovative monetary policy instrument frequently referenced in various speeches and statements that has not been included. That is, the targeted reduction the statutory reserve requirement ratio (also named as Targeted Downgrade).

<sup>6</sup> Monetary Policy Yearbook, PBOC, 2014-2024.

<sup>7</sup> Also referred as Targeted Medium-term Lending Facility (TMLF) in some reports due to the predominance of medium-term operations.

However, our summary of China's monetary policy instrument framework concludes with one last critical consideration: whether the innovative monetary policy instruments referenced in these yearbooks qualify as unconventional monetary policy instruments. The unconventional monetary instruments employed to address Covid-19 possess distinct targets, which underscore their functionality and specificity in this context, also their characteristics that underscore the functionality and specificity.

In light of our discussion regarding the effects of Covid-19, we determine that the previously mentioned monetary policy instruments should be categorized as unconventional monetary policies enacted in response to the pandemic. This classification is primarily due to the instruments' ability to effectively address transmission channel blockages and structural conflicts arising from the pandemic.

Covid-19 represents an external public health crisis, with its economic effects demonstrating a dual freeze in both supply and demand. Control measures have disrupted production chains and suppressed consumption activities, resulting in a sudden interruption of corporate cash flows, particularly for small and medium-sized enterprises lacking reserve buffers. Additionally, declining household incomes further diminish debt-repayment capabilities. This fundamentally contrasts with traditional economic recessions, which are characterized by insufficient demand, or financial crises, which are marked by liquidity shortages. Conventional monetary policies, including universal interest rate cuts and reductions in reserve requirement ratios, depend on interest rate transmission channels and the rational responses of market participants. However, due to the pandemic's impact, the interest rate transmission mechanism initially becomes ineffective as banks' risk preferences significantly decline. Despite reductions in policy interest rates, credit spreads may widen as a result of deteriorating

corporate balance sheets, thereby counteracting the benefits of lower financing costs (Yi, 2020). The liquidity trap intensifies progressively. As nominal interest rates near the zero lower bound, households and businesses tend to prioritize cash hoarding rather than enhancing investment or consumption, resulting in monetary expansion not effectively translating into demand. Despite not achieving a zero interest rate, pandemic-related uncertainties have led to a significant decline in the marginal propensity to consume, reaching historical lows. In the first quarter of 2020, the household savings rate increased to 37%, while the disparity between M2 growth and GDP growth expanded to 12 percentage points, suggesting that monetary easing has encountered challenges. The Covid-19 pandemic has further exacerbated existing structural issues. The pandemic's impact has been sector-specific, disproportionately affecting the service sector, small and medium-sized enterprises, and low-income groups compared to sectors like technology and healthcare. Aggregate-level instruments can intensify capital idleness; for instance, the U.S. quantitative easing in 2020 resulted in the Nasdaq index achieving a record high, whereas the bankruptcy rate of small and medium-sized enterprises rose by 48% year-on-year.

In addressing these two issues, the PBOC effectively utilized the previously mentioned monetary policy instruments as unconventional instruments. The Standing Lending Facility (SLF) and Medium-term Lending Facility (MLF) were primarily employed to mitigate liquidity segmentation. The Standing Lending Facility (SLF) functioned as the upper boundary of the interest rate corridor, established at 3.4% amid the global dollar shortage in March 2020, thereby preventing the transmission of variations in money market interest rates to the financing costs of the real economy. The MLF injected medium-term liquidity into primary dealers, amounting to 4.3 trillion CNY in 2020, to protect the credit-granting capacity of the banking system and avert a

recurrence of the 2008 liquidity crisis (Pan, 2022). Targeted Downgrade in reserve requirements and Targeted Lending initiatives were implemented to mitigate the liability constraints encountered by small and medium-sized banks. The PBOC established a preferential reserve requirement ratio ranging from 0.5 to 1.5 percentage points for banks that satisfied inclusive finance assessment criteria, resulting in the release of 550 billion CNY in 2020. This policy mandated that the funds be allocated exclusively for small and micro loans at notably reduced interest rates, thereby directly addressing the barriers to credit transmission associated with the inflexibility of small and medium-sized banks' liability costs (Ma et al., 2021). Empirical evidence indicates that the growth rate of small and micro enterprise loans at beneficiary banks exceeded the industry average by 8 percentage points (Pan, 2022). Ultimately, PSL was employed to reconstruct essential supply chains. During the pandemic, PSL was predominantly allocated for the targeted enhancement of medical infrastructure, exemplified by the Leishenshan Hospital and Huoshenshan Hospital, and did not substantially influence the overall economy. This may result from the implicit fiscal subsidy characteristics of PSL, potentially distorting market pricing. In general, these monetary policy instruments should be regarded as unconventional monetary policy instruments used by the PBOC in response to Covid-19.

This section examines each unconventional monetary policy instrument individually, detailing their implementation in China and assessing their use in response to the Covid-19 outbreak.

### **1) Targeted Downgrade**

The concept of Targeted Downgrade was initially implemented by PBOC in 2014<sup>8</sup>. This

<sup>8</sup> Announcement on the Opening of Refinancing Loans in Support of Small and Micro Enterprises and the Expansion of Credit

policy instrument aims to deliver targeted support to agriculture, integral to the national economy, and to small and medium-sized enterprises (SMEs), which are particularly vulnerable. It seeks to enhance liquidity for both sectors, thereby alleviating the financing constraints encountered in agricultural and SME development in rural areas. The Targeted Downgrade primarily affects the China Agricultural Development Bank, local rural commercial banks, rural cooperative banks, and certain small to medium-sized enterprises in rural regions. As of 2024, Targeted Downgrade has been executed 19 times, focusing on agriculture and SMEs, with the target of bolstering critical and vulnerable sectors of national economic development. The implementation effects indicate that following multiple rounds of Targeted Downgrade, the SRR for agricultural development banks has decreased by approximately 6 percent, while the SRR for local rural banks and other financial institutions has declined by about 1 to 2.5 percent. This has significantly enhanced liquidity in rural areas while simultaneously boosting the activity of SMEs through Targeted Downgrade, resulting in a positive policy outcome. The Targeted Downgrade policy experienced a significant modification in 2017. The initial focus on agriculture and SMEs was shifted to encompass financial institutions at various levels, provided their loans in the realm of financial inclusion met specific criteria. This adjustment also included SMEs, self-employed individuals with limited assets, and certain disadvantaged groups, such as those seeking start-up loans or student loans. This shift renders Targeted Downgrade less confined to its sectoral function and more inclusive. However, it also positions Targeted Downgrade as a conventional monetary policy instrument<sup>9</sup>. Therefore, we would not take Targeted Downgrade into account in the subsequent discussion of the effectiveness of unconventional monetary policy instruments.

Investments in Small and Micro Enterprises, PBOC, 20 March, 2014.

<sup>9</sup> Extension of the previous Targeted Downgrade assessment for loans to agriculture-related and SMEs to loans in the inclusive financial sector, announcement, PBOC, 30 September, 2017.

## 2) Lending facility-type instruments

Lending facility-type innovative monetary policy instruments implemented by PBOC include two different categories, Standing Lending Facility (SLF) and Medium-term Lending Facility (MLF).

The Standing Lending Facility primarily serves as a means for financial institutions to address their significant long-term liquidity requirements. Financial institutions initiate the liquidity investment process, and PBOC provides loans to these institutions in the form of collateral or credit borrowing. The loans are offered in three different durations, overnight, 7 days, and 1 month. The Medium-term Lending Facility is a mechanism used by the central bank to offer medium-term funding in the form of base currency. Its purpose is to enhance loan recovery and provide targeted assistance to ARF (Agriculture, Rural and Farmers), and small and medium-sized enterprises (SMEs). The facility offers loans with varying durations of 3 months, 6 months, and 1 year. The interest rate can be renegotiated and extended close to the maturity date. Financial institutions have the authority to initiate the process of applying for lending facility instruments in order to engage in one-to-one transactions with the central bank. The interest rates of lending facilities and interbank lending rates are closely related, which will assist China in establishing the upper limit of the interest rate corridor. Figure 2.3 illustrates the regulatory logic of Lending facility-type instruments.

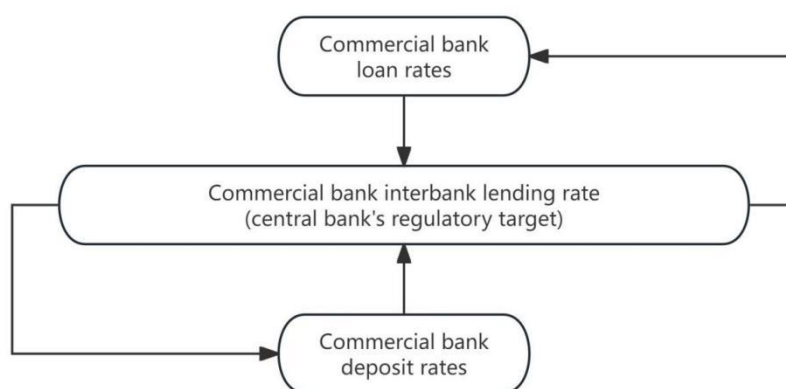


Figure 2.3: Lending facility-type regulatory logic

### a) Standing Lending Facility (SLF)

Standing Lending Facility (SLF) as a innovative monetary policy instrument to meet the increased liquidity requirements of originators. The SLF serves as a short-end interest rate adjustment instrument, with borrowing and lending maturities ranging from one day to three months. The system comprises low-interest overnight and 7-day repo funding operations, effectively regulating market liquidity. It offers financial institutions substantial liquidity support over extended timeframes. The fundamental operating principle of the SLF is that during a liquidity crunch in the money market, market interest rates rise. Commercial banks and various financial institutions face an urgent need to supplement their funds to sustain market liquidity, resulting in a significantly elevated cost of liquidity at that time. Currently, commercial banks and various financial institutions have the option to submit borrowing applications to the central bank, using their assets as collateral, thereby obtaining liquidity at a reduced cost. The replenishment of liquidity in commercial banks and financial institutions will lead to a reduction in the volatility of market interest rates, resulting in a downward adjustment of short-term interest rates. In a short-term economic context, commercial banks are likely to ease financing and loan audit standards for enterprises. This

adjustment will reduce capital costs for businesses, enabling them to secure adequate funding to expand production capacity and stimulate a short-term economic surge. The realization process of SLF is primarily driven by financial institutions as the initiators, whereas the People's Bank of China assumes a more passive role. This provides SLF with a distinct advantage, allowing financial institutions to fully exercise their initiative by proactively monitoring and reporting on the economic situation. The implementation process of financial institutions applying for SLF operations according to their liquidity needs reflects market demand and indirectly aids the central bank's liquidity management. Furthermore, SLF allows the central bank to better understand the macroeconomic direction and dynamics with greater accuracy and intuition.

Since June 2013, PBOC has been using the SLF as a necessary complementary instrument to open market operations to provide a channel for regulating market liquidity. Among the innovative monetary policy instruments issued in China, SLF can be called a representative instrument for more targeted market liquidity acquisition based on its 'one-to-one, point-to-point' operational characteristics. The so-called 'one-to-one, point-to-point' refers to the fact that SLF will only be traded between the central bank and commercial banks and various types of financial institutions, and not for the whole society. In essence, SLF is a instrument for commercial banks and various financial institutions to apply for credit lines from the central bank in the form of collateral. However, under normal circumstances, in order to become qualified collateral recognised by the central bank, the quality level of credit assets needs to reach a certain height and standard. Based on this nature, the standing lending facility is naturally characterised by the following features. First, targeting. That is, the originator of the SLF must operate on a 'one-to-one, point-to-point' basis with the central bank. Second, collateralisation. That is, the originator of the SLF must participate in the collateralisation process, using its own assets as collateral, and

cannot borrow at will. Finally, environmental dynamics. That is, the SLF originator must select appropriate collateral according to the dynamic changes in the economic environment.

It is worth noting that Discount Window Lending, as a conventional monetary policy instrument analogous to the SLF, cannot be identified the same. The SLF and Discount Window Lending utilized by the PBOC exhibited distinct operational targets, mechanisms of action, and target entities in their responses to the impact of the Covid-19 pandemic. The SLF serves as an upper limit instrument within the interest rate corridor, primarily offering short-term liquidity support (generally 1–3 months) to deposit-taking financial institutions, including commercial banks, with the target of stabilizing interbank market interest rate fluctuations. In March 2020, amid the global dollar shortage, the SLF interest rate was established at 3.4%. Liquidity was provided by accepting high-grade credit bonds and other collateral to ensure that money market interest rates did not surpass the upper limit of the corridor (He et al., 2020). The operation is fundamentally defensive, aimed at mitigating systemic risks arising from liquidity stratification.

Discount Window Lending directly facilitates the credit restoration of the real economy. Commercial banks discount their outstanding commercial bills, primarily those issued by SMEs, to the central bank to secure low-cost funds. For instance, the special rediscount rate was lowered to 2.25% in 2020. This instrument mitigates corporate distress via two channels. Initially, it lowers the bill financing costs for banks, resulting in reduced discount rates for enterprises; for instance, Jiangsu Bank's discount rate for small and micro enterprise bills was reduced by 50 basis points in 2020. Additionally, it broadens the range of acceptable collateral for bills by including those issued by enterprises involved in epidemic prevention and control, thereby

offering targeted assistance to the cash flow of struggling enterprises (PBOC, 2020).

### **b) Medium-term Lending Facility**

In September 2014, PBOC initiated the use of the Medium-term Lending Facility (MLF) as a novel monetary policy instrument to offer medium-term base money support to financial institutions. MLF resembles SLF, yet it exhibits distinct differences. Both are issued as qualified collateral; however, MLF is typically executed via a bidding process. The MLF typically has a loan maturity ranging from 3 months to 10 years and serves as a medium- to long-term interest rate adjustment instrument. The fundamental operational principle of MLF resembles that of SLF, as both involve commercial banks and various financial institutions borrowing from the PBoC using collateral. In contrast to SLF, which typically has a term of 3 months, MLF generally spans 6 to 9 months and may be extended as necessary. Simultaneously, SLF interest rates are established directly by the central bank, whereas MLF is determined through a tender process. Consequently, the MLF typically offers a lower interest rate compared to the SLF, more effectively addresses long-term liquidity management requirements, and presents reduced risk relative to the SLF. Additionally, SLF serves as a short-term policy instrument designed to mitigate short-term liquidity risks in the money market. In contrast, MLF functions as a medium- to long-term policy instrument, focusing primarily on regulating financing costs within the money market. MLF can influence market interest rates, mitigate inflation risk, and contribute to interest rate stabilization, thereby facilitating the marketization of interest rates.

However, the role of MLF extends beyond this; its significant advantages also contribute to the development of China's SMEs and the application of the ARF field. The reasons for this may include that the collateral required by MLF originators is broader than that of SLF, indicating that obtaining MLF is less difficult and less risky.

Secondly, the MLF aims to lower financing costs in the money market, addressing a significant liquidity challenge for agricultural development and the functioning of SMEs. Third, in comparison to SLF, MLF offers greater flexibility regarding the operating timeframe and available funds. Upon the expiration of the lending period, both parties may engage in amicable negotiations concerning the timeframe and interest rate for renewal or extension, thereby effectively sustaining the medium- and long-term transmission effect of interest rates.

The unique advantages of MLF have led to its gradual emergence as a policy signal in open market operations, coinciding with the ongoing improvement of China's monetary policy framework. In recent years, MLF has gained significance as an innovative monetary policy instrument. It has emerged as a primary mechanism for the central bank's medium- and long-term liquidity injections. Following the 2019 reform of the Loan Prime Rate (LPR), the MLF interest rate has evolved into a critical policy interest rate that influences the LPR, effectively serving as an anchor for interest rates in the credit market.

### **c) Pledged Supplementary Lending (PSL)**

The evolving economic landscape has prompted the PBOC to adopt new monetary instruments for proactive regulation, moving away from a passive response to fluctuations in market liquidity. This shift aims to replace the former strategy of passively accepting foreign exchange inflows to mitigate economic conditions. The People's Bank of China's application of monetary policy instruments has evolved in response to shifts in the economic landscape. Consequently, the overarching framework of monetary policy has transitioned from a focus on quantity to an emphasis on price-based instruments. In this context, enhancing the State Development Bank's support for key projects related to shantytown renovation and expanding financial

institutions backing for shantytown initiatives to ensure appropriate, long-term, and stable funding sources aligns with the initial targets of the PBOC's launch of the PSL. To achieve the stated targets, safeguard the implementation of policies in critical areas, and strengthen project development in underperforming regions, the PBOC initiated Pledged Supplementary Lending in April 2014 to facilitate low-cost borrowing for commercial banks.

The PSL is an innovative monetary policy instrument, akin to the SLF and MLF. Its implementation necessitates that financial institutions in sound operational condition provide specific collateral qualifications to submit applications to the PBOC. Similar to the MLF, it serves as a mechanism for medium to long-term interest rate adjustment. The PSL typically operates over a duration of 3 to 5 years. Unlike other policy instruments, the PSL is more focused and is primarily executed to achieve national policy targets.

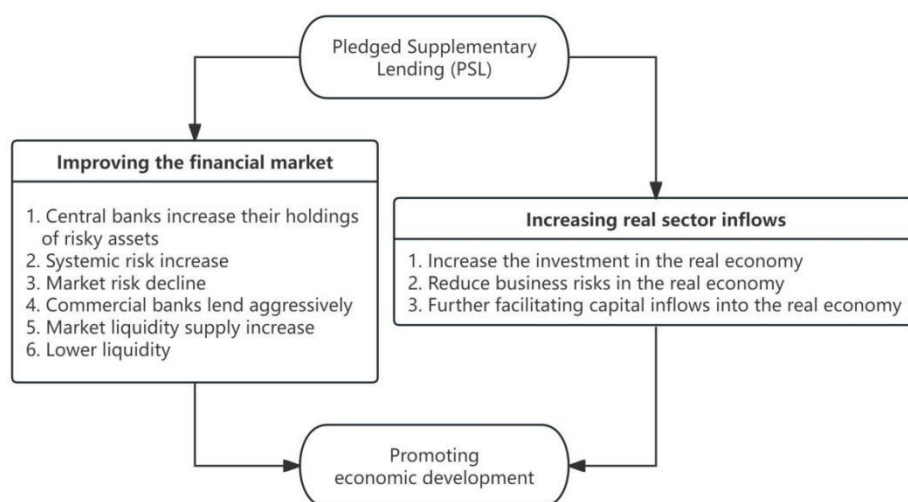


Figure 2.4: Pledged Supplementary Lending regulatory logic

Figure 2.4 illustrates the basic regulatory logic of PSL. To address the adverse impacts

of economic overheating, the Central Bank will lower the collateral exchange rate in relation to liquidity to regulate infrastructure activities. The expense associated with acquiring market liquidity rises for commercial banks and financial institutions. Financial institutions that satisfy operational criteria will likely decrease their access to central bank funds to enhance funding, increase efficiency, and lower costs, resulting in a decline in overall loanable funds in the market. In this context, the composition of banks' assets and liabilities has evolved, necessitating that each subsequent transaction conducted by banks undergoes heightened scrutiny and evaluation to ensure the continued functionality of the financial system, thereby resulting in more stringent lending conditions. Banks will actively utilize available monetary policy instruments to sustain operations and improve liquidity. Financial institutions, guided by the principle of profit maximization and the need to mitigate financial risk, anticipate that borrowers possess the capacity to repay loans punctually and maintain robust security qualifications capable of withstanding a defined level of risk in financial transactions. In our country, institutions providing such high guarantees are not predominant. A significant number of small enterprises in China's market exhibit low qualifications, insufficient capital, and poor operating conditions. These enterprises demonstrate low competitiveness, lack support from financial institutions, and possess limited resilience to external shocks. The PSL implemented by the PBOC exhibits the characteristics outlined above. Primarily, given that the majority of national policy targets pertain to infrastructure development, which entails extended construction durations and prolonged operational return periods, the PSL emphasizes the provision of long-term loans. Secondly, the PSL directly governs the money supply and indirectly influences medium- and long-term market interest rates in the money market, thereby integrating the features of both quantitative and price-based instruments. Thirdly, PSL resembles refinancing as it constitutes a targeted monetary infusion. PSL differs in that it necessitates the originator's assets as collateral, thereby

mitigating the credit risk associated with refinancing. Ultimately, PSL's primary service targets are more focused and aim to enhance national infrastructure. The PBOC does not regulate the operating period of PSLs, thereby decreasing borrowing costs.

In comparison to other innovative monetary policy instruments, the PSL is constrained in both the direction of fund allocation and the range of eligible issuance targets. The operational mechanism of PSL resembles that of SLF and MLF, wherein financial institutions submit qualified collateral to the central bank. In return, the central bank extends a specified amount of financial support to commercial banks, aligned with PSL's regulatory policy, and offers a designated policy interest rate. The majority of PSL's service objects are part of the national infrastructure, leading to substantial financial involvement in each project. Consequently, the significant funds influenced by PSL contribute to a reduction in social financing costs for projects, thereby indirectly benefiting the real economy. In addition, from the perspective of the actual implementation effect, after PBOC set up the PSL in 2014, its placement reached 698.1 billion in the following year, and by 2016, the PSL's placement reached 971.4 billion, an increase of 40 percent compared with the initial period when it was first set up. The expansion of the PBOC's operating targets from one national development bank to three policy banks aims to enhance the utilization of the PSL.

### **2.2.5 Transmission framework**

Monetary Policy Transmission refers to the whole process of how the central bank's policy intention affects market interest rates, credit supply, asset prices, expectations, and ultimately output and price levels through various channels. In standard theory, monetary policy is defined to be transmitted through 5 main channels. Those are

Interest Rate Channel, Credit Channel, Asset Price Channel, Exchange Rate Channel and Expectation Channel.

However, monetary policy transmission in China is unique due to the significant differences between China's economic system, financial structure, and degree of capital account openness and that of developed countries. Compare to major western economies, the bank-dominated financial system in China makes the credit channel more important. Also, the soft budget constraints such as state-owned enterprises and local government platforms have weakened the effectiveness of the interest rate channel. Moreover, the management characteristics of the exchange rate system weakened the spontaneous adjustment function of the foreign exchange channel. In addition, the low degree of marketisation makes the expectations channel of limited utility.

More specifically, the limitations on the expectation channel within China's monetary policy transmission mechanism arise mainly from three institutional constraints. Interest rate and exchange rate marketisation reforms are incomplete, hindering the effective transmission of policy signals through price mechanisms, resulting in challenges for market participants in forming stable expectations (He, 2013). The central bank has enhanced market communication; however, the dual-track interest rate system leads to low transmission efficiency of policy interest rate changes to deposit and loan rates, thereby diminishing the effectiveness of forward guidance (Ren et al., 2019). Conflicts among various monetary policy targets diminish the stability of expectations. The central bank is tasked with balancing various targets, including stabilizing growth, mitigating risks, and restructuring the economy. Policy orientations can be perceived by the market as discretionary decisions, which diminishes the credibility of expectation management (He, 2019). Third, microeconomic entities

exhibit a lack of sensitivity. The lenient budget constraints of state-owned enterprises and the tendency of residents to engage in precautionary savings diminish the wealth effect channel, thereby rendering the microeconomic basis for expectation transmission unstable (He, 2013; Song, 2008).

Scholars have primarily examined the effectiveness of China's monetary policy channels, focussing on the Interest Rate Channel, Credit channel, Asset Price Channel, and Exchange Rate Channel, due to the limitations imposed by China's financial structure and system.

The Forecasting and Analysis Division of the Department of Survey and Statistics of the People's Bank of China, in collaboration with the Survey and Statistics Division of the Wuhan Branch (2013), asserts that the credit and goods transmission channels of China's monetary policy operate with relative smoothness. Liu (2013) posits that both the credit channel and the monetary channel of China's monetary policy function effectively in tandem. However, the monetary channel's impact is limited in the short term, with the credit channel serving as the primary transmission mechanism for short-term monetary policy. Wei and Guo (2013) contend that the credit channel significantly explains the real economy, whereas the interest rate channel exhibits a lag, and the exchange rate channel plays a somewhat minor role. Zhu and Li (2013) contend that the corporate balance sheet channel of monetary policy transmission in China is fundamentally effective, yet exhibits asymmetry regarding sectoral impacts. Zeng (2014) posits that the monetary policy asset price transmission channel is present to some degree in China. However, the limitations in the development of the capital market hinder both the investment effect and the wealth effect of the stock market. Zhang (2019) evaluates the effectiveness of different monetary policy channels in China, arguing that the credit channel has been consistently upheld by the central

bank, though it has increasingly been supplanted by the interest rate and exchange rate channels in recent years.

Subsequently, we present a summary discussion of the four types of transmission channels.

### **1) Interest Rate Channel**

The Keynesian school posits that monetary policy can foster economic growth via the interest rate mechanism. Expansionary monetary policy, exemplified by an increase in the money supply by the central bank, results in a short-term liquidity effect that subsequently lowers interest rates. The decrease in interest rates results in lower financing costs, leading to a reduction in the expenses associated with goods and services acquired by businesses via credit, while simultaneously enhancing the return on investment. This subsequently encourages firms to increase investment, leading to a rise in aggregate output (Chong et al., 2006; Kontonikas & Zekaite, 2018).

Innovative monetary policy diverges from the conventional interest rate transmission mechanism by not only lowering market interest rates through an increased money supply but also influencing market interest rates directly via its own interest rate adjustments. The interest rate level of the SLF is determined by a combination of monetary policy regulation and the necessity to influence market interest rates. One purpose of innovative monetary policy is to reduce social financing costs. The interest rate of the SLF is typically lower than the prevailing market interest rate. Following the PBOC implementation of SLF operations, the market interest rate tends to decline gradually, thereby reducing the cost of social financing. The MLF interest rate serves as the medium-term policy interest rate, enabling the PBOC to modify the financing costs for financial institutions. By adjusting the MLF interest rate, the PBOC can

influence capital allocation towards sectors of the real economy that align with national policy targets, thereby facilitating a reduction in social financing costs. The PSL represents a significant financial provision with extended maturity offered to financial institutions, aimed at supporting projects addressing critical weaknesses in essential sectors of the national economy and enhancing public utilities, which may also contribute to reducing the cost of social financing. The TL operates through an interest rate transmission channel similar to that of the MLF, though it is more targeted, and the TL rate typically offers a 15 basis point advantage over the MLF rate.

Empirical evidence from China confirms that the introduction of MLF operations has significantly lowered the marginal cost of funding for commercial banks, particularly benefiting sectors like small and micro enterprises (He & Wang, 2019). Furthermore, the differentiated interest rates under TL operations have shown positive effects in guiding credit towards green finance and innovation-driven enterprises (Yu & Zhang, 2020). In the euro area, similar targeted interest rate instruments, such as the TLTRO, have also demonstrated effectiveness in stimulating lending to the real sector (Boeckx et al., 2017). Recent data from the Bank of Japan suggests that yield curve control strategies, another form of interest rate-based innovation, have anchored long-term interest rates, indirectly supporting investment and economic output (Hattori & Yetman, 2021).

A decrease in the interest rate of an innovative monetary policy instrument results in corresponding adjustments in the market interest rate. This, in turn, lowers the cost of social financing, prompting enterprises to increase investment spending and households to enhance consumption spending, ultimately fostering economic growth.

## 2) Credit Channel

Monetary policy influences loan sizes and subsequently impacts the real economy via the bank credit channel and the corporate balance sheet channel (Bernanke & Gertler, 1989). The bank credit channel, viewed from the banking entity's perspective, considers bank loans as the primary source of financing within the economic system. Consequently, the credit allocation by the banking sector directly influences the volume of loans and the investment capacity in the market. A reduction in the reserve ratio by the central bank enhances the lending capacity of commercial banks, thereby increasing the funds accessible to firms, which subsequently influences investment and aggregate output (Claudio & Haibin, 2008). The firm balance sheet channel begins at the firm level, positing that monetary policy influences not only market interest rates but also significantly affects the financial condition of firms. An accommodative monetary policy enhances firm stock prices, while a reduction in interest rates decreases interest payments and improves operating conditions for firms. Increased assets and decreased liabilities reduce the risk of default for firms, thereby enhancing their access to credit. This, in turn, fosters elevated levels of investment and gross output (Bernanke & Blinder, 1992).

The credit transmission mechanism of innovative monetary policy instruments closely resembles that of conventional monetary policy outlined previously. The PBOC employs innovative monetary policy instruments to enhance the liquidity of commercial banks. This is succeeded by an expansion in credit provision or restructuring by financial institutions, resulting in heightened social investment and, ultimately, economic growth. The SLF serves as a liquidity supply channel for the PBOC, facilitating substantial long-term liquidity provision to financial institutions. The credit transmission of SLF is limited to adjustments in the credit scale of financial institutions, rather than alterations in their credit structure. The PBOC can establish

varying interest rates for different types of guarantees under MLF and TL, thereby regulating the medium-term financing costs of financial institutions and directing more funds towards real economy sectors aligned with national policy targets. The credit transmission of MLF and TL can be achieved through modifications in both the credit scale and the credit structure of financial institutions. The targeted nature of PSL results in a credit transmission mechanism akin to that of MLF and TL, which can also be adjusted through modifications in the credit structure of financial institutions.

Studies show that following PSL implementations, credit to the housing and infrastructure sectors significantly increased, demonstrating the effectiveness of PSL in reorienting credit structure (Zhou & Wen, 2020). Similarly, empirical analysis of MLF usage has indicated a marked rise in credit extension to advanced manufacturing sectors, in alignment with policy goals (Liu & Zhang, 2021). The European Central Bank's use of targeted refinancing operations (TLTROs) also supports the argument that credit incentives under targeted instruments lead to measurable growth in bank lending (Altavilla et al., 2020). From an international perspective, India's Targeted Long-Term Repo Operations (TLTRO 2.0) showed positive results in improving credit flow to NBFCs and MSMEs during the Covid-19 period (RBI, 2021).

### **3) Asset Price Channel**

Monetary policy influences investment and consumption via the asset price channel, leading to alterations in aggregate demand and, consequently, aggregate output. Tobin's Q theory posits that expansionary monetary policy by the central bank leads to increased liquidity, resulting in higher asset prices. This phenomenon causes the market value of firms' stocks to exceed their replacement costs, indicating that Tobin's Q is greater than 1. Currently, firms are more likely to enhance investment and broaden production (Faria et al., 2011). The increase in asset prices will enhance

residents' disposable income via the wealth effect, subsequently leading to an increase in consumption expenditure. The combined influence of investment and consumption leads to an expansion of aggregate demand, resulting in increased output (Ghossoub & Reed, 2014; Jia & Kong, 2016).

The transmission mechanism of innovative monetary policy instruments within the asset price channel aligns with conventional monetary policy instruments. Innovative monetary policy instruments can control interest rates by altering the money supply and can also influence market interest rates through their own rates, thereby enhancing the asset price transmission process associated with these instruments.

For instance, research shows that the expansion of MLF significantly boosted the valuation of equity markets in China by improving investor expectations (Shen & Wang, 2020). In the case of Japan, the Bank of Japan's unconventional policies, including ETF purchases, had substantial upward effects on stock prices and real estate values (Harada & Masujima, 2019). Moreover, recent evidence from the eurozone suggests that targeted interest rate reductions indirectly support asset price stability and portfolio rebalancing, especially among institutional investors (Fratzscher et al., 2020). A domestic study also revealed that increased liquidity under SLF positively correlates with real estate market activity in Tier-2 cities (Chen & Li, 2022).

Nonetheless, the efficacy of the asset price channel in China's monetary policy is comparatively limited. This is primarily attributed to three institutional constraints. The capital market remains underdeveloped, with substantial policy intervention in the stock and real estate markets. This leads to an incomplete price formation mechanism, which diminishes the Tobin Q effect and the wealth effect (Dong et al., 2008; Zeng et al., 2014). The proportion of financial assets in household asset allocation

is relatively low, and the short-term wealth effect of the stock market is weak or negative, leading to insufficient sensitivity of consumption behavior to changes in asset prices (Hong, 2012). The process of interest rate liberalisation remains incomplete, hindering the transmission mechanism through which monetary policy affects asset prices via interest rates. Furthermore, inadequate exchange rate flexibility constrains the regulatory influence of cross-border capital flows on asset prices (Song, 2008; Ren, 2019).

#### **4) Exchange Rate Channel**

The exchange rate denotes the ratio between the local currency and the foreign currency, reflecting the relative price of the currencies involved, normally expressed by nominal exchange rate. The opening of the capital account and the advancement of international trade have heightened the significance of the exchange rate in the macroeconomic management of monetary policy. The monetarist school posits that monetary policy influences the real economy via the exchange rate channel. When the central bank enacts expansionary monetary policy, characterized by lower interest rates, the investment appeal of the national currency diminishes, leading to a decrease in the exchange rate. According to the Mundell-Fleming model under conditions of high capital mobility and a floating exchange rate, a reduction in domestic interest rates leads to capital outflows, depreciating the nominal exchange rate and thereby increasing net exports (Fleming, 1962; Mundell, 1963). Friedman (1953) also emphasized that exchange rate adjustments serve as automatic stabilizers under monetary disturbances, influencing external balances and domestic output. Consequently, net exports in foreign trade increase, which stimulates total output (Kim & Lim, 2018). Empirical results from China's monetary easing in 2015 demonstrate that a 100-basis-point MLF rate cut led to an RMB depreciation of approximately 1.2% over the subsequent quarter, which boosted export volumes,

particularly in the machinery sector (Wang & Xie, 2017). In emerging economies such as Brazil and Turkey, similar mechanisms have been observed where expansionary monetary instruments contributed to currency depreciation and short-term export booms (Calvo et al., 2020). The ECB's policies during the sovereign debt crisis also provide supporting evidence that unconventional monetary easing led to euro depreciation and increased competitiveness for eurozone exports (Gambacorta et al., 2014). Additionally, during the Covid-19 period, the Federal Reserve's emergency rate cuts weakened the dollar and led to capital inflows into emerging markets, creating export advantages for those regions (Hofmann et al., 2021). Innovative monetary policy is similar to conventional monetary policy in this regard.

## **2.3 Chapter summary**

In this chapter, we discuss the framework of the People's Bank of China's (PBOC) monetary policy system, which consists of a targeting framework, an operational framework, instrumental framework, and a transmission framework. This discussion addresses the distinctions between conventional and innovative monetary policies. Innovative monetary policy, as defined in the official PBOC yearbook, is distinct from unconventional monetary policy. Some innovative monetary policy instruments are increasingly being classified as conventional operations as China's economic and financial system continues to improve and their usage becomes more frequent. In the following discussion regarding the effectiveness of unconventional monetary policy, it is essential to specify the policy instruments that must be accurately included in the analysis. This chapter concludes with the inclusion of Standing Lending Facility, Medium Term Lending Facility, Pledged Supplementary Lending, Targeted Lending, and Exchange Control in the analysis of the effectiveness of unconventional monetary policy.

Those monetary policy instruments employed by the PBOC in response to Covid-19 are classified as unconventional due to their distinct characteristics that differentiate them from conventional monetary policy instruments. The PBOC has not officially recognized uniqueness as a conventional monetary policy instrument in any statements or documents. The adaptability aligns with the characteristics of China's current monetary policy framework and the requirements of the transition.

Furthermore, our discussion indicates that the transmission channels and policy targets in monetary policy operations remained unchanged in response to Covid-19; only the focus shifted. Consequently, we maintain our focus on the credit channel, the interest rate channel, the asset price channel, and the exchange rate channel for the analysis of channel effectiveness. The targets of the PBOC's monetary policy in response to Covid-19 are defined as optimizing the output gap, stabilizing the price level, and stabilizing the exchange rate.

# Chapter 3

## Impact of Covid-19 on China's economy

Covid-19 had a wide-ranging impact on the Chinese economy, especially on the tertiary industry (service sector). The tourism, catering, retail, culture and entertainment sectors of the tertiary industry bore the brunt of the impact due to stringent measures during the outbreak's prevention and control, such as mass blockades, travel restrictions and social isolation. These sectors rely on the movement of people and offline consumption, and the reduction in people going out and gathering during the epidemic led to a sharp contraction in demand.

In contrast, the secondary industry (manufacturing), although also affected by supply chain disruptions and production delays, recovered relatively quickly as production gradually resumed and government support policies were implemented. The primary sector (agriculture) suffered relatively little direct impact.

What makes the shock particularly significant for the services sector is that it accounts for a significant share of the Chinese economy and many of its sectors rely on face-to-face interactions. Tourism, for example, experienced a huge downturn in 2020, with travel bans and quarantine measures leading directly to a sharp drop in consumer demand. Meanwhile, service sectors such as finance and banking have faced operational challenges, but have been able to maintain a degree of business continuity through adjustments to working practices (e.g., working from home) and supportive government policies.

To cope with the shock, the Chinese government and the People's Bank of China launched a series of fiscal and monetary policies, including lowering lending rates, providing specialised loans, and targeting support to small and medium-sized enterprises (SMEs) and industries severely affected by the epidemic, in order to alleviate the pressure on capital and promote economic recovery. These initiatives have helped the tertiary industry to recover gradually, but prolonged weak consumer demand remains a major obstacle to the industry's recovery.

The reporting of Covid-19 by PBOC and the Chinese Ministry of Economy, as well as the report of the United Nations Development Programme in China<sup>10</sup>, corroborate this view that the impact of Covid-19 on China's economy is short-term dramatic and long-lasting, especially for the tertiary industry. Therefore, it is important for us to clarify exactly how the Covid-19 shock to the Chinese economy complexity exists. This chapter decomposes the shocks caused by Covid-19, discussing direct, indirect, and interaction shocks using different models.

### **3.1 How Covid-19 evolved into an economic crisis**

Outbreaks in a region first affect the consumption and production of the population. For example, China, the first country in the world to successfully respond to Covid-19, chose to lockdown the city of Wuhan and mobilised supplies and personnel from across the country to support Wuhan in order to break the chain of transmission during the early stages of the outbreak. Many other countries have also implemented embargo measures of varying intensity. In the case of China's lockdown of Wuhan, for example, not only did consumption and production in Wuhan cease on all fronts, but other provinces and cities also caused a reduction in production in order to support Wuhan.

<sup>10</sup> Assessment Report on Impact of Covid-19 Pandemic on Chinese Enterprises, April 7, 2020

In addition, the infected population will also lose their production capacity. Thus, the impact of the epidemic will therefore be felt first and foremost on the supply side.

The immediate impact of the virus is an increase in the number of infected people and deaths, hence the need for governments to take appropriate containment and mitigation actions, such as travel restrictions (World Bank, 2020). Disruptions in trade and commerce can also occur from the closure of business activities and the inability of workers to work in factories and other workplaces, as markets will be deprived of a large supply of goods. Travel bans, and restrictions on the entry of goods, people and capital also lead to disruptions in aggregate supply (Asian Development Bank, 2020).

Following the blow received on the supply side, the demand side will also be seriously affected. This disruption of aggregate demand refers to: the disruption of trade and supply chains, which then depresses commodity exports. And, the decline in foreign financing, such as foreign direct investment, foreign aid, remittances, tourism receipts and capital inflows (World Bank, 2020). Meanwhile, referring to the Asian Development Bank (2020), aggregate demand was effectively disrupted by a sharp and temporary reduction in consumption and investment, both in China and other affected countries, while the spillover effects of the decline in aggregate demand were conducted to other sectors and economies through trade and production.

Sachs (2020) points out that there may be an interaction among aggregate demand and supply shocks. When curbs such as lockdown are implemented, it means that the circular flow of income is also restricted. When household spending is reduced, uncertainty in the economy rises, leading to a reduction in demand. The reduction in market demand will affect the firm, causing it to lose revenue. After the firm runs out of cash to pay labour wages, this situation puts further pressure on household spending,

eventually creating a vicious circle. This situation implies that a supply shock induces a demand gap and vice versa. Another domestic effect of the embargo is the creation of unprecedented capital outflows from emerging markets, causing severe damage to the value of companies severely affected by the epidemic. This situation was also linked to the devaluation of exchange rates, which affected the prices of imported goods. At the same time, many emerging countries were severely affected by the epidemic due to international supply chains, leading to global supply problems as well.

China was the first country to start a massive outbreak of Covid-19, and the Chinese economy was hit hard, especially in Hubei province, the epicentre of the epidemic. In terms of data, China's GDP in the first quarter of 2020, at the height of the epidemic, decreased by 6.8% year-on-year, while GDP in the second and third quarters grew by 3.2% and 4.9% year-on-year, but below the 6% to 7% growth rate of previous years. As a result of the epidemic, demand and supply fell sharply in the short term, leading to a 14.3% drop in China's manufacturing PMII index in February 2020 compared to January and a 24.5% drop in the non-manufacturing business activity index compared to January, with a significant drop in demand from consumer sectors such as transportation, tourism, accommodation and catering, and residential services. This has caused considerable volatility in China's macro and micro economies<sup>11</sup>.

Yin et al. (2020) incorporated Covid-19 shocks into a New Keynesian DSGE model in order to thoroughly examine the effects of the epidemic on China's macroeconomy. Their findings indicate that, while the long-term effects were minimal, Covid-19 had a notable immediate effect on the national economy, resulting in a substantial decrease in overall demand. This decline was primarily driven by reduced consumption and investment demand. Furthermore, the unemployment and inflation rates exhibited a

<sup>11</sup> Data source from CEIC database and National Bureau of Statistic of China.

distinct increasing trajectory as a result of elevated production expenses and a substantial decrease in production inputs. The impact of the Covid-19 on China's macroeconomy can be divided into three phases. The first stage, during the epidemic, faces a short-term decline in demand and supply. In the second stage, after the epidemic is effectively controlled, there will be a wave of rebound in demand. In the third stage, after the epidemic, capacity and industry chain adjustments will be made for the purpose of preventing similar public health events. It is easy to see the short-term impact of the epidemic shock, with China's GDP showing negative growth in the first quarter of 2020, a significant drop in demand for consumption and investment, and a contraction in the supply of services and industrial production. After the full resumption of work and production, China's consumer economy rebounded strongly, especially in terms of consumer demand from entertainment and leisure services and short-haul tourism. In the long term, however, a restructuring of the industrial chain is already inevitable, and China will inevitably have to explore new directions in the global division of labour and the reshaping of the industrial chain.

## **3.2 Explore the structure of economic shock caused by Covid-19**

Throughout the course of human progress, occurrences such as natural disasters, accidents, calamities, infectious diseases, social unrest, and other significant emergencies are not infrequent. These events often have a significant influence on economic and social advancement within a specific timeframe and geographical area, and may even have broader consequences. As a result, the need for corresponding evaluation and analysis has arisen. Recent research has yielded extensive studies on the economic consequences of emergencies, particularly natural catastrophes such as hurricanes (Hallegatte, 2008), floods (Zhang et al., 2012), and earthquakes (Chen et al.,

2008). An economic impact evaluation was conducted on accidental disasters such as electricity shortages (Anderson et al., 2007), water cuts (Rose and Liao, 2005), traffic disruptions (Tsuchiya et al., 2007), and port closures (Rose and Wei, 2013). An economic effect evaluation was conducted on environmental emergencies such as extensive smog (Mu and Zhang, 2013) and the impact of animal diseases (Miler et al., 2019).

Considerable scholarly focus has been devoted to studying the economic consequences of sudden-onset epidemics. Ambrus et al. (2020) showed that the 1854 cholera epidemic in London had a lasting effect on the geographical pattern of poverty in the city. Yang and Chen (2003) conducted an estimation of the economic consequences of the SARS pandemic in China. They also suggested solutions to address the issue and assessed the economic effects of the implemented policy measures. Following the emergence of Covid-19, its economic ramifications have garnered significant interest throughout several areas of society.

Over the years, studies on the economic consequences of emergencies have transitioned from subjective assessments to target measurements, and from focusing on specific areas to considering their global ramifications. Preliminary investigations mostly concentrated on theoretical examinations of impact mechanisms and conceptual frameworks. For instance, West and Lenze (1994) explored the modelling of the economic consequences of disasters using conceptual frameworks and techniques. These studies have been influential in later empirical and policy investigations. Over the past few years, there has been a shift in analysing the economic effects of emergencies. The focus has moved from analysing direct impacts to analysing systemic impacts. Quantitative research methods, such as ex-ante prediction (Yang and Chen, 2003) and ex-post assessment (Ambrus et al., 2020), have gained increasing attention.

The former can assist in developing strategies and actions to address catastrophes, while the latter can serve as a foundation for decision-making to enhance the efficiency of fiscal expenditure recovery following disasters.

Quantitative research methods are used to study the economic effects of emergencies like epidemics. Among these methods, the Input-Output (IO)<sup>12</sup> model and the Computable General Equilibrium (CGE) model are commonly used to assess the precise magnitude of the economic impacts of epidemics (Okuyama and Santos, 2014). Research conducted using the Input-Output model, as demonstrated by Yang and Chen (2003), Santos and Haines (2004), Chen et al. (2008), and Liu et al. (2020), provides significant insights into inter-industry connections. This allows for the measurement of both direct and indirect effects of emergencies. Furthermore, the model's structure is straightforward and user-friendly. Nevertheless, the IO model has a drawback in that it fails to capture the price adjustment mechanism based on supply and demand of products, and consequently cannot account for product substitution. This limitation may result in an overestimation of the impact of emergencies, and the corresponding IO table tends to be outdated compared to the current reality. On the other hand, the CGE model, which is built upon the IO model, provides a more detailed representation of how different economic actors respond to changes in prices. This addresses a limitation of the IO model, which does not take into account the impact of price fluctuations (Rose and Liao, 2005; Miller et al., 2019). Furthermore, econometric models are frequently employed to calculate the elasticity coefficients of particular economic indicators in relation to unforeseen circumstances. Incorporating these models with the IO model or the CGE model will significantly improve the study's dependability.

<sup>12</sup> Encompasses the incorporation of an IO model alongside an econometric or planning model.

Undoubtedly, the effect of Covid-19 on the Chinese economy was not isolated or brief, and its overall impact was not immediate. The Covid-19 pandemic, being an unforeseen and exceptional event, was expected to have a slow and significant impact on the Chinese economy. Therefore, before discussing the effectiveness of the unconventional monetary policy implemented in response to Covid-19, it is particularly important to analyse more precisely the impact of Covid-19 on the Chinese economy.

The overarching process of Covid-19's influence on the Chinese economy can be succinctly outlined as follows. Firstly, Covid-19 shocks to the economy as a whole are divided into demand and supply side. Secondly, for each side, shocks are classified into direct shocks, indirect shocks (or higher-order effects, Rose (2004)), and interaction shocks according to the transmission process. In addition, when time effects are taken into account, a distinction can also be made between short-term and long-term shocks for each type of shock. Figure 3.1 illustrates the design of the research programme in this chapter that disaggregates the impacts of Covid-19.

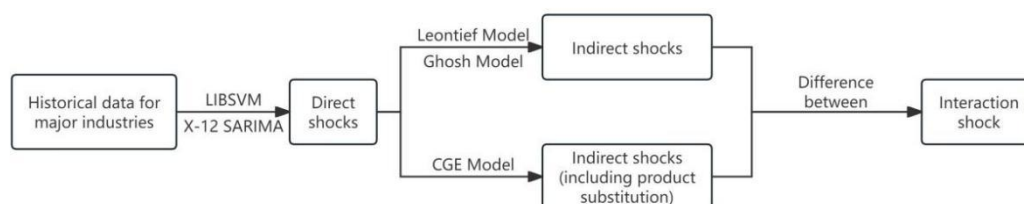


Figure 3.1: Decomposition process for Covid-19 shocks

To analyse the impact of Covid-19, we follow a systematic approach. Firstly, we employ the X-12 SARIMA model to estimate the direct shocks on the supply side caused by Covid-19. Simultaneously, we use the LibSVM to estimate the direct shocks on the demand side. Next, we utilise the Leontief and Ghosh models to estimate the indirect shocks on the supply side and demand side, respectively, without considering product

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substitution. Additionally, we employ the CGE model to estimate the indirect shocks on the supply side and demand side, taking into account mutual substitution between products. Finally, we compare the results of the indirect shocks in both cases to assess the interaction effects.

### **3.2.1 Direct shock**

The pandemic has a direct impact on the economic system, namely at the micro level. It affects both the supply and demand sides, directly impacting enterprises, which are the fundamental units of the economic system. This exacerbates the pressure on their operations and survival. The epidemic directly affected the operations of businesses, causing a lack of available workers and raw materials. This resulted in the inability of businesses to function properly or at all, leading to the emergence of non-functioning sectors within the economy. Domestic and worldwide epidemics will immediately result in certain enterprises under-ordering or losing orders due to decreased demand. Several polls conducted in China, such as Zhu et al.(2020), indicate that the factors mentioned above have significantly burdened numerous companies with severe cash flow constraints. Undoubtedly, the outbreak might potentially bring about favourable consequences for the telecommunications, express delivery, and anti-epidemic materials production sectors.

Typically, we expect immediate and noticeable effects on economic indices from direct shocks in the short term. Hence, we posit that the disparities in the economic indicators between the simulated Covid-19-free setting and the real environment might be regarded as immediate disruptions caused by Covid-19 directly. To implement this concept, our initial step is to replicate the economic data in a setting unaffected by the Covid-19 pandemic.

### 1) X-12 SARIMA model

Forecasting the time series directly using the moving average regression method would be deemed unfeasible due to the significant seasonal influences observed in China's economic indicators. Thus, it is necessary to remove the seasonal patterns from the time series prior to making any forecasts. To accomplish this target, we employ the X-12 Seasonal Autoregressive Integrated Moving Average (SARIMA) model to exclude seasonal characteristics from the unprocessed data those represent demand side.

SARIMA is an extension of the ARMA model, with the major characteristic of stabilising time series by differencing them at least once (i.e. ARIMA), then introducing seasonal differences, and ultimately producing a regression forecast model.

An autoregressive model (AR) can be written as:

$$X_t = c + \sum_{i=1}^p \varphi_i X_{t-i} + \varepsilon_t \quad (3.1)$$

where  $\varepsilon_t$  is the Gauss White Noise.

The moving average model (MA) can be written as:

$$X_t = \mu + \varepsilon_t + \sum_{i=1}^q \theta_i \varepsilon_{t-i} \quad (3.2)$$

where  $\mu$  is the mean value of  $X_t$  (often assumed to equal 0), and  $\varepsilon_t, \varepsilon_{t-1}, \dots$  are the white noise.

The ARMA model, generally abbreviated ARMA (p, q), is created by combining the two models above and can be written as:

$$X_t = c + \varepsilon_t + \sum_{i=1}^p \varphi_i X_{t-i} + \sum_{i=1}^q \theta_i \varepsilon_{t-i} \quad (3.3)$$

Using the lag factor representation and ignoring the constant term  $c$ , move  $X$  to the left-hand side of the equation:

$$(1 - \sum_{i=1}^p \varphi_i L^i) X_t = (1 + \sum_{i=1}^q \theta_i L^i) \varepsilon_t \quad (3.4)$$

Simplify the above equation:

$$\varphi(L)X_t = \theta(L)\varepsilon_t \quad (3.5)$$

where  $\varphi(L) = 1 - \sum_{i=1}^p \varphi_i L^i$ , and  $\theta(L) = 1 + \sum_{i=1}^q \theta_i L^i$

Or simplified as ARMA(p,q).

A differencing procedure can change a non-stationary and unusual time series into a stationary time series. For example, a  $d$ -order differencing is when a total of  $d$  differencing operations are executed. ARIMA (Autoregressive Integrated Moving Average) is thus an ARMA-based model with a  $d$ -order difference operation, which can be written as:

$$(1 - \sum_{i=1}^p \varphi_i L^i)(1 - L)^d X_t = (1 + \sum_{i=1}^q \theta_i L^i)\varepsilon_t \quad (3.6)$$

Or simplified as ARIMA(p,d,q).

As a result, SARIMA (Seasonal Autoregressive Integrated Moving Average) is a model that adds seasonal differences to ARIMA, can usually be represented as SARIMA(p,d,q)\*(P,D,Q)S, where P, D, and Q are the parameters that result from the process of periodization applied to p, d, and q. S represents the duration between successive periods. The fundamental concept of SARIMA is applying ARIMA periodically at period intervals to transform a non-stationary and non-periodic time series. This transformed series is then analysed by using ARIMA again to eliminate periodicity and provide more precise predicting outcomes.

The SARIMA model enables accurate prediction of time series data that exhibits seasonal patterns. Given that direct shocks can be categorised as either supply side or demand side, and that the demand side is typically represented by industry operating

income, and that the operating income series aligns with the demand series generated by the SARIMA model, we employ the SARIMA model to estimate the direct shocks on the demand side. We have opted to utilise data on company receipts from the primary affected sectors to examine the direct influence on overall demand caused by theCovid-19.

The primary effect ofCovid-19 on China's economy is shown in the demand for services, which subsequently triggers a chain of consequences throughout the entire economic system. The primary consequence ofCovid-19 on production operations in China is seen in the imposition of an embargo policy as a result of the pandemic. This policy has led to a shortage of offline service workers and a lack of offline service requests from consumers. Thus, we determine the industries whose ultimate consumption is susceptible to the epidemic by considering their attributes and the extent to which they are affected by the epidemic. Ultimately, we chose real estate, transport and storage, wholesale and retail, catering and accommodation, and finance as representative industries. We also considered other tertiary industries and the entire economy. The chosen sectors are directly impacted by the residential segregation policy and are intricately linked to consumption. Table 3.1<sup>13</sup> presents the estimation of direct demand side shocks produced using the SARIMA model.

Table 3.1: Estimation of direct shocks for demand side

Estimation	First Quarter Shock	MSE	R2
Entire Economy	-5.816*** (0.0004)	0.001560703	99.267
Real Estate	-6.546**	0.012199639	96.152

<sup>13</sup> Data source: CEIC database

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	(0.0272)		
Transport and Storage	-22.079***	0.002237180	99.677
	(0.0002)		
Wholesale and Retail	-24.720***	0.002752162	99.221
	(0.0003)		
Catering and Accommodation	-6.814***	0.007021650	97.446
	(0.0014)		
Finance	-7.458***	0.001729400	98.344
	(0.0009)		
Other Tertiary Industry Sectors	-5.744***	0.008530087	97.403
	(0.0016)		

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\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

It is evident that the retail and wholesale trade, as well as the transportation and storage industries, were the most severely affected by the Covid-19 pandemic. These industries are predicted to see direct shocks of over 20% during the first quarter. The level of direct shocks to other selected economic sectors is relatively similar in magnitude.

## 2) LIBSVM

LIBSVM is an intuitive and efficient software programme for Support Vector Machine pattern identification and regression. It was conceived and constructed by Professor Lin Chih-Jen of National Taiwan University. LIBSVM contains a limited number of options for SVM regularisation. It has a wide range of default parameters, which can effectively address many issues. Additionally, it includes a feature for doing interaction tests, specifically Cross Validation.

All models generated by the LIBSVM in this study are non-linear models based on the RBF (Radial Basis Function) kernel function.

Inner products in the form of low-dimensional data models:

$$f(x) = \sum_{i=1}^m (\hat{a}_i - a_i) x_i^T x + b \quad (3.7)$$

To replace the prior inner product form, define a low-dimensional to high-dimensional mapping:

$$f(x) = \omega^T \phi(x) + b = \sum_{i=1}^m \alpha_i y_i \phi(x_i)^T \phi(x) + b \quad (3.8)$$

After mapping to a high-dimensional feature space,  $\phi(x_i)^T \phi(x_j)$  represents the inner product.

We use the RBF kernel function to make our predictions, the expression is:

$$\kappa(x_i, x_j) = \exp\left(-\frac{\|x_i - x_j\|^2}{2\sigma^2}\right) \quad (3.9)$$

where  $\sigma > 0$  is the width of RBF.

The SVR model's decision function can be written as:

$$f(x) = \sum_{i=1}^m (\hat{\alpha}_i - \alpha_i) \kappa(x_i^T, x_j) + b \quad (3.10)$$

where  $\kappa(x_i^T, x_j) = \phi(x_i)^T \phi(x_j)$  is the kernel function.

To assess the direct shock on the supply chain caused by the pandemic, our primary focus is on estimating the effect of the epidemic on labour supply. As per the theory of economic growth, capital and labour inputs are the fundamental components that underpin economic expansion. In the immediate future after the outbreak, Covid-19 primarily affected the availability of workers, while the impact on capital was not readily apparent.

Generally, we can quantify shortages in the workforce by examining variations in the unemployment rate. At the onset of the Covid-19 pandemic in early 2020, China's National Bureau of Statistics (NBS) released data on registered and surveyed unemployment rates. These rates stood at 3.66% and 5.8% respectively, representing a marginal decrease of 0.1% and an increase of 0.6% compared to the first quarter of 2019. However, unemployment data for this period have been extremely widely questioned (Zhuang, 2020; Zhang, 2021; Wei, 2021). There is a significant likelihood that the lockdown strategy may have hindered individuals from registering at the Talent Centres, which are China's labour market sector. This might have potentially caused a decrease in the Registered Unemployment Rate. Regarding the surveyed unemployment rate, it solely indicated if individuals lost their jobs during the period when the lockdown policy was implemented, without considering their ability to commute to their workplace and work as usual.

Another prevalent method for indicating shortages in the workforce is by considering the mean number of hours worked each week. Nevertheless, certain industries that permit telecommuting enable employees to operate remotely from their homes during the lockdown. Consequently, the poll fails to reliably quantify the average number of hours worked.

Consequently, we examined a broader range of variables to match the data on the shortage of available workers. Ultimately, we opted for a monitoring survey carried out by a research team affiliated with the Chinese Academy of Social Sciences. The monitoring survey yielded the proportion of working conditions in each industry, as presented in Figure 3.2<sup>14</sup> and Table 3.2<sup>15</sup> below.

<sup>14</sup> Data source: Report of the online survey on the state of the labour force, March to May, Chinese Academy of Social Sciences.

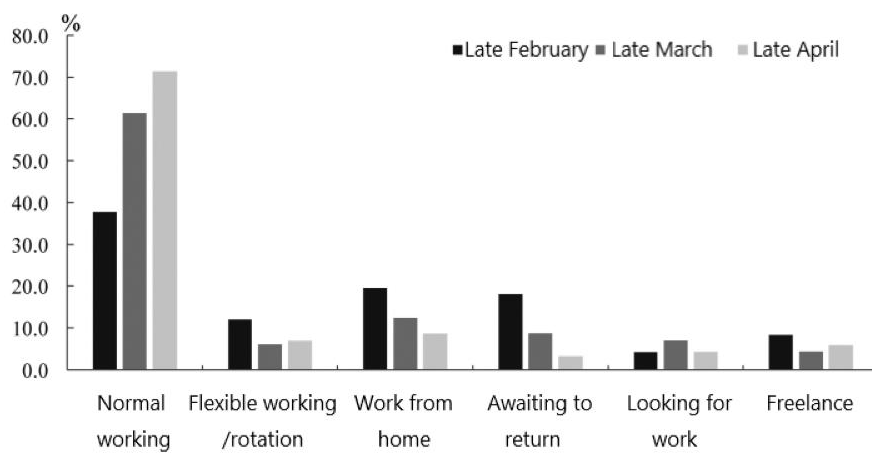


Figure 3.2: Aggregate working situation for early 2020

<sup>15</sup> Data source: Survey report on the structure of the labour force during the epidemic, 18 June 2020, Chinese Academy of Social Sciences.

Table 3.2: Working situation for industries

Industries	Late February		Late March		Late April	
	Normal working	Awaiting to return	Normal working	Awaiting to return	Normal working	Awaiting to return
Agriculture, forestry and fishing	26.2	9.8	67.2	3.3	null	3.0
Mining	41.7	25.0	73.1	3.9	86.7	10.0
Manufacturing	51.3	31.9	79.9	8.9	89.1	0.9
Electricity, gas and water production and supply	48.2	22.2	85.4	4.2	84.1	3.3
Construction	23.5	43.4	59.1	18.7	79.8	3.9
Wholesale and retail trade	33.0	22.8	64.5	7.9	69.3	2.7
Transport, storage and post and telecommunications	51.7	18.8	71.2	6.4	80.6	1.3
Accommodation and catering	24.5	39.6	45.0	19.9	59.1	7.0
Information transmission, computer services and software	36.3	12.3	60.5	7.1	75.5	0.8
Finance	29.7	6.1	67.2	4.8	74.3	2.9
Real Estate	43.9	9.5	69.2	5.3	77.8	2.8
Rental and business services	18.4	22.9	69.3	5.3	60.5	3.7
Scientific Research, Technical Services and Geological Survey	16.9	7.7	63.8	3.8	73.5	1.7
Water, Environment and Public Facilities Management	51.3	18.0	79.0	10.5	93.2	2.3
Residential Services and Other Services	49.4	21.7	61.3	9.8	79.1	4.1
Education	10.0	21.0	11.9	15.4	35.1	10.7

Industries	Late February		Late March		Late April	
	Normal working	Awaiting to return	Normal working	Awaiting to return	Normal working	Awaiting to return
Health and Social Work	65.6	9.2	83.0	6.1	88.3	2.7
Culture						
Sports and Recreation	18.6	21.7	43.3	15.4	56.4	3.2
Public administration, social security and international organisations	67.3	4.3	84.0	2.5	92.5	0.8

Although it is evident that China's labor supply is gradually recovering, the labor supply shock was still rather severe in the early stages of the epidemic, with fewer than 40% of the workforce available for regular work. Only around 70% of the labor force has returned to regular employment as of the second quarter of 2020. The primary sector as a whole has recovered the quickest among industries. Individual industries that played a significant role in fighting the Covid-19 pandemic, such as transportation and healthcare, recovered their labor supply the fastest under government regulation.

China's official measure of labour supply changes is the unemployment rate, which includes the urban survey unemployment rate, urban registered unemployment rate, rural survey unemployment rate, and rural registered unemployment rate. The urban survey unemployment rate and the urban registration unemployment rate are predominantly utilised by macroeconomic researchers. Of which, the urban registered unemployment rate is determined by the number of labour market registrations in each municipality. In the first quarter of 2020, Covid-19 resulted in restrictions on the population's ability to transfer personal files and register in the labour market. Hence, we have designated the urban survey unemployment rate as the goal indicator for

estimation, shown as Figure 3.3<sup>16</sup>. It is clear that unemployment has risen significantly since the outbreak of Covid-19, and the trend in this indicator is more consistent with our expectations.

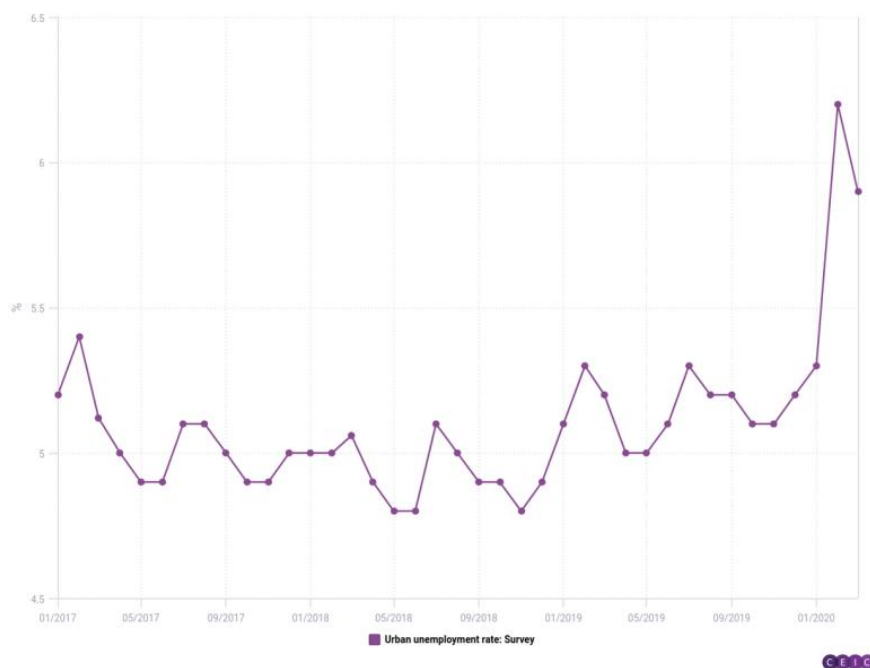


Figure 3.3: Urban survey unemployment rate

However, the indicator will need to be somehow adjusted. The reasons are set out below. The initial issue is that during the first quarter of 2020, a considerable number of Chinese workers were unable to access their workplaces due to the lockdown policy, although they were not classified (or surveyed as self-identified) as unemployed. Consequently, we must identify the individuals who are not unemployed yet are not actively contributing work. Secondly, the return-to-work rates are not uniform among industries, as the table above illustrates. Consequently, it is necessary to adjust for fluctuations in labour supply according to the employment and return-to-work rates across various industries. Lastly, we also need to take into account the change of actual

<sup>16</sup> Data source: CIEC database

working hours of the workers on board, shown as Figure 3.4<sup>17</sup>. Clearly, there is a sharp decrease happened after the outbreak of Covid-19, indicates our consideration is necessary.

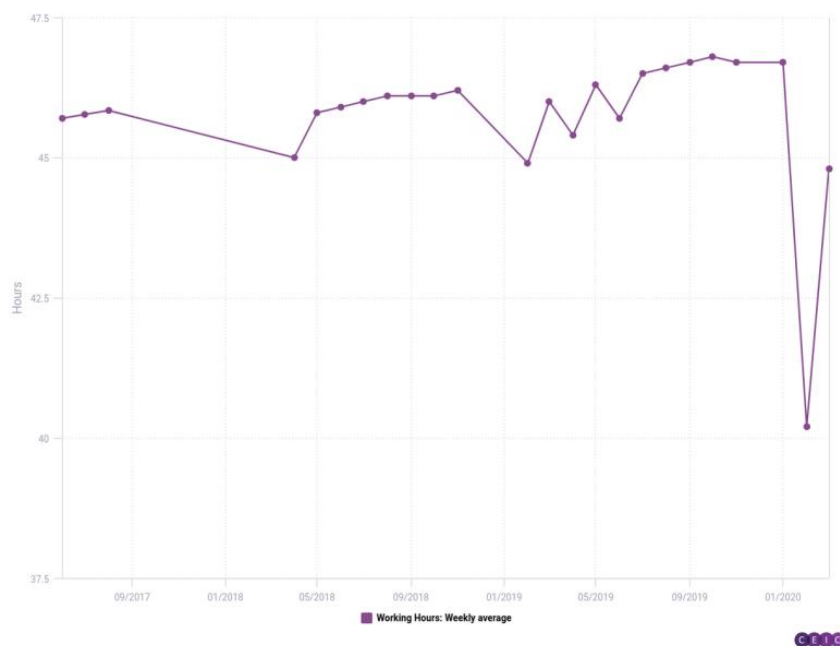


Figure 3.4: Working hours

Thus, we define the labour supply shock as:

$$L_s = \frac{1}{2} * (\sum_{i=2}^3 ((1 - r_i) - \sum_j ((1 - r_i) * \frac{E_j}{E} * \theta_{ij} * \frac{W_i}{W}))) \quad (3.11)$$

where  $L_s$  is the direct shock to labour supply,  $r_i$  is the monthly urban survey unemployment rate, which includes February and March 2020.  $E_j$  is the number of private sector employees in each industry, and  $E$  is the original number of private sector employees.  $\theta_{ij}$  is the percentage of the industry's on board workers in the month, and  $W_i$  is the average weekly working hours in the month, when  $W$  is the original average weekly working hours.

<sup>17</sup> Data source: CIEC database

Since lockdown measures were scarcely enforced in mainland China in January 2020, with the earliest application being on January 24 in Wuhan, Hubei Province, we posit that the urban survey unemployment rate for January 2020 accurately represents the labour supply. Consequently, we concentrate our data on February and March. We use the year-end data of 2019 for  $E$ , as the statistics regarding the number of private employees in the business are reported annually. In selecting  $W$ , we utilise January 2020 as the reference point and examine the variations observed in February and March, as indicated by the pattern illustrated in Figure 3.4. Finally, since we focus on labour supply shocks in February and March, we average it to express labour supply shocks in the first quarter of 2020. All data originate from the National Bureau of Statistics of China.

Table 3.3: Estimation of direct shocks for labour supply

Estimation of Direct Shocks	First Quarter Shock	MSE	R2
Real Estate	-0.133*** (0.0026)	0.01015660	96.924
Transport and Storage	-12.944*** (0.0003)	0.00204381	99.399
Wholesale and Retail	-21.250*** (0.0004)	0.00432455	98.720
Catering and Accommodation	-16.552*** (0.0002)	0.00140419	99.471
Finance	0.611*** (0.0007)	0.00168506	99.602
Other Tertiary Industry Sectors	4.071*** (0.0019)	0.00934520	97.370
Labour Supply	-11.671**	0.00268546	90.250

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(0.0192)

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\*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.1$

Ultimately, the examination reveals that the direct labour supply shock of Covid-19 on the Chinese economy is -11.671%. Considering that at the end of March 2020, there were no significant blockades in the country, apart from Hubei and adjacent provinces<sup>18</sup>, also the service sector began to implement extensive remote work<sup>19</sup>. Therefore, this estimation result figure broadly aligns with expectations.

### 3.2.2 Indirect shock without substitution

Indirect shocks from Covid-19 are defined as systemic shocks that result from direct shocks through inter-firm or inter-industry linkages. As indirect shocks can be seen as a derivative effect of direct shocks transmitted through the economic system, and their final impact on the economy may even be greater than that of direct shocks, indirect shocks are of great value and need to be studied. In the absence of countermeasures, the direct impact of the epidemic on some enterprises and industries may have a serious impact on the competitiveness of the entire industry chain through industry linkages, turning the local risk caused by Covid-19 into an overall risk. Likewise, the direct positive impact of the epidemic on some industries could also lead to greater indirect positive impacts, which could effectively offset the negative impact of the epidemic, such as a surge in export orders for manufacturing industries corresponding to anti-epidemic supplies.

<sup>18</sup>Covid-19 briefing, National Health Commission of China, 30 March 2020.

<sup>19</sup>Covid-19 briefing, Ministry of Labour and Social Security of China, 4 April 2020.

### 1) Demand side shock - Leontief model

Assuming that the Chinese national economy can be divided into  $n$  industrial sectors, the relationship between value added and final demand can be established from the Leontief model (i.e. the demand-driven IO model) as follows:

$$X = \hat{U}^T(I - A^d)^{-1}Y \quad (3.12)$$

$$V = \hat{U}^T X \quad (3.13)$$

where  $V$  is a vector of value added, whose element  $\tilde{v}_i$  represents the value added of sector  $i$ .  $\hat{U}$  is a vector of value added rates, whose element  $\hat{u}_i$ , represents the value added rate of sector  $i$ .  $X$  is a vector of total output, whose element  $x_i$ , represents the total output of sector  $i$ .  $Y$  represents a vector of final demand for domestic products, whose element  $y_i^d$  represents the final demand of sector  $i$ .  $A^d$  represents the IO coefficient between sectors from the demand side, whose element  $a_{ijd}$  denotes the share of sector  $j$ 's total inputs in products from sector  $i$ .  $(I - A^d)^{-1}$  is the Leontief inverse matrix, which reflects the complete consumption of products from other sectors for each sector's end use. The superscript  $T$  indicates the transpose of the vector.

The direct impact of the epidemic on the economic system from the demand side is the change in value added caused by the epidemic through the direct shock on the various final products (demand)  $\hat{U}^T \Delta Y$ . With the direct shock of the epidemic on the relevant industries specified, the total shock of the epidemic on the economic system from the demand side through inter-industry linkages can be expressed as  $\hat{U}^T(I - A^d)^{-1} \Delta Y$  based on the former two equations, and the indirect shock is  $\hat{U}^T[(I - A^d)^{-1} - I] \Delta Y$ .

### 2) Supply chain shock - Ghosh model

Based on a supply-driven IO model, the Ghosh model (Ghosh, 1958), the relationship between total output and initial inputs (value added) can be established as follows:

$$X = \tilde{V}^T (I - \tilde{A}^s)^{-1} \quad (3.14)$$

$$Y = D^T X \quad (3.15)$$

where  $\tilde{A}^s$  denotes the product allocation coefficient matrix, whose elements  $a_{ij}^s$  represents the share of sector  $i$ 's product allocated to sector  $j$ .  $(I - \tilde{A}^s)^{-1}$  is the Ghosh inverse matrix with diagonal elements of  $b_{ijs}$ .  $D$  is the final product rate vector with elements  $d_i = 1 - \sum a_{ij}^s$ .

However, the Ghosh model has been criticised in theory for being based on Say's Law, i.e. that supply automatically creates demand. This criticism is justified in the case of a positive stimulus, i.e. an increase in output in a sector, but not in the case of output constraint in a sector. In this case, the downstream sector does experience a fall in output due to the unavailability of the sector's products, and the Ghosh model is more characteristic of a demand-driven model than a supply-driven model (Rose and Wei, 2013). Therefore, based on the original Ghosh model, we choose to refer to Rose and Wei (2013) to treat it so that it can be used to estimate supply-side shocks. Processing steps are:

- 1) Determine the epidemic shock to sectoral labour inputs  $\Delta l_i$ .
- 2) The direct shock  $\Delta X$  on total output is determined from the IO coefficient with the element  $\Delta x_i = \Delta l_i \frac{x_i}{l_i}$ .
- 3) The direct shock on initial inputs  $\Delta v_i = \frac{\Delta x_i}{b_{ij}^s}$  and the direct shock on final product  $\Delta y_i = \Delta x_i (1 - \sum a_{ij}^s)$  can be determined from equation in step 2.

4) The total supply-side output shock  $\Delta X = \Delta \tilde{V}^T (I - \tilde{A}^s)^{-1}$  is determined from equation in step 3.

5) Determine the total shock on final product  $\Delta Y = D^T \Delta X = D^T [\Delta \tilde{V}^T (I - \tilde{A}^s)^{-1}]$  according to equation in step 4.

Therefore, the indirect shock can be expressed as  $D^T [\Delta \tilde{V}^T (I - \tilde{A}^s)^{-1} - I]$ .

### 3.2.3 Indirect shock with substitution

Covid-19 materially alters supply and demand in each sector through direct and indirect shocks, resulting in changes in the relative prices of products in each sector. Specific impacts can be categorised and briefly described as follows.

Supply chain: (i) Substitution occurs in the supply of factors, such as the substitution of capital for labour or substitution between raw materials. (ii) Increased labour mobility, where some workers may look for new employment opportunities because the industry they were working in or the company they worked for was affected by the epidemic, thus triggering a corresponding substitution effect; (iii) Import substitution, i.e. when some imported products are difficult to obtain, the same type of domestic product replaces the imported goods, typically for example chilled products, anti-epidemic supplies at the beginning of the epidemic in China, etc.

Demand side: (i) consumers reduce some consumption activities due to the impact of the epidemic, but at the same time increase some alternative consumption activities, such as the restaurant industry, which received a devastating blow in the early stages of the epidemic in China, but the third service sector, which corresponds to online

products, grew significantly. (ii) Some companies, affected downstream in their chains, may adjust their customer mix by finding new customers to replace those whose demand for their products has fallen as a result of the downturn. (iii) The world economic downturn has resulted in some enterprises' exports being hampered, and some of these exports or services may be diverted to domestic sales. The impact of this component is particularly evident in the context of the trade war between the US and China. (iv) A reduction in consumption will lead to an increase in savings, which in turn will have a tendency to be converted into investment, thus creating a substitution of investment for consumption.

Therefore, following the immediate shock, the enduring consequences of Covid-19 mostly manifest as a cumulative outcome resulting from a dual influence on both supply and demand. Both the Leontief model and the Ghosh model, which we employ, do not consider the possibility of substitution between items when assessing indirect effects. Hence, by considering the substitution between products and recalculating the combined effects, we can define the disparity between the newly obtained results and the two previous estimates as the interaction effect of the economic system in response to the different types of Covid-19 shocks mentioned earlier.

### **3.2.3.1 CGE Model**

The CGE model (Computable General Equilibrium Model) can be applied to many areas of research and can give practical policy recommendations. Unlike other early empirical models, the CGE model is an inherently consistent macroeconomic model based on neoclassical micro theory. CGE model can be used to fully assess the effects of policy implementation and includes consideration of substitution between products.

The CGE model is based on the behaviour of economic agents such as households,

government and enterprises, and forms the basis for the determination of supply and demand for various products and factors of production. The main structure of the CGE model includes:

### 1) Production module

Assuming that each production sector seeks to achieve a given output at a minimum cost. The production function uses the Leontief function and the nested form of Constant Elasticity of Substitution (CES), i.e. output and intermediate inputs and total factor inputs are related to the Leontief function. The relationship between total factor inputs and various factors of production (labour, capital) inputs is a CES function. The production module of this model can be expressed as:

$$X_i = \min (A_{Z_{ji}}Z_{ji}, A_{Q_i}Q_i) \quad (3.16)$$

$$Q_i = [\alpha_{L_i}(A_{L_i}L_i)^{(\sigma_{Q_i}-1)/\sigma_{Q_i}}] + (1 - \alpha_{L_i})(A_{N_i}N_i)^{(\sigma_{Q_i}-1)/\sigma_{Q_i}}]^{(\sigma_{Q_i}/(\sigma_{Q_i}-1))} \quad (3.17)$$

$$N_i = [\alpha_{K_i}(A_{K_i}K_i)^{(\sigma_{N_i}-1)/\sigma_{N_i}}] + (1 - \alpha_{K_i})(A_{F_i}F_i)^{(\sigma_{N_i}-1)/\sigma_{N_i}}]^{(\sigma_{N_i}/(\sigma_{N_i}-1))} \quad (3.18)$$

$$F_i = \{ \sum_j [\alpha_{Z_{bki}}(A_{Z_{bki}}Z_{bki})^{(\sigma_{F_i}-1)/\sigma_{F_i}}] \}^{(\sigma_{F_i}/(\sigma_{F_i}-1))} \quad (3.19)$$

where  $Z_{ji}$  is intermediate synthetic input of type  $j$  (including raw material supplying industries).  $Q_i$  is labour synthetic input.  $Z_{bki}$  is raw material of type  $k$  consumed at the end of each sector.  $N_i$  is capital synthetic input.  $L_i$ ,  $K_i$  and  $F_i$  denote labour input, capital input and final product respectively.  $A$  denotes the efficiency of each input, whose change reflects technological progress.  $\alpha$  and  $\sigma$  denote the share coefficient and elasticity of substitution respectively. The above four equations imply that total output is both a multi-layer nested CES function of labour, capital and the raw materials they are combined with, and a Leontief production function of intermediate inputs.

### 2) Residential consumption and saving module

Assume that residents seek to maximise their utility under a certain expenditure budget constraint, which is the disposable income minus savings resulting from labour

income after taxes, corporate dividends, government transfers and net overseas remittances, and whose utility is a Klein-Rubin function of various synthetic commodities or services:

$$\max \prod_i (Z_{Hi} - Z_{Hi}\psi)^{\beta_i} \quad (3.20)$$

$$\text{s. t. } P_{Z_{Hi}}Z_{Hi} \leq (1 - s)[(1 - t_H)(wL^S + U_{HP}) + U_{HG} + U_{HF}] = HE \quad (3.21)$$

where  $Z_{Hi}$  is the basic demand per capita for synthetic consumption commodity  $i$ .  $\psi$  is the total population.  $P_{Z_{Hi}}$  is the price of synthetic commodities consumed by the population.  $\beta$  is the share coefficient of expenditure on various commodities in total consumption.  $L^S$  is the total supply of labour.  $w$  is the wage rate.  $U_{HP}$  is the property income received by residents from firms.  $U_{HG}$  is government transfers.  $U_{HF}$  is net overseas remittances.  $s$  is the savings rate.  $t_H$  is the income tax rate.  $HE$  is the total expenditure of residents.

The household saving is determined by the household income and expenditure. We assume that the household income is determined by wage rate  $w$ , labour supply (employment)  $L^S$ , capital price  $P_K$ , net overseas remittances  $U_{HF}$  and government transfers  $U_{HG}$ .

$$HY = w * L^S + P_K * K^S + U_{HF} + U_{HG} \quad (3.22)$$

Thus the household saving:

$$HS = HY - HE \quad (3.23)$$

### 3) Investment module

Assuming that the investment received by each sector depends on its capital stock and its relative expected rate of return:

$$Z_{Vi} = \alpha_{Vi} \left( \frac{R_i}{\Omega} \right)^{\delta_i} K_i \quad (3.24)$$

where  $R_i$  is the net rate of return on capital for sector  $i$  and  $\Omega$  is the interest rate,

then  $\frac{R_i}{\Omega}$  is the static expected relative rate of return for sector  $i$ .  $\alpha_{Vi}$  and  $\delta_i$  are the investment size coefficient and the investment elasticity coefficient, respectively. In addition, the public investment sectors are assumed to have an investment elasticity coefficient of zero, i.e. their investment is proportional to their capital stock ( $Z_{Vi} = \alpha_{Vi}K_i$ ). Further, the demand for sector  $j$  for each type of investment commodity,  $Z_{Vji}$ , is assumed to be a fixed share of their total investment demand, and sectoral inventories are assumed to vary in proportion to their total output.

#### 4) Government behaviour module

The government receives revenue through various taxes and foreign transfers, and incurs expenditure through subsidies to businesses and residents and the purchase of various products, the difference being government savings. The price fluctuations due to the Covid-19 effect contain a combination of cost increases due to direct shocks (higher production prices) and cost decreases due to government subsidies and market price decreases (i.e. issuing coupons etc.), leading to a new equilibrium:

$$P_{pi} - G_{pi} = P_{ci} - G_{ci} \quad (3.25)$$

where  $P_{pi}$  is the aggregate production price for industry  $i$  and  $G_{pi}$  is the government subsidy for the corresponding industry.  $P_{ci}$  is the aggregate market price of the final commodity for industry  $i$  and  $G_{ci}$  is the total amount of government coupons for the corresponding industry.

As for the government income and consumption, we assume that:

Government income:

$$GY = PT + DVAT + TARF + IMCT + IMVAT + DCT + DT \quad (3.26)$$

where  $GY$  is the government income,  $PT$  is the production tax,  $DVAT$  is the domestic value-added tax,  $TARF$  is the import tariffs,  $IMCT$  is the consumption tax on imported

commodities,  $IMVAT$  is the import value-added tax,  $DCT$  is the consumption tax on domestic commodities, and  $DT$  is the individual income tax.

Government consumption for commodities demand:

$$GC = shrg_{cc} * (GY - U_{HG}) \quad (3.27)$$

Government saving:

$$GS = (1 - shrg_{cc}) * (GY - U_{HG}) \quad (3.28)$$

Where  $shrg_{cc}$  is the composition of government consumption.

## 5) International trade module

In the assumptions of existing studies, the international trade module is usually based on the assumption that the supply of imports and exports (demand) is determined by the price of imports and exports as well as the demand (supply) abroad, so that the total supply of commodities and the supply to domestic and foreign countries respectively can be described by a Constant Elasticity of Transformation (CET). However, in the earliest days of China's response to the Covid-19 shock, there was almost no export of some commodities and at the same time a great demand for imports (e.g. medical equipment such as masks and respirators). However, after the epidemic was gradually brought under control, the early excess production and the surge in demand from abroad led to a sharp U-shaped rise in exports of the corresponding commodities. At the same time, as China's import and export management policies for various commodities were different at different stages of the epidemic, the prices of some commodities were also out of control for a short period of time, so it is not reasonable to continue to use CET to describe the "black swan" event. Taking into account the above considerations, I propose to use the change in the total price of imported and exported commodities, together with the international market price and exchange rate, as the basis for judging the extent of the impact on the international

trade module.

Armington function (Armington, 1969) between imports and domestic commodities:

$$QC(CC) = AA(CC) * [\delta(CC) * QD(CC)^{\rho(CC)} + (1 - \delta(CC) * IMP(CC)^{\rho(CC)})]^{1/\rho(CC)} \quad (3.29)$$

CET function between exports and domestic commodities:

$$Q(CC) = AT(CC) * [\varepsilon(CC) * QD(CC)^{\rho(CC)} + (1 - \varepsilon(CC) * EXP(CC)^{\rho(CC)})]^{1/\rho(CC)} \quad (3.30)$$

Where:  $QC(CC)$  is the quantity of composite commodity supplied to or consumed in domestic market,  $QD(CC)$  is the quantity of domestically-produced commodity,  $AA(CC)$  is the scaling parameter of Armington function,  $AT(CC)$  is the scaling parameter of transformation function,  $\delta(CC)$  is the substitution rate of Armington assumption,  $\varepsilon(CC)$  is the substitution rate of transformation assumption,  $QD(CC)$  is the quantity of domestically-produced commodity sold in domestic market,  $\rho(CC)$  is the substitution elasticity of composite commodities, and  $IMP/EXP$  are the import and export respectively.

## 6) Equilibrium conditions and macroscopic closure assumptions

The market is assumed to be in equilibrium, where producers earn zero net profit, supply and demand for all commodities and factors are equal, investment and savings are balanced, and the balance of payments of each market player (e.g. residents) is balanced. The macro closure of the model is based on the following principles: technological progress and tax rates are exogenous; savings are exogenous and determine the total scale of investment; exchange rates are exogenous and act as benchmark prices; and government transfers are exogenous.

Detailed, the close module includes 4 balance assumptions:

Commodity market balance:

$$Q(CC) = \sum_{Ps} XX(Ps, CC) + HE + GC(CC) + Z_V(CC) \quad (3.31)$$

Where  $XX(Ps, CC)$  is the intermediate input matrix between production of enterprises and composite commodities.

Factor market balance:

$$L^s = \bar{L}^d \quad (3.32)$$

$$K^s = \bar{K}^d \quad (3.33)$$

Saving and investment balance:

$$Z_V = HS + GS \quad (3.34)$$

Trade closure:

$$PEXP * EXP = PIMP + IMP + Z_{VF} \quad (3.35)$$

where  $PEXP$  is the price of export and  $PIMP$  is the price of import.

## 7) Model dynamization mechanism

The model is dynamic in a recursive manner through exogenous labour supply growth rates, technological progress and investment-driven capital accumulation:

$$K_i^* = K_i(1 - d_i) + Z_{Vi} \quad (3.36)$$

where:  $K_i^*$ ,  $K_i$ ,  $Z_{Vi}$  and  $d_i$  denote the closing capital stock, opening capital stock, new investment and capital depreciation rate of sector  $i$ , respectively. Further, assumptions also include that the growth rates of capital and total capital in each sector are endogenous, and the changes in population, changes in labour supply and technological progress are exogenous. Of these, the Covid-19 shock manifests itself first and foremost as a change in labour supply. On this basis, since we focus on the short-run indirect shocks from Covid-19, we assume that technological progress is 0.

### 3.2.3.2 Data processing and baseline scenarios

The time frame selected for the policy simulation of this part spans from 2017 to 2035.

The base period is set as 2017, while the historical simulation period covers the years 2018 to 2019. The forecast and policy simulation period extends from 2020 to 2035. Since the release of input-output tables by the National Bureau of Statistics of China is only for every year ending in 7 and 2 (e.g., 2012 and 2017), we need to calculate to obtain the Input-Output (IO) tables for 2020 based on the basis table for the year 2017 and the subsequent extended tables. In non-benchmark years, the National Bureau of Statistics of China publishes the corresponding extended tables for researchers to calculate the input-output tables for that year. Accordingly, we obtained the IO table for 2020 based on the benchmark table for 2017 and the extended tables for 2018, 2019 and 2020<sup>20</sup>.

Based on the studies conducted by Zhang (2013), Yao et al. (2010), and Yang (2016), we established and computed the different elasticity coefficients. The resulting values are presented in the Table 3.4.

Table 3.4: Value setting of elasticity

Armington's value of elasticity of substitution		Export elasticity	
Agro-food	16.12	Short-term export price elasticity	-0.67
Industrial product	3.63	Short-term export income elasticity	2.43
Construction	0.25	Long-term export price elasticity	-2.12
Services	2.27	Long-term export income elasticity	7.14

The exogenous variables employed in this model primarily consist of macro- and industry-level variables that may be directly observed, such as population, aggregate labour supply, GDP, value added in different domestic demand sectors, imports, and exports. To establish the growth rates of the various exogenous variables across the

<sup>20</sup> The 2020 IO table can be found in the website of National Bureau of Statistics of China.

historical simulation period, we choose to utilise the average growth rates of the appropriate indicators for the first three years of the simulation period.

Ultimately, we employ the forecast simulation to ascertain the fundamental scenario for China's economic progression in the years 2020-2035. Within the forecast simulation, the real GDP and its sectoral value added are considered as exogenous variables, and the total factor productivity is assumed to remain constant at the average level observed over the first three years of the historical simulation period. Table 3.5 represents the values and source periods of the main exogenous variables in the baseline scenario.

Table 3.5: Values of key exogenous variables in the baseline scenario

Variable	Value (%)
Average annual change in real GDP <sup>21</sup>	6.3(2018-2020), 5.5(2021-2025), 4.8(2026-2030), 4.3(2031-2035)
Share of primary sector <sup>22</sup>	7.0(2020), 6.3(2025), 5.6(2030), 4.8(2035)
Share of secondary industry	38.5(2020), 36.1(2025), 36.9(2030), 31.7(2035)
Share of tertiary sector	54.5(2020), 57.6(2025), 60.5(2030), 63.5(2035)
Annual average change in total labour supply <sup>23</sup>	-0.65(2018-2020), -0.36(2021-2025), -0.75(2026-2030), -1.07(2031-2035)

### 3.2.4 Interaction shock

As previously stated in our discussion on the utilisation of the CGE model, the impact

<sup>21</sup> Referring to China Statistical Yearbook, Institute of Quantitative and Technological Economics of the Chinese Academy of Social Sciences and China Economic Trend Research Institute of Economic Daily (2020).

<sup>22</sup> Referring to the group of the Macroeconomic Research Centre of the Chinese Academy of Social Sciences (2020).

<sup>23</sup> Referring to Qi (2018).

of Covid-19 on the Chinese economy can be influenced by the interplay of product substitution linkages.

However, we contend that substitution connections should primarily arise from variety, where the significant routes of impact are the various interactions among distinct industries, different products, and consumers with altered preferences. The conventional meaning of substitution typically pertains to commodities or services of a similar nature. In actual economic contexts, particularly in nations like China, characterised by significant product variety, it may be imprecise to categorise such intricate shocks as substitution effects. Consequently, we have named it as interaction shocks rather than substitution effects.

Using the CGE model, we can simulate the combined impacts of a direct shock on demand, a direct shock on supply, and a simultaneous shock on both supply and demand. The CGE model incorporates product substitution, while the IO model does not. Therefore, the difference between the combined effects mentioned above and the corresponding chain effects can be described as the interaction effects of the economic system in response to these types of shocks.

### **3.2.5 Shock estimation result and chapter summary**

By considering the estimations of the aforementioned models and converting the anticipated shocks from each industry into shocks on the overall Chinese economy in terms of GDP, based on the industry's contribution, we derive the subsequent breakdown of Covid-19 shocks. Table 3.6 illustrates the shock estimation result of demand side, while Table 3.7 is for supply chain.<sup>24</sup>

<sup>24</sup> There is no T-value provided in the output because the CGE model in this chapter was built using deterministic simulation method.

Table 3.6: Covid-19's shock on China's GDP --- Demand side

Key industries	Direct	Indirect	Aggregate	Interaction shock	Comprehensive shock
Real Estate	-0.36%	-0.27%	-0.63%		
Transport and Storage	-0.49%	-0.45%	-0.94%		
Wholesale and Retail	-0.95%	-0.91%	-1.86%		
Catering and Accommodation	-0.23%	-0.17%	-0.39%	-	-
Finance	-0.45%	-0.37%	-0.83%		
Other Tertiary Industry Sectors	-1.12%	-0.67%	-1.79%		
Aggregate	-3.60%	-2.84%	-6.44%	1.79%	-4.65%

Table 3.7: Covid-19's shock on China's GDP --- Supply chain

Key industries	Direct	Indirect	Aggregate	Interaction shock	Comprehensive shock
Real Estate	-0.96%	-0.40%	-1.36%		
Transport and Storage	-0.71%	-0.29%	-1.00%		
Wholesale and Retail	-1.61%	-0.50%	-2.11%		
Catering and Accommodation	-0.41%	-0.15%	-0.56%	-	-
Finance	-0.47%	-0.15%	-0.62%		
Other Tertiary Industry Sectors	-1.20%	-0.37%	-1.57%		
Aggregate	-5.36%	-1.87%	-7.23%	4.96%	-2.26%

In general, the effect of Covid-19 on the Chinese economy, particularly in the tertiary industry, is more pronounced in terms of decreased demand rather than disruptions in

the supply chain. Following the occurrences of SARS, the financial crisis, and Covid-19, the Chinese economy has observed a notable rise in the savings rate and a decline in the consumption rate. This trend aligns with the target reality that the impact on the demand side is more substantial.

The direct impact on the supply chain is about -5.36%, which is greater than the direct impact on the supply side (-3.6%). This is consistent with China's lockdown policy implemented after the Covid-19 outbreak, as well as the decrease in consumer spending outside the home due to fear of the epidemic.

Regarding indirect shocks, the demand side experiences a negative shock of around -2.84%, which is more than the -1.87% shock experienced by the supply chain. When considering our definition of indirect shocks, it becomes apparent that the demand side experiences a greater number of indirect shocks over a longer period of time. This implies that the population's perception of demand and consumption may have been permanently influenced, potentially resulting in a long-term change in their consumption behaviour. Therefore, the people may be more likely to increase the percentage of savings and decrease spending in the tertiary sector. This idea is also rather plausible when considering the trend of changes in the business income data of the tertiary industry. Nevertheless, the government's propaganda operation has the potential to offset and reverse this tendency, despite the fact that the credibility of the Chinese government might have declined after Covid-19. Nevertheless, there are still cases that prove that the appeal of the Chinese government is still at a high level. The successful local government propaganda in Zibo City, Shandong Province (focused on catering - BBQ) and Harbin City, Heilongjiang Province (focused on tourism - winter speciality tourism), has been shown to effectively change people's demand and consumption perspectives.

Based on our definition of interaction shocks, the supply chain experiences a higher percentage of positive shocks from substitution effects (about 4.96%) compared to the demand side (1.79%). This implies that China's comprehensive industrial system and ample selection of alternative options may effectively make up for the unexpected shortage of some products, hence highlighting the significance of reforming the supply side of the economy.

In general, the Covid-19 pandemic has had a significant and severe impact on China's GDP. The tertiary industry, in particular, has been struck the hardest, resulting in a recession of around 6.92% of GDP. This recession surpasses the rate of economic growth that China has experienced in previous years, which has been steady but falling. Hence, the efficacy of unconventional monetary measures enacted in response to the Covid-19 pandemic is a crucial subject for deliberation. Also in the following examination of unconventional monetary policy in response to Covid-19 should focus on its role in stimulating output, as well as on monetary policy instruments targeting the tertiary sector (especially small and medium-sized enterprises (SMEs)).

### **3.4 Shortcoming**

Our analysis of the Covid-19 shocks still presents opportunities for enhancement. The use of the Leontief and Ghosh models does not consider specific characteristics of China, like the divergence between urban and rural economies. The similar deficiency is seen in the design of the CGE model, wherein the behavioural module for the Chinese government is not entirely congruent with the real functioning of Covid-19. The Chinese government has employed a broad array of measures to accelerate economic recovery, some of which are challenging to assess. Certain provinces, like Hubei and

Heilongjiang, have implemented targeted coupons and vouchers; nevertheless, the government's work report does not expressly specify the overall amount or the timeframe of these operations. The primary issue is that the government report lacks clarity regarding whether the amounts for coupons, vouchers, and similar things are included in the calculation of government expenditure.

Furthermore, a fundamental inquiry is whether the patterns of economic and governmental behaviour across many sectors in China post-Covid-19 mirror those observed prior to the pandemic. While it is evident that Covid-19 had extensive and systematic repercussions in China, we are now unable to ascertain whether models based on the initial experience can accurately forecast the post-Covid-19 scenarios. These are questions that may need to wait for China's economy to run for a while longer before the answers can be explored in the possible problems.

# Chapter 4

## Effectiveness of unconventional monetary policy

The primary criterion for assessing unconventional monetary policy is its effectiveness. This analysis focuses on the origin and definition of unconventional monetary policy. The primary aim of unconventional monetary policy, employed during atypical economic conditions, is to fulfill a specific target at a designated time. Therefore, the evaluation of unconventional monetary policy effectiveness is critically important.

This chapter is structured into two sections to analyze the effectiveness of China's unconventional monetary policy in response to Covid-19, as discussed in our previous conversation regarding China's monetary policy system. The initial section examines the efficacy of unconventional monetary policy instruments through the instrumental framework, alongside an analysis of the transmission channel framework. In the subsequent section, we examine the effectiveness of various types of unconventional monetary policy portfolios, acknowledging that the PBOC typically employs policy portfolios in real-world applications.

This chapter utilizes two models to assess the efficacy of unconventional monetary policy. Initially, we employ the TVP-SV-VAR model to examine the time-varying impacts of independent monetary policy instruments and channels during the pandemic's onset. Secondly, we employ the DSGE model to examine the relative effectiveness of artificially established monetary policy combinations within the theoretical framework. This enables a thorough analysis of the effectiveness of

unconventional monetary policy. The two models complement each other across various dimensions.

Initially, they enhance one another regarding the subjects of analysis. The TVP-SV-VAR model is appropriate for analyzing instruments or channels that were utilized independently or can be identified historically. The DSGE model is appropriate for analyzing hypothetical, combination-based policies, including combinations of independent instruments and specialized policies. The two models emphasize distinct policy dimensions. Additionally, their methodologies are complementary. The TVP-SV-VAR model offers empirical evidence derived from real data. The DSGE model offers mechanisms for explanation and facilitates counterfactual simulations grounded in theoretical frameworks. The integration of the two strengthens the robustness and persuasiveness of research conclusions. The two models also address each other's deficiencies. The TVP-SV-VAR model is potentially constrained by the Lucas critique and lacks adequate structural explanations. The DSGE model is subject to limitations arising from model specification biases and an oversimplification of reality. The integration of the two models facilitates mutual validation, allowing for the enhancement of strengths and mitigation of weaknesses, which results in more comprehensive and reliable research conclusions.

## **4.1 Unconventional monetary policy instruments employed in response to the Covid-19**

During the outbreak, the PBOC refrained from utilising short-term liquidity mediation measures and prioritised medium-term lending facility activities. Hence, we exclusively offer an elaborate explanation of the utilisation of the rest 3 policy instruments: Standing Lending Facility, Medium-term Lending Facility, and Pledged

Supplementary Lending. Also, in conjunction with our discussion of the decomposition of Covid-19 shocks, we will also focus on the Targeted Lending set up specifically for tertiary SMEs, as well as the special management operations for foreign exchange reserves. All data in the tables in this section are sourced from the CEIC database.

### **4.1.1 Standing Lending Facility**

There was an increased utilisation of the standing lending facility during the outbreak. With the exception of April 2021, the PBOC conducted standing lending facility operations every month between January 2020 and December 2022. During this time frame, the PBOC carried out a total standing lending facility operation of CNY 2875.21 billion. In 2020, the PBOC conducted a total of CNY 1862.30 billion in standing lending facility operations. In 2021, the amount was CNY 760.29 billion, and in 2022, it was CNY 252.62 billion. The highest amount of standing lending facility operations conducted were those with a one-month maturity, totaling CNY 167.55 billion. The total value of one-month standing lending facility activities was CNY 151.51 billion in 2020, CNY 12.99 billion in 2021, and CNY 3.05 billion in 2022. The second largest facility is the 7-day standing lending facility activities, which spans over a period of seven days and amounts to a total of CNY 99.965 billion. In 2020, the total amount of 7-day standing lending facility operations was CNY 34.44 billion. In 2021, it increased to CNY 49.902 billion, and in 2022, it decreased to CNY 15.623 billion. The overnight standing lending facility has the lowest frequency of operations among all the lending facility activities, with a cumulative total of CNY 20.006 billion. In 2020, a total of CNY 2.80 billion was used for a cumulative overnight standing lending facility operation. In 2021, the amount increased to CNY 131.37 million, and in 2022, it decreased to CNY 65.89 million. During January 2020, the interest rate of the standing lending facility had three modifications, specifically in April 2020, January 2022, and August 2022.

Except for April 2020, when the standing lending facility rate for all maturities declined by 0.3 percentage points, the standing lending facility rate for all maturities decreased by 0.1 percentage points on both occasions. The interest rates for the one-month standing lending facility decreased from 3.85% to 3.35%, the seven-day standing lending facility decreased from 3.5% to 3.0%, and the overnight standing lending facility decreased from 3.35% to 2.85%. Table 4.1 displays the comprehensive monthly usage of the Standing Lending Facility.

Table 4.1: Standing Lending Facility placements (billion)

Date	Overnight	7-day	1 month	Month-end balance
01/2020	0.10	68.00	292.40	292.4
02/2020	0.00	30.00	330.00	330
03/2020	0.00	0.00	306.30	306.3
04/2020	0.00	0.00	272.00	272
05/2020	0.00	6.80	135.00	141.8
06/2020	0.00	47.00	26.00	73
07/2020	0.70	0.10	25.50	25.5
08/2020	0.00	0.00	9.50	9.5
09/2020	0.00	21.50	3.00	24.5
10/2020	0.00	0.00	7.00	7
11/2020	0.50	36.00	45.00	81
12/2020	1.50	135.00	63.40	198.4
01/2021	110.00	215.00	51.70	331.7
02/2021	0.00	34.00	0.00	0
03/2021	0.00	35.00	29.40	64.4
04/2021	0.00	0.00	0.00	0
05/2021	0.00	30.00	0.00	30

Date	Overnight	7-day	1 month	Month-end balance
06/2021	3.00	37.50	45.00	85.5
07/2021	0.02	2.30	0.00	1.3
08/2021	0.60	0.00	0.00	0
09/2021	0.30	23.30	1.00	14.3
10/2021	2.92	0.00	0.00	0
11/2021	6.45	0.41	0.00	0.33
12/2021	8.08	121.51	2.80	126.8
01/2022	0.50	23.00	0.00	23
02/2022	2.62	0.00	24.50	27
03/2022	13.64	0.00	0.00	12.6
04/2022	0.51	2.55	0.00	2.5
05/2022	2.33	0.05	0.00	1.8
06/2022	12.14	2.00	0.00	13.41
07/2022	4.95	0.03	0.00	0
08/2022	6.84	0.00	0.00	4.81
09/2022	5.49	4.20	0.00	8.2
10/2022	6.47	10.00	0.00	5
11/2022	5.40	1.00	0.00	4.05
12/2022	5.00	113.40	6.00	123

Examining the patterns in month-end balances and interest rates of the standing lending facility prior to and following the outbreak of the epidemic, the average monthly balance of the standing lending facility stood at CNY 39.29 billion before the onset of the Covid-19 pandemic. Following the outbreak and as of the conclusion of 2022, this amount decreased to CNY 7.336 billion, representing a reduction of almost 81% compared to the period prior to the epidemic. Figure 4.1 clearly shows a decline in the

month-end balance of the standing lending facility. Examining the trend of interest rates on standing lending facilities before and after the epidemic, Figure 4.2 reveals that the interest rates on standing lending facilities with durations of 1 month, 7-day, and overnight moved in opposite directions before and after the epidemic. Prior to the outbreak, the three interest rates experienced a gradual increase, however during the epidemic, they exhibited a more pronounced and progressive decline. This suggests that the SLF played an important role in the unconventional monetary policy operations of the Chinese government and central bank in response to Covid-19.

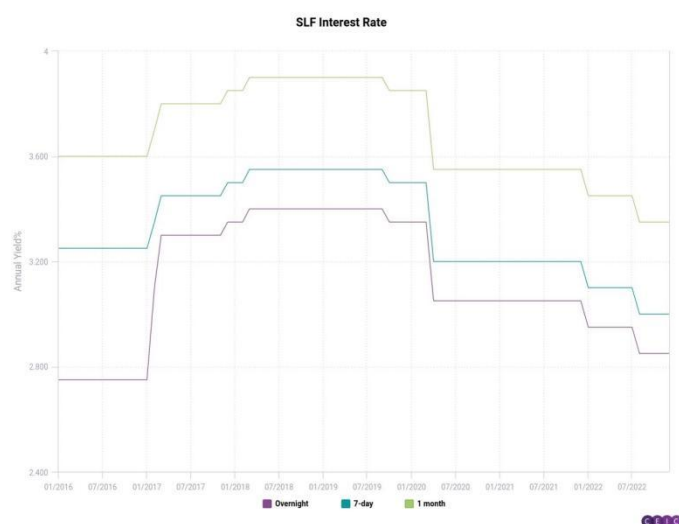


Figure 4.1: Standing Lending Facility interest rate

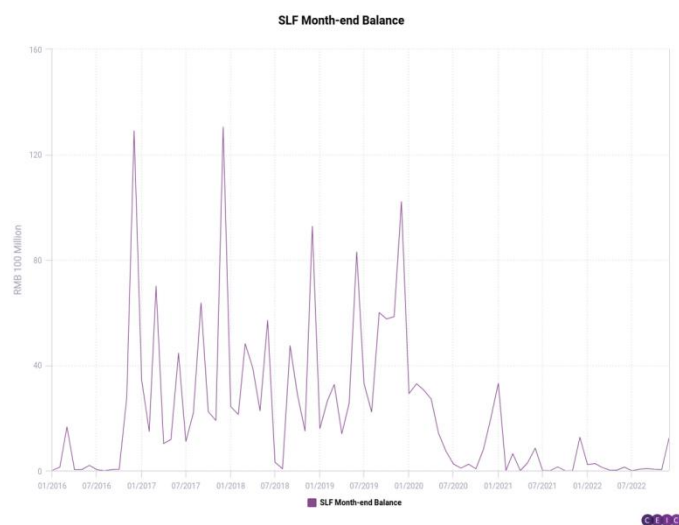


Figure 4.2: Standing Lending Facility month-end balance

Before the pandemic, the SLF functioned as the upper boundary of the interest rate corridor for central bank liquidity management, primarily aimed at addressing the short-term, substantial liquidity requirements of financial institutions. It offered collateralized loans with durations ranging from 1 to 3 months to mitigate abnormal fluctuations in money market interest rates and ensure the stability of short-term interest rates.

### 4.1.2 Medium-term Lending Facility

Between January 2020 and 2022, the PBOC conducted 37 medium-term lending facility operations, amounting to a total of CNY 1,425 billion. In 2020, the PBOC carried out 13 operations for medium-term lending and borrowing facilities, with a total value of CNY 515 billion. In 2021, there were 12 operations with a total value of CNY 455 billion, and in 2022, there were also 12 operations with a total value of CNY 455 billion. The medium-term lending facilities undertaken during this time had a tenure of 1 year. The minimum sum for each operation was CNY 100 billion, while the highest amount was also CNY 100 billion. The largest operation took place on 15 November 2021. From January 2020 to 2022, the interest rate for the one-year

medium-term loan and borrowing facility was adjusted four times. These adjustments took place on February 17, 2020, April 15, 2020, January 17, 2022, and August 15, 2022, respectively. With the exception of the second instance where the medium-term lending facility rate decreased by 0.2 percentage points, the rate has decreased by only 0.1 percentage points on the other three occasions. The rate changed from 3.25 percent in January 2020 to its current value of 2.75 percent. Table 4.2 displays the precise utilisation of Medium-term Lending Facilities on a monthly basis.

Table 4.2: Medium-term Lending Facility operations (billion)

Date	Quantity of input	Month-end balance
15/01/2020	30	399
17/02/2020	20	419
16/03/2020	10	429
15/04/2020	10	419
15/05/2020	10	409
15/06/2020	20	355
15/07/2020	40	355
17/08/2020	70	370
15/09/2020	60	410
15/10/2020	50	440
16/11/2020	80	480
30/11/2020	20	480
15/12/2020	95	515
15/01/2021	50	535
18/02/2021	20	535
15/03/2021	10	535
15/04/2021	15	540

Date	Quantity of input	Month-end balance
17/05/2021	10	540
15/06/2021	20	540
15/07/2021	10	510
16/08/2021	60	500
15/09/2021	60	500
15/10/2021	50	500
15/11/2021	100	500
15/12/2021	50	455
17/01/2022	70	475
15/02/2022	30	485
15/03/2022	20	495
15/04/2022	15	495
16/05/2022	10	495
15/06/2022	20	495
15/07/2022	10	495
15/08/2022	40	475
15/09/2022	40	455
15/10/2022	50	455
15/11/2022	85	440
15/12/2022	65	455

Examining the patterns in the final balance of medium-term lending facilities and interest rates prior to and following the onset of the Covid-19 pandemic. Prior to the outbreak, the mean month-end balance of medium-term lending facilities stood at CNY 423.48 billion. Following the pandemic, this amount rose to CNY 469.87 billion,

reflecting an approximate 11% growth compared to the period before the epidemic. Figure 4.3 clearly illustrates that the month-end balance of medium-term lending facilities exhibited a noticeable increase trajectory following the onset of the Covid-19 pandemic. Furthermore, the 1-year medium-term lending facility rate exhibited a contrary movement to that of the standing lending facility interest rate, both prior to and following the outbreak. Prior to the Covid-19 epidemic, the rate increased steadily and thereafter declined gradually but more steeply. These findings indicate that the Chinese government and central bank considered MLF to be a significant unconventional monetary policy instrument in addressing the impact of Covid-19.

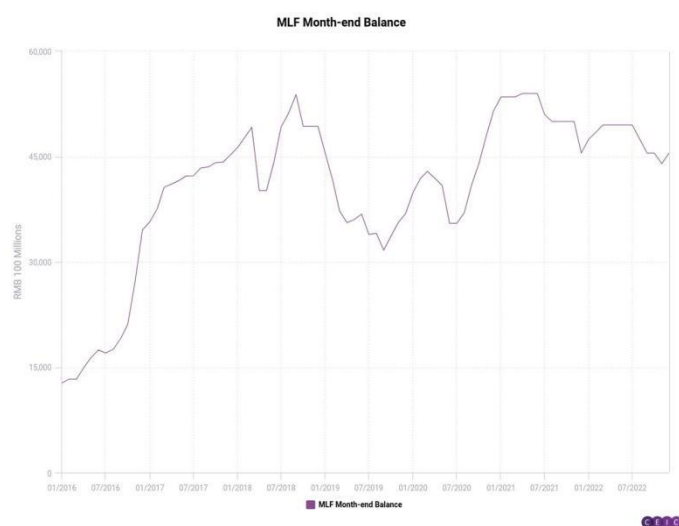


Figure 4.3: Medium-term Lending Facility month-end balance

Before the pandemic, the MLF was designed to supply commercial banks with medium-term base money injections, generally lasting from 3 months to 1 year, to influence medium-term market interest rates and facilitate credit distribution to the real economy. Financial institutions must supply eligible collateral, including high-credit bonds, to enhance the central bank's targeted management of medium- and long-term liquidity.

### 4.1.3 Pledged Supplementary Lending

Pledged Supplementary Lending exhibits lower levels of transparency compared to the Standing Lending Facility and Medium-term Lending Facility. Upon careful examination and calculation, it was discovered that the PBOC only provided PSL to certain banks in January 2020, granting a total of CNY 20 billion. This lending was given to the China Development Bank, Export-Import Bank of China, and Agricultural Development Bank of China. In February 2020, the PBOC provided a net amount of CNY 0.2 billion in Pledged Supplementary Lending to the same banks. However, between 2020 and 2022, the PBOC did not engage in any other PSL operations, except for the Medium-term Lending Facility and the Standing Lending Facility. Instead, it solely focused on recovering the maturity of previously PSL. Furthermore, the interest rate for the PSL has stayed constant at 2.75% from 30 November, 2015. Table 4.3 displays the operation amount and balance data for the specific PSL on a monthly basis. Positive numbers represent the PSL placed, while negative values represent the amount retrieved.

Table 4.3: Net input of Pledged Supplementary Lending (billion)

Date	Net input	Month-end balance
01/2020	20	3557.4
02/2020	0.2	3557.6
03/2020	0	3557.6
04/2020	-12.6	3545
05/2020	0	3545
06/2020	-35.9	3509
07/2020	-52.4	3456.6
08/2020	-2.6	3454

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Date	Net input	Month-end balance
09/2020	-19.7	3434.3
10/2020	-7.3	3427
11/2020	-158.8	3268.2
12/2020	-33.2	3235
01/2021	0	3235
02/2021	-24.6	3210.4
03/2021	-16.4	3194
04/2021	-17.8	3176.2
05/2021	-39.6	3136.6
06/2021	-44	3092.6
07/2021	-77.5	3015.1
08/2021	-104.6	2910.5
09/2021	-26.2	2884.4
10/2021	-46.6	2837.8
11/2021	-20	2817.8
12/2021	-16.1	2801.7
01/2022	-1.7	2800
02/2022	0	2800
03/2022	-63.7	2736.3
04/2022	-27.5	2708.8
05/2022	-88.5	2620.3
06/2022	0	2620.3
07/2022	-52.1	2568.2
08/2022	-28.2	2539.9
09/2022	108.2	2648.1
10/2022	154.3	2802.4

Date	Net input	Month-end balance
11/2022	367.5	3169.9
12/2022	-17.1	3152.8

Given that PBOC only implemented a significant positive PSL placement in September 2022, following the Covid-19 epidemic, it is evident that the PSL was not considered a primary unconventional monetary policy measure in reaction to the pandemic. The CNY 20 billion sized PSL placement in January 2020 was a planned monetary policy operation announced by the PBOC in the fourth quarter of 2019. Therefore, we believe that it was not a significant response to the Covid-19 pandemic.

Prior to the pandemic, PSL functioned mainly as a targeted structural support mechanism in accordance with national strategic priorities. The initial focus was on offering long-term, low-cost funding to development finance institutions, such as the China Development Bank, for specific purposes, including urban renewal projects, major infrastructure initiatives, and other livelihood programs. It additionally functioned to regulate medium- and long-term liquidity while directing targeted credit allocation.

#### 4.1.4 Targeted Lending

The targeted lending policy of the PBOC is a set of policy initiatives aimed at offering advantageous interest rates and focused financial assistance through loans to particular industries, firms, or regions. The primary target is to effectively facilitate economic growth in particular sectors to stimulate economy, particularly small and medium-sized enterprises (SMEs) and key industries. The implementation of targeted lending policies often necessitates China's comprehensive economic regulation and

control to address the negative impact on the economy, counteract financial risks, and bolster crucial economic sectors.

Targeted lending is not an isolated strategy, but rather a instrument employed by the PBOC within the macro-control framework. Following the year 2010, as the need for economic structural transformation and upgrading grew, and the negative consequences of extensive monetary easing (such as real estate market bubbles and excessive speculation in the capital market) became more evident, PBOC progressively transitioned to a strategy of 'targeted easing'. The year 2014 marked a significant milestone for the targeted lending strategy. Subsequently, the PBOC has prioritised structural reforms through targeted operations, facilitating the allocation of resources to crucial sectors. Herein lies the peculiarity of targeted lending in China. Should structural monetary policy, in China's monetary policy system, be defined as conventional monetary policy? Within the discourse among Chinese academics, the overarching trajectory of structural monetary policy, which the PBOC has implemented for over ten years, has persisted unaltered. The primary target of structural monetary policy has always been to improve and optimise the structure of the supply chain. Conversely, targeted lending has shifted in tandem with the movement of the major stimulated target. China's inaugural targeted lending strategy, known as a targeted reserve ratio reduction, was implemented in 2014 specifically for rural related firms as well as SMEs. In 2016, anti-poverty programmes were added to the stimulus target. In 2017, green credit and financial poverty alleviation were added. In 2019, PBOC announced the gradual expansion of SMEs, one of the stimulus targets, to private companies. It is thus clear that the targeted lending instrument was in fact consistently and steadily implemented before Covid-19 occurred.

In the aftermath of the Covid-19 epidemic, PBOC intensified its targeted lending efforts,

specifically directing it towards producers of anti-epidemic materials and SMEs that suffered significant economic losses. In 2021, targeted lending to establishments engaged in the production of anti-epidemic products were terminated. Here, the targeted lending policy appears unconventional in its response to Covid-19. PBOC has made it clear that this adjustment is focused on SMEs that are heavily impacted by Covid-19. In line with our discussion of the decomposition of the Covid-19 shock, this unconventional targeted lending operation should have been aimed at SMEs in the tertiary industry.

Unfortunately, specific subsidy data for tertiary industry SMEs are not explicitly given in the PBOC report and database, nor even explicitly available for all SMEs in a clear time series. Therefore, we choose to extract SMEs-oriented lending data from the business report of the four major commercial banks in China, i.e., Industrial and Commercial Bank of China (ICBC), Agricultural Bank of China (ABC), China Construction Bank (CCB), and Bank of China (BOC). In contrast, targeted lending operations do not distinguish tertiary industry SMEs separately in the banks' reports. To achieve this target, we referred to the quarterly report on support to the tertiary sector from the CBRC (China's Banking Regulatory Commission) database. The report provided information on the specific amount of special targeted lending towards SMEs and the description of whether it was successfully executed, which being marked as anti-pandemic specialisation. Following this, we corresponded with the CBRC and requested information on the monthly proportion of targeted lending mandates granted to banks. Ultimately, we generated the monthly targeted lending disbursements to SMEs in the tertiary sector from the four major banks, by multiplying the monthly ratios with the amounts specified in the bank reports, shown as Figure 4.4.

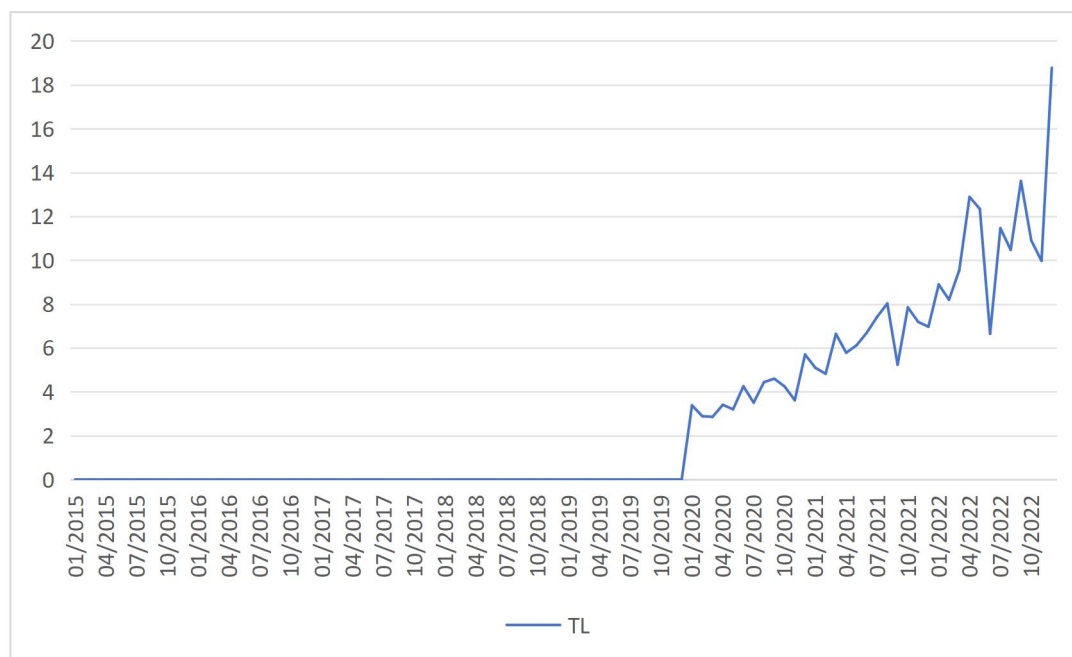


Figure 4.4: Anti-Covid-19 Targeted Lending (billion)

It is evident that Anti-Covid-19 Targeted Lending, a unique type of targeted lending created especially for Covid-19, was put into effect right away following the outbreak and has since intensified. As a result, we think it is appropriate and essential to incorporate it into the unconventional monetary policy instruments that were employed this time.

Prior to the pandemic, TL primarily encouraged commercial banks to enhance credit availability for small and medium-sized enterprises (SMEs) and other underserved sectors by implementing differentiated reserve requirement ratios or special re-lending quotas. This approach aimed to lower financing costs and facilitate targeted liquidity distribution to specific economic sectors, thereby optimizing the credit structure.

#### 4.1.5 Special management of foreign exchange: Foreign Exchange Management Index (FEMI)

The foreign exchange management policy of China refers to the system implemented by

the State to regulate and control the foreign exchange market and transactions. This is achieved by policy measures that focus on capital flows, currency exchange, and foreign exchange reserve management. The primary targets are to uphold financial stability, advance balance of payments, and enable economic structural reform. The formulation and practice of these policies are collaboratively undertaken by the State Administration of Foreign Exchange (SAFE) and PBOC.

Once the CNY became part of the IMF's Special Drawing Rights (SDR) currency basket in 2016, China's foreign exchange management strategy started to progressively focus on promoting the openness of capital markets and effectively managing cross-border capital flows. This trend is ongoing up to the present day.

With the escalation of trade tensions between the United States and China in 2018, the pressure on the devaluation of the CNY intensified considerably. Since then, foreign exchange management strategies have increasingly relied on the purchase and sale of foreign exchange reserves to implement market-oriented reforms. Following the onset of the Covid-19 pandemic, China started to rely increasingly on foreign exchange reserves, particularly the sale of reserves denominated in US dollars. This assertive effort to sell foreign exchange reserves was the first of its nature, following China's reform of its foreign exchange system in 1994, when it initiated the implementation of a floating exchange rate regime. Hence, given Yi Gang's statement regarding the priority of exchange rate stabilisation in the PBOC's response to Covid-19, we regard the PBOC's management in foreign exchange reserves as a related unconventional monetary policy.

Before the pandemic, amidst incomplete capital account liberalization, the management of foreign exchange primarily aimed to mitigate risks linked to irregular

cross-border capital flows. This was accomplished by utilizing instruments like the adjustment of the forward foreign exchange risk reserve ratio and the establishment of cross-border financing leverage ratios to mitigate one-sided speculative behavior, thus ensuring exchange rate stability and the security of the financial system, rather than directly supplying liquidity.

In addition, the foreign exchange management instruments employed by China in response to Covid-19, including the dynamic adjustment of the forward foreign exchange risk reserve ratio, represent a departure from conventional practices. The primary distinction between the two is that the former employs market-based, price-oriented macroprudential measures, which influence market expectations through flexible adjustments to transaction costs (e.g., the reserve ratio) instead of administrative prohibitions, and aims to specifically mitigate short-term abnormal fluctuations. The policy targets emphasize the maintenance of financial stability during extreme shocks, such as pandemic-induced capital outflows. This approach is characterized by a temporary and precise hedging nature, contrasting sharply with the long-term institutional framework of traditional foreign exchange management reliant on capital account controls.

There exist several methods by which central banks might engage in the foreign currency market, and the unconventional foreign exchange trading conducted by China is among them. Weymark (1997) establishes the following correlation between exchange rate volatility and changes in foreign exchange reserves:

$$\varpi_t = \eta \Delta r_t / (\Delta e_t + \eta \Delta r_t) \quad (4.1)$$

where  $\Delta r_t$  is the change in foreign exchange reserves,  $\eta = -\partial \Delta e_t / \partial \Delta r_t$ . When  $\Delta e_t = 0$  and  $\varpi_t = 1$ , it means that the central bank maintains a fixed exchange rate.  $\varpi_t = 0$  means that the exchange rate is allowed to float freely.  $\varpi_t \in (0,1)$  indicates that the

central bank implements a managed floating exchange rate regime by partially intervening in exchange rate fluctuations. Equation can be rewritten as:

$$\Delta e_t = \eta \Delta r_t / \varpi_t - \eta \Delta r_t \quad (4.2)$$

The volatility of foreign exchange reserves is assumed to be depend on the underlying equilibrium of foreign exchange reserve fluctuations and the level of the exchange rate:

$$\Delta r_t = g_0 + \Delta r_t^* + g_1 e_t + \varepsilon_{rt} \quad (4.3)$$

$$\Delta r_t^* = g_2 (i_t - \pi_t) + g_3 y_t \quad (4.4)$$

In the above equation, the fundamental equilibrium of foreign exchange reserves is determined by several macro variables such as output gap, real interest rate and exchange rate, and  $\varepsilon_{rt}$  is the residual. This leads to the foreign exchange management function as:

$$t = \frac{\eta}{\varpi_t} g_{0,t} + \frac{\eta}{\varpi_t} g_{1,t} \Delta e_t + g_{2,t} f_{t-1} + \frac{\eta}{\varpi_t} g_{3,t} (i_t - \pi_t) + \frac{\eta}{\varpi_t} g_{4,t} y_t + \varepsilon_{ft} \quad (4.5)$$

However, this function has an obvious autocorrelation problem in our study. Namely, in our design of using the TVP-SV-VAR model, we will use FEMI as a proxy variable for unconventional foreign exchange management policies, whereas the interest rate is the intermediate target and the nominal exchange rate and output gap are the final targets. Therefore, we chose to define FEMI as the share of the portion of foreign exchange market pressures that is shared due to the intervention actions of the central bank in the equation of Weymark (1997), i.e.:  $FEMI = \eta \Delta r_t / \varpi_t$ . Figure 4.5 illustrates the historical trend of FEMI we calculated. Clearly, with the continuing optimization of China's monetary policy framework, PBOC became more and more focused on foreign exchange, leads the general trend of FEMI oscillating upwards.

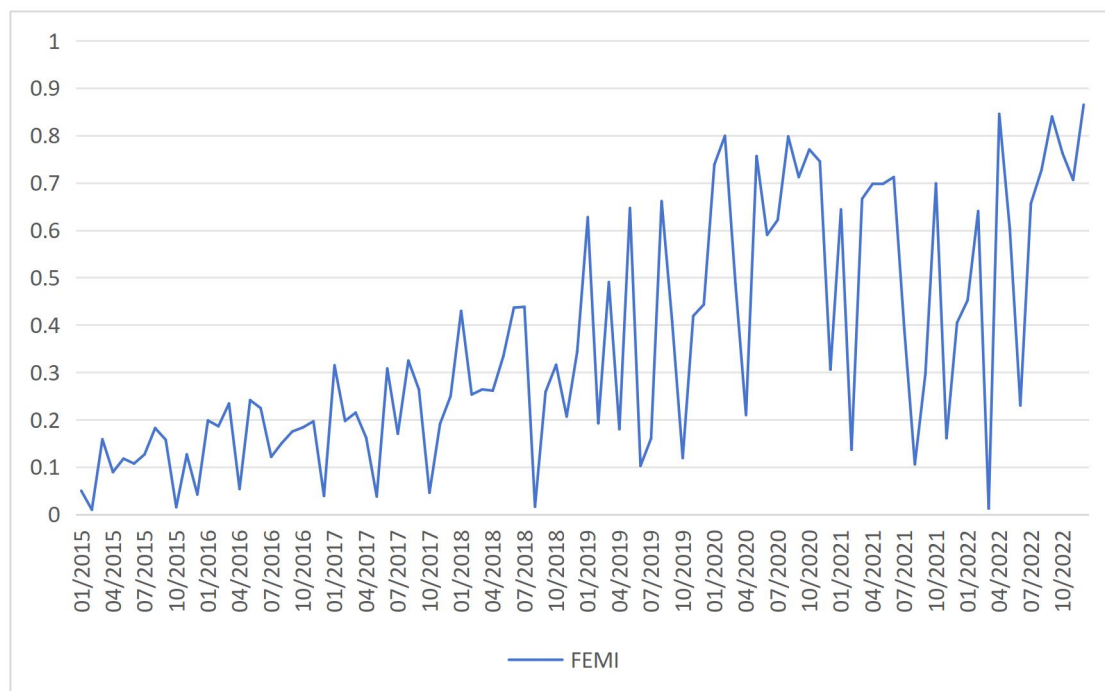


Figure 4.5: Foreign Exchange Management Index

Clearly, China's unconventional foreign exchange management measures in response to Covid-19 demonstrate seasonal characteristics, largely attributable to cyclical fluctuations in foreign exchange demand from market participants. Between June and August annually, foreign-invested enterprises and overseas-listed companies undergo a significant increase in dividend payments and profit repatriation requests. This period is further intensified by overseas students acquiring foreign exchange for tuition and living expenses, leading to a peak in foreign exchange demand during the summer months. During the Chinese New Year period, which generally occurs between January and February, there is a notable increase in overseas travel and consumer spending by residents. This, coupled with heightened debt repayment and financial settlement requirements from businesses, contributes to the peak in foreign exchange activity during winter. The PBOC utilizes unconventional control methods, including the dynamic adjustment of the risk reserve ratio for forward foreign exchange sales, to reduce pro-cyclical foreign exchange demand during certain periods, thus averting

excessive fluctuations in exchange rates. This illustrates the responsive adjustment of policy operations to seasonal variations in foreign exchange supply and demand.

Under China's distinct economic system, the choice to sustain a restricted capital account openness renders foreign exchange controls a significant policy barrier characteristic of the country. The fundamental principle underlying this is that the People's Bank of China actively regulates cross-border capital flows using macroprudential instruments, including forward foreign exchange sales risk reserves and adjustments to the cross-border financing leverage ratio, thereby mitigating the impact of external financial shocks on domestic financial stability. This mitigates excessive volatility in exchange rates and foreign exchange reserves resulting from significant inflows and outflows of short-term speculative capital. Monetary policy independence has been enhanced, mitigating the necessity to compromise interest rate policy autonomy in the context of unrestricted capital flow, as illustrated by the Trilemma. This development fosters a stable exchange rate environment and provides policy space for domestic targeted operations, including structural instruments such as the Medium-term Lending Facility and the Pledged Supplementary Lending.

## **4.2 Effectiveness of unconventional monetary policy instruments**

After analysing the introduction of five types of unconventional monetary policy instruments, we have concluded that the appropriate instruments to consider using in response to Covid-19 are the Standing Lending Facility and the Medium-term Lending Facility. Furthermore, we incorporate the money supply M2, which is the most crucial monetary policy instrument, into our scope of analysis. Quantitative easing, being a form of unconventional monetary policy used during periods of economic crisis, can be

classified as one of the unconventional instruments for managing monetary policy. Abnormal M2, in this context, can also be seen as one of these unusual instruments.

Vector autoregression (VAR) models are frequently employed to capture the dynamic process of change between economic variables, serving as a means to depict the reciprocal influence mechanism among nominal variables. The model consists entirely of endogenous variables, obviating the necessity to differentiate between variable kinds.

The Time-varying Parameters Stochastic Volatility Vector Autoregression (TVP-SV-VAR) model incorporates time-varying parameters and stochastic fluctuations into the VAR model, enhancing its flexibility and adaptability to the dynamic nature of economic variables in the real world. Simultaneously, the time-varying parameter of the TVP-SV-VAR model implies that the coefficients of the model will undergo changes as time progresses. The inclusion of this element enhances the ability of the TVP-SV-VAR model to accurately represent the evolving correlation between economic variables. Furthermore, the stochastic volatility component of the TVP-SV-VAR model captures the inherent randomness and varying intensity of fluctuations in the model as time progresses. This quality enables the model to more accurately depict the attributes of fluctuations present in actual data, such as the phenomena of volatility clustering typically observed in economic and financial data.

The primary benefit of the TVP-SV-VAR model is its capacity to endogenously capture the nonlinear, time-varying features of economic structures and policy transmission mechanisms. The model facilitates the dynamic evolution of the coefficient matrix (time-varying parameters, TVP) and the variance of the random disturbance term (random fluctuations, SV) over time. This characteristic renders it especially effective

for analyzing structural changes in economic relationships and the dynamic progression of policy effects in response to significant exogenous shocks, such as the Covid-19 pandemic. The data-driven approach diminishes dependence on existing theoretical frameworks, showcasing significant adaptability in managing new and intricate unconventional monetary policy instruments. Calculating time-varying impulse response functions allows the model to accurately characterize the dynamic effects and their temporal evolution of a singular policy instrument shock or specific transmission channel at a given moment, thereby offering a robust econometric instrument for evaluating the time-varying and heterogeneous characteristics of policy effects.

The TVP-SV-VAR model, while advantageous, presents several notable limitations. The identification of this phenomenon is predominantly based on statistical constraints rather than a robust microeconomic theoretical framework. This reliance can result in ambiguity regarding the interpretation of shocks—such as demand, supply, or policy shocks—and the associated economic mechanisms. Additionally, it encounters the challenge posed by Lucas' critique, which suggests that inferred policy effects derived from historical relationships may lose their efficacy due to fundamental shifts in expectations and policy rules. The model's extensive parameterization, characterized by time-varying parameters and random fluctuations, results in the curse of dimensionality, which in turn leads to increased computational complexity and stringent demands for data quality and length. Variable selection requires careful consideration. The standard assumption that all variables are endogenous may be inadequate when addressing policy instruments that exhibit partial exogeneity, as the model's sensitivity to noise or unmodeled structural breaks in the data can lead to suboptimal outcomes. Consequently, we employed breakpoint detection to resolve this issue.

The TVP-SV-VAR model is deemed appropriate for the primary aim of this section, which is to assess the effectiveness of China's unconventional monetary policy instruments in response to Covid-19 and their transmission mechanisms independently. Covid-19, as a significant and rapidly evolving exogenous shock, is likely to induce substantial and swift alterations in policy transmission mechanisms. The model's capacity to account for time-varying and uncertain factors offers an optimal empirical framework for this analysis. The primary function of generating time-varying impulse responses allows for the accurate isolation and measurement of the distinct dynamic effects of specific unconventional monetary policy instruments or transmission channels on macroeconomic targets during various phases of the pandemic, including the outbreak, containment, and recovery phases. This empirical approach emphasizes the dynamic effects of a single instrument or channel using historical data, aligning with the initial decomposition analysis requirements of this study. It addresses the limitations of structural models in effectively managing non-standard policies and their independent time-varying effects.

### 4.2.1 Construction of the TVP-SV-VAR model

With reference to Primiceri (2005), Nakajima (2011) and Del Negro and Primiceri's (2015) time-varying parameter vector autoregressive model with stochastic fluctuations, TVP-SV-VAR, we focus on shocks to macroeconomic indicators due to unconventional monetary policies. The model is improved by improving the basic SVAR model so that the parameters can vary over time and obey the stochastic wandering. First consider the SVAR model with the basic structure:

$$Ay_t = F_1y_{t-1} + \dots + F_sy_{t-s} + u_t, \quad t = s + 1, \dots, n \quad (4.6)$$

where  $y_t$  is the  $k \times 1$  matrix of  $w$  observable variables,  $A$ ,  $F_1$ ,  $F_s$  are the  $k \times k$  matrix of coefficients,  $u_t$  is a  $k \times 1$ -dimensional structural shock matrix and  $u_t \sim N(0, \Sigma\Sigma)$ , where:

$$\Sigma = \begin{pmatrix} \sigma_1 & 0 & \dots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \dots & 0 & \sigma_k \end{pmatrix} \quad (4.7)$$

$A$  is a lower triangular matrix:

$$A = \begin{pmatrix} 1 & 0 & \dots & 0 \\ \alpha_{21} & \ddots & \ddots & 0 \\ \vdots & \ddots & \ddots & 0 \\ \alpha_{k1} & \dots & \alpha_{k,k-1} & 1 \end{pmatrix} \quad (4.8)$$

Further rewritten as a simplified SVAR model:

$$y_t = B_1 y_{t-1} + \dots + B_s y_{t-s} + A^{-1} \Sigma \varepsilon_t \quad (4.9)$$

where  $\varepsilon_t \sim N(0, I_k)$ ,  $B_i = A^{-1} F_i$ ,  $i = 1, \dots, s$ . Further, the model can be expressed as:

$$y_t = X_t \beta + A^{-1} \Sigma \varepsilon_t, \quad X_t = I_k \otimes (y'_{t-1}, \dots, y'_{t-s}), \quad t = s+1, \dots, n \quad (4.10)$$

All parameters in this model are fixed and do not vary over time.

Next, we further extend the model formulation to a TVP-SV-VAR model with all parameters to be estimated over time:

$$y_t = X_t \beta_t + A_t^{-1} \Sigma_t \varepsilon_t, \quad t = s+1, \dots, n \quad (4.11)$$

where  $\alpha_t$  is the stacking vector of the lower triangular elements of the matrix  $A_t$ , and all time-varying parameters obey a first-order random walk process:

$$\begin{cases} \beta_{t+1} = \beta_t + \mu_{\beta t} \\ \alpha_{t+1} = \alpha_t + \mu_{\alpha t} \\ h_{t+1} = h_t + \mu_{h t} \end{cases} \quad (4.12)$$

$$\begin{pmatrix} \varepsilon_t \\ \mu_{\beta t} \\ \mu_{\alpha t} \\ \mu_{h t} \end{pmatrix} \sim N \begin{pmatrix} I & 0 & 0 & 0 \\ 0 & \Sigma_{\beta} & 0 & 0 \\ 0 & 0 & \Sigma_{\alpha} & 0 \\ 0 & 0 & 0 & \Sigma_h \end{pmatrix} \quad (4.13)$$

where  $h_t = (h_{1t}, \dots, h_{kt})'$ , and  $h_{jt} = \log \sigma_{jt}^2$ ,  $j = 1, \dots, k$ ,  $t = s + 1, \dots, n$  is also satisfied.

For  $t = s + 1, \dots, n$ , we have:

$$\beta_{s+1} \sim N(\mu_{\beta_0}, \Sigma_{\beta_0}), \quad \alpha_{s+1} \sim N(\mu_{\alpha_0}, \Sigma_{\alpha_0}), \quad h_{s+1} \sim N(\mu_{h_0}, \Sigma_{h_0}) \quad (4.14)$$

where  $\Sigma_{\beta}$ ,  $\Sigma_{\alpha}$ ,  $\Sigma_h$  are all diagonal matrix.

## 4.2.2 Variable selection

According to the theory of monetary policy transmission, the central bank through the operation of monetary policy instruments directly causes changes in the operating target, and changes in the operating target are transmitted to the entire financial system through certain channels, causing changes in the intermediary target, which in turn affects macroeconomic operations and achieves the ultimate goal of monetary policy. Therefore, to study the effectiveness of a certain monetary policy instrument, we can study the size of the impact of such monetary policy instruments on the intermediary target and the ultimate goal of monetary policy. Therefore, the selection of variables for the study of the effectiveness of unconventional monetary policy can be

divided into three parts.

The initial step is determining the ultimate target of unconventional monetary policy. Drawing from our analysis of China's monetary policy target system and insights from meetings, reports, and other sources released by the PBOC on Covid-19, we have determined that China's primary goals in addressing the Covid-19 shock are output assurance, price levelling, and exchange rate stabilisation. Hence, we use the output gap, the consumer price index, and the U.S.-China nominal exchange rate (NUSCNY) as equivalent measures for the three ultimate targets.

The second step is the selection of the intermediation target of unconventional monetary policy. Furthermore, we selected the intermediate targets independently for each of the four primary channels. In the context of the credit channel, our analysis of China's monetary policy suggests that the optimal intermediate targets are Total Social Financing (TSF) and M2. Nevertheless, the placement of M2 in this particular problem is very contentious. Within the context of real monetary policy operations, M2 is commonly regarded as one of the monetary instruments. Furthermore, the dissemination of money and liquidity to the market via several policy instruments can also be regarded as a means to enhance the money supply. Hence, we opt to omit M2 from the intermediate target and classify it as one of the instruments of monetary policy. Referring to Yi Gang's statement in November 2013, the 7-day repo rate or Shanghai Interbank Offered Rate (SHIBOR) could become China's new benchmark rate. In March 2015, Yi Gang reiterated his stance on SHIBOR in a press conference at the NPC and CPPCC meetings, arguing that “the possibility of SHIBOR as a benchmark rate is gradually maturing”. Therefore, we set the intermediation target of the interest rate channel as 1-month Shanghai Interbank Offered Rate (SHIBOR). To account for the unique characteristics of the real estate industry in the Chinese

economy, we have selected Real Estate Price (REP), Bond Price (BP), and Stock Price (SP) as intermediate targets for the price channel. Most studies in the foreign exchange channel opt to use the US-China nominal exchange rate as the intermediate target. Given the strong association between stabilising exchange rates and the international trade target as stated by Yi Gang, the current governor of PBOC, we have decided to utilise the US-China real exchange rate as the desired intermediate target. The US-China real exchange rate holds greater intrinsic value as a benchmark for international investors and trading parties to guide their trade decisions, in contrast to the nominal exchange rate. Thus, we employ the nominal exchange rate as the ultimate target and the real exchange rate (RUSCNY) as the intermediate target to emphasise the significance of the foreign exchange channel in the implementation of exchange rate targeting.

In the specified model settings, the method of exchange rate role determination diverges from conventional Western economic research. The prevailing view in Western discourse posits that the real exchange rate is the primary indicator affecting competitiveness and trade growth, and therefore, it should be considered the ultimate target. Given China's distinct economic system, within the framework of its monetary policy, it is posited that designating the nominal interest rate as the primary target and the real interest rate as an intermediate target is fundamentally grounded in institutional logic and practical reasoning. The People's Bank of China establishes policy interest rates, including the MLF rate, as the primary operational target, with modifications directly indicating the central bank's regulatory targets. Governor Yi Gang has indicated that fluctuations in nominal interest rates influence market expectations via official signal transmission mechanisms, with the scale and timing of adjustments directly addressing various ultimate targets, including stabilizing growth and mitigating risks. In crisis responses, such as the 30-basis-point reduction in the

MLF rate during the initial phases of the 2020 pandemic, the main aim is to provide a clear countercyclical regulatory signal to stabilize confidence in the financial system.

The real interest rate theoretically affects trade competitiveness by influencing the real exchange rate and financing costs. However, its role has been redefined as an intermediate target within the context of China's structural transformation for three reasons. The central bank's policy framework asserts that the real interest rate ought to be maintained at a level that is slightly below the real economic growth rate, in order to ensure debt sustainability and maintain policy flexibility. This relationship is influenced by factors including the savings rate and the level of marketization, which are beyond the direct control of the central bank. Financial frictions, including pricing disparities between state-owned and private enterprises, along with external shocks like supply-side inflation, lead to considerable delays and inefficiencies in the transmission of real interest rates to the real economy. This phenomenon highlights the efficiency of policy penetration rather than its ultimate effects. Third, the enhancement of China's trade competitiveness depends on a diversified policy mix, including export tax rebates and industrial chain policies. Additionally, the impact of real interest rates is diminished by exchange rate management instruments, such as counter-cyclical factors, and capital account controls. Pan<sup>25</sup>(2023) also noted that the competitiveness of RMB assets arises from the stability of real interest rates, but its formation mechanism is dependent on expectation management influenced by nominal interest rates, rather than through active adjustments of real interest rates.

Adjustments to nominal interest rates directly reflect the effectiveness of policy, which is the ultimate goal, while changes in real interest rates act as an intermediate indicator for assessing policy impact on the real economy. The allocation of roles within

<sup>25</sup> Pan Gongsheng, Director-General of the State Administration of Foreign Exchange of China.

the PBOC's multi-target framework corresponds to the distinct features of China's transmission mechanism amid its transitional phase.

Current research examining monetary policy through the TVP-SV-VAR model generally adheres to a framework that encompasses a direct analysis of the response of policy instruments to final objectives, alongside a descriptive analysis of time-varying attributes. While these studies employ the TVP-SV-VAR model to account for parameter time-varyingness, they do not elucidate the mechanisms of policy transmission, offering only statistical correlations instead of causal explanations.

This section builds on the conventional framework by incorporating tests for the mediating effects of transmission channels, establishing a three-stage analytical chain. Initially, we examine the efficacy of unconventional monetary policy instruments through conventional methodologies. Also we analyze the PBOC's current monetary policy framework by decomposing the transmission mechanism into four categories of mediating variables. This approach facilitates an examination of the time-varying characteristics of each channel's contribution while testing the mediating effects.

As a conclusion, the last step is determining the operational targets of unconventional monetary policy. Based on our discussion of the independent instruments of unconventional monetary policy in China, we choose Standing Lending Facility (SLF), Medium Term Lending Facility (MLF), Targeted Lending (TL), and Foreign Exchange Management Index (FEMI) as unconventional monetary policy instrument variables.

All of the above data, except for the output gap and EMI, are from the CEIC database, and the original data sources are the National Bureau of Statistics of China and PBOC. The processes of calculating the Output Gap and FEMI are described below.

### 4.2.3 Data preprocessing

Neither of the frequencies of the variables we have chosen coincide. In the majority of research, the output gap is computed on a quarterly or even annual basis. The reason for this is that the investment indicators used to compute the output gap are published on a quarterly basis, but national labour force metrics are published annually and provincial labour force statistics are published quarterly by provincial statistical agencies. In contrast, the China Financial Supervisory Authority (CFSA) and the Shanghai Stock Exchange and Shenzhen Stock Exchange publish monthly data on real estate price, bond price, and stock price. Theoretically, we can use the mixed-frequency data to construct a TVP-SV-VAR model. However, given the swift effect of Covid-19 on China's economic period, quarterly statistics, being long-term, may not precisely represent the reactions of variables to shocks and offer more immediate guidance to researchers and policy makers. Consequently, we have not only computed China's output gap but also monthlyised it in the subsequent analysis.

#### 1) Calculation of quarterly output gap

At present, there exist two primary categories of widely used techniques for measuring output gaps: the Production Function Approach and the Detrending Procedure. The Production Function Approach is supported by economic growth theory and systematically examines the economic function in relation to the theory, which is characterised by robust theory and logic. The Detrending Procedure, albeit lacking robust economic theory, has emerged as the predominant and expeditious iterative approach for measuring output gaps, mostly because of its varied entry angles. Among these methods, the HP filtering technique is extensively employed by other researchers in the entire field of output gaps. We opt for the Production Function Approach as the statistical method to quantify China's production gap.

The fundamental concept of the Production Function Approach is comprised of two primary components: the assessment of the total production function and the measurement of labour force statistics. To determine the total production function, it is necessary to first estimate the beginning capital stock. Subsequently, the capital stock at each stage should be determined using the perpetual inventory approach. To quantify labour data, we apply the HP filtering technique to determine the prospective employment participation rate and potential employment by considering the economically active population and the number of employed individuals. Once the labour data is acquired, a regression analysis is conducted using the provided equation, and the total factor productivity is obtained as the residual. Following HP filtering, the trend of total factor productivity is captured. Ultimately, by substituting the known capital stock, trend total factor productivity, and potential employment into the original equation, an estimate of potential production may be obtained. This estimate additionally enables the evaluation of the output gap. The data used spans from 1995 to 2022, processed quarterly. The investment-related statistics are sourced from the National Bureau of Statistics of China, while the labor-related data are derived from the aggregated data published by the province statistical bureaus. The reason for selecting 1995 as the reference period is based on the recommendations of several Chinese researchers (Zhuo, 2009; Chen, 2015; Kuang, 2019) for determining the depreciation rate. Therefore, we have decided to adopt the same base period as they use.

We choose to measure the production function in the Cobb-Douglas form.

$$Y_t = AK_t^\alpha L_t^\beta \quad (4.15)$$

where  $Y_t$  is real output,  $A$  is the rate of technological growth,  $K_t$  is real capital input,  $L_t$  is labour input,  $\alpha$  and  $\beta$  are the elasticity of capital and the elasticity of labour,

respectively. Simultaneous logarithms on both sides of the equation can be obtained:

$$\ln(Y_t) = \ln(A) + \alpha \ln(K_t) + \beta \ln(L_t) \quad (4.16)$$

Assuming that the returns to scale are constant, i.e.,  $\alpha + \beta = 1$  satisfied, the following equation is satisfied:

$$\ln(Y_t/L_t) = \ln(A) + \alpha \ln(K_t/L_t) + \varepsilon_t \quad (4.17)$$

where the residual term  $\varepsilon_t$  is the total factor productivity (TFP). We use the OLS model for estimation, which yields the basic equation for the capital stock:

$$K_t = I_t/p_t + (1 - \delta_t)K_{t-1} \quad (4.18)$$

where  $K_t$  and  $K_{t-1}$  are the real capital stock in years  $t$  and  $t-1$ , respectively.  $I_t$  is the nominal investment in year  $t$ ,  $p_t$  is the price index for investment in fixed assets used for deflating, and  $\delta_t$  is the depreciation rate in year  $t$ . And to calculate the capital stock for each year, the capital stock for the base year must first be calculated. According to the perpetual inventory method, the capital stock of the base period will be depreciated out in the year  $1/\delta$ . Therefore, based on the nominal investment, growth rate and depreciation rate in 1995, the capital stock in 1995 can be found:

$$K_t = \frac{I_t/p_t}{g+\delta} \quad (4.19)$$

where  $g$  is the nominal investment growth rate in the base period. For the depreciation rate of fixed assets  $\delta$ , with reference to most of the existing studies, we choose to set it at 5%. The results of the real capital stock measurements are shown in Figure 4.6.

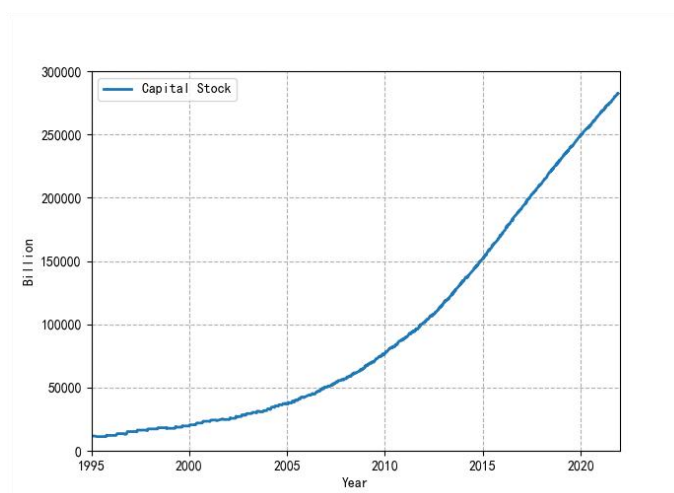


Figure 4.6 : Capital Stock

After obtaining an estimate of the real capital stock, total factor productivity can be obtained by estimating Equation 4.2.3 using the least squares (OLS) method. Subsequently, trend total factor productivity can be obtained by HP filtering. The curve of total factor productivity and trend total factor productivity is shown in Figure 4.7.

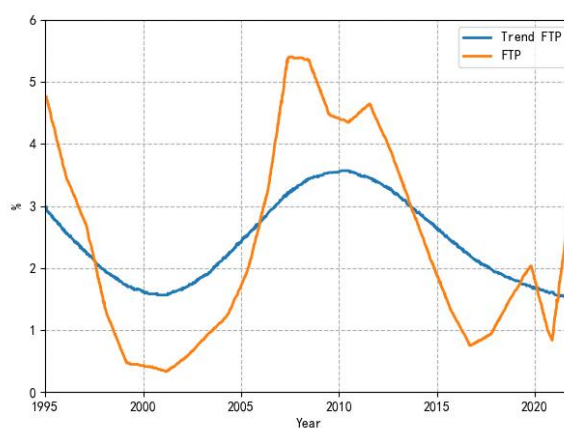


Figure 4.7: FTP and Trend FTP

Then, potential employment  $L_t$ , also known as full employment, is the level of employment obtained when a country's economy grows to a potential output and can be expressed as:

$$L_t = LS_t \times Tr_t \times (1 - NAWRU_t) \quad (4.20)$$

where  $LS_t$  is the number of persons of working age,  $Tr_t$  is the trend participation rate, and  $NAWRU_t$  is non-wage-induced unemployment. We chose to use the HP-filtered trend value of the ratio of the economically active population to the total population as a proxy for the trend participation rate. As for the HP-filtered trend value for non-wage-induced unemployment, we define it as 1 minus Ratio of employment to economically active population. The resulting trend in potential employment is shown in Figure 4.8.

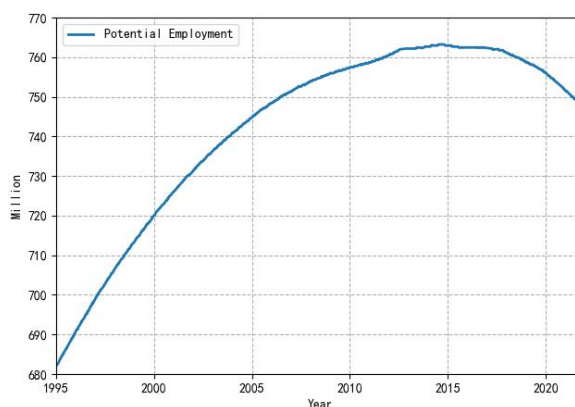


Figure 4.8: Potential employment

Finally, by substituting the measures of real capital stock, potential employment, and trend total factor productivity into Equation 4.2.3, the quarterly output gap measure under the Production Function Approach can be obtained. Considering the data period we use for the subsequent empirical study, Figure 4.9 gives the trend of the quarterly output gap from the first quarter of 2015 to the fourth quarter of 2022.

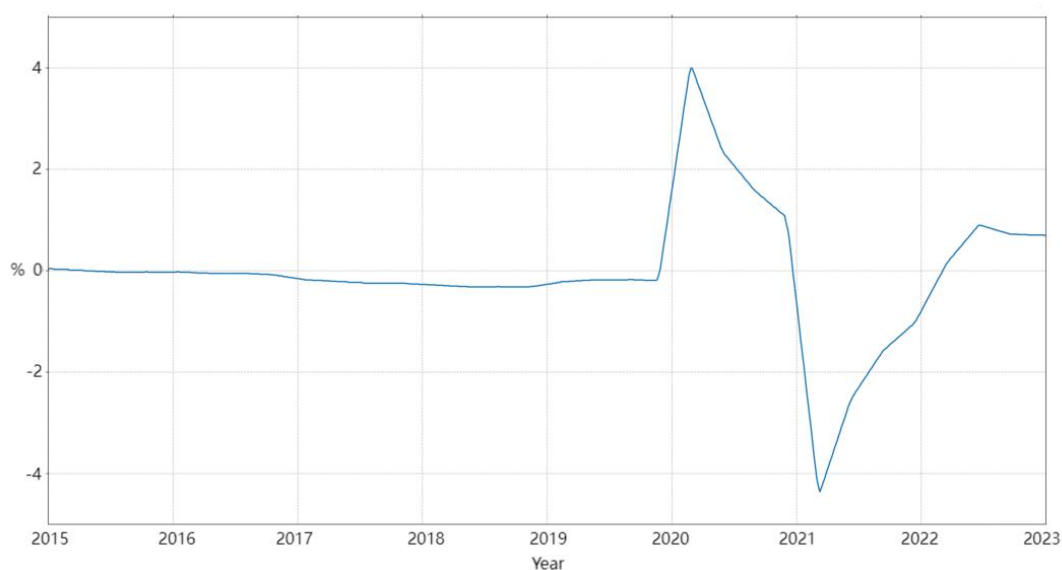


Figure 4.9: Quarterly Output Gap

It is evident that the output gap grew right after the Covid-19 outbreak, indicating that the virus had a particularly negative short-term effect on the Chinese economy. But within a quarter, the output difference begins to close quickly, returning to the previous level of excess output in 2021. This is in line with our previous analysis of the Covid-19 shock, which showed that the labor supply rapidly recovered and that the Chinese economy started to recover rapidly. This is a really useful follow-up discussion of which unorthodox monetary policy methods have had a commensurate effect.

One issue to consider is the relevance of the output gap calculated using the HP filter method during the significant outbreak of Covid-19, when China's economy experienced substantial supply-side disruptions. Hamilton (2017) discusses a related issue in systemic questioning, indicating that temporary shocks may be misclassified as trend components or lead to end-of-sample bias. Nonetheless, it is posited that, despite these limitations, the HP filter method retains significance as a baseline description. The method provides a transparent and reproducible approach for distinguishing between trends and cycles, serving as a widely recognized benchmark in empirical research and

policy institutions, including the ECB<sup>26</sup>. China exhibited rapid recovery and rebound characteristics in the early stages of the Covid-19 outbreak. During the pandemic shock period, we interpret the output gap, derived from filtering, as a short-term deviation of actual output from its pre-pandemic trend, reflecting a combination of supply and demand shocks. Furthermore, as discussed in Chapter 3 regarding the decomposition and analysis of the pandemic shock, these external indicators predominantly signify supply constraints, such as disruptions in manufacturing supply chains and significant reductions in tourism and on-site service sector output. The output gap obtained from the HP filter method should be understood as a cyclical demand gap that can be recovered. Despite the technical limitations of the HP filter method during significant, temporary shocks, and given that the output gap in this chapter is mainly utilized to examine the dynamic effectiveness of unconventional monetary policy instruments rather than its absolute value, the results remain valuable.

Furthermore, if a certain kind of unconventional monetary policy instrument has an optimizing influence on the output gap, the output gap should actually reduce when the target of output gap optimization will be investigated in the subsequent TVP-SV-VAR model analysis. We choose to treat the output gap negatively in the future treatment of the output gap in order to more naturally reflect the optimization effect in the impulse response analysis that follows. In other words, a positive change in the output gap indicates optimization, but a negative change indicates deterioration in the discussion that follows.

## **2) Estimating the monthly output gap**

Theoretically, we could directly use interpolation or averaging to translate the output gap into monthly data. However, as discussed earlier, the Covid-19 shock to the Chinese

<sup>26</sup> ECB, The impact of Covid-19 on potential output in the euro area, 07/2020.

economy manifested itself very quickly, and China recovered relatively quickly from its response measures. Therefore, we need to estimate the monthly output gap data as precise as possible to ensure that the results obtained are consistent with the actual situation.

Numerous estimating methods, including moving average, exponential smoothing, linear regression, grey forecasting, artificial neural networks, support vector machines, and others, are available, according to statistics. Any single forecasting technique, however, requires some assumptions about the projected object and its surroundings, and whether the environment changes gradually or quickly, the single model's predictive ability deteriorates significantly. Furthermore, the resultant best model could alter even if the environment in which the data is forecasted does not change much but only slightly. Given the advancements in statistical computing techniques and software technology, researchers have increasingly focused on improving the reliability and precision of model estimation. They have proposed several integrated approaches to increase the efficiency of model estimation and prediction accuracy. Among these methods, the model averaging method has gained significant attention.

Individual estimating models are contrasted with combinatorial estimating. In essence, model averaging is the process of applying various weights to the output of a chosen individual model in order to generate a new single estimation. Or, to put it another way, a non-linear or linear average of the output of the chosen individual estimations in order to produce a model that is adaptive to the data analysis environment.

However, the validity and precision of the data are just as crucial a need for prediction accuracy as the model's quality. The improper data will prevent a good model from producing accurate and realistic forecasts. So, in order to apply model averaging for a

specific set of data, we must guarantee both the accuracy of the data and the model's optimisation.

### **a) Limitation of traditional estimating method**

The effects of Covid-19 are still being felt worldwide, and this globalised epidemic has had an especially severe economic impact. The issues presented by Covid-19, such as a lack of data and significant oscillations, have also been experienced by economics, one of the most frequently employed forecasting disciplines. Some of the fundamental data, such as GDP, are released quarterly in the databases maintained by the statistical offices of many countries. Covid-19 was first positively recognised by humans and its effects were first felt in the economy of mainland China in January 2020. This also has the effect of making it clear that many of the data for the first quarter of 2020 will deviate from the trend of earlier periods. At the same time, the Chinese National Bureau of Statistics would not have had to disclose some of the data in January or February of every year if the Chinese New Year, a significant aspect of Chinese culture, had not been present. As a result, there are gaps in and anomalies in some Chinese economic data for the first quarter of 2020, which significantly restricts the application of popular seasonal modelling techniques such as X-12 ARIMA.

The effects of Covid-19, a public health black swan event, go far beyond the global epidemics that peak in 2020 and do not start to fade until mid- to late-2022. The data issues that China faces extended into 2022. For instance, the first quarter should see a significant increase in passenger and logistics numbers because Chinese New Year is traditionally seen as a time to spend with family. However, many people in 2021 adhered to the Chinese government's directive to "spend the New Year locally" and did not celebrate Chinese New Year with their relatives who were in other provinces or cities. Any model that adds 2020 to 2022 into the data period may become distorted as

a result of this extraordinary occurrence and the fact that data for the month is not published in the first place.

In this scenario, instead of using the usual seasonal simulations, we think that data can be gathered from other publically accessible data sources to fill in the gaps using predictions from machine learning models. Regarding the choice of data sources, we think the internet is a good source of high frequency data and is fairly indicative of the actual experiences and views of residents.

#### **b) Dataset for model averaging considering social media information**

Therefore, we develop a new internet data collection method, then use model averaging to create an optimised model to estimate output gap indicators. In brief, we integrate monthly output gap data with pertinent information sourced from internet social media. We then selected a number of monthly indicators related to the output gap to be used in conjunction with the social media indicators to translate the calculated quarterly output gap into monthly estimates. The selected indicators and the corresponding rationale are presented in Table 4.4. All data were obtained from the China National Bureau of Statistics, CEIC and Wind.

Table 4.4: Other indicators to estimate monthly output gaps

Indicator	Designator	Reason
Consumer confidence index	CCI	CCI reflects consumers' expectations about the future state of the economy and is usually a forward-looking indicator of consumer spending and economic activity. When CCI falls, consumer spending decreases, which in turn leads to a decline in real output and a widening of the output gap. When CCI rises, consumption and economic activity strengthen and the output gap is likely to narrow.
Purchasing managers index	PMI	PMI is a measure of activity in the manufacturing and service sectors, reflecting changes in economic activity such as production, orders, employment, etc. PMI provides an immediate insight into economic activity. Typically, a rising PMI means that economic activity is strengthening, real output is growing, and the output gap is narrowing or positive. A falling PMI implies a contraction in economic activity and a widening of the output gap.
Business inventory	BI	Business inventory reflect the amount of unsold goods held in reserve by firms, can be considered as an indicator of the balance between demand and supply. When business inventory increases too fast, it may indicate a lack of demand and a backlog of products by firms, resulting in actual output falling below potential output and a widening of the output gap. A significant reduction in inventory may indicate strong demand, increased output and a narrowing of the output gap.
Government spending	GS	Government spending is an important factor affecting economic output, especially during economic downturns. When government spending increases, it usually boosts economic activity, real output increases and the output gap narrows. Cuts in government spending

Indicator	Designator	Reason
		may lead to a slowdown in economic activity and a widening of the output gap.
Industrial production index	IPI	Industrial production is an important component of the real output of the economy, while the IPI measures changes in the output of the industrial sector and is often used as a leading indicator of economic activity. Therefore, changes of IPI usually provide a direct reflection of the widening or narrowing of the output gap.

For the social media information, we chose to use 2010 as the base year. Because China's representative social media platform, Sina Weibo (Sina Microblog), only became operational in 2008 and replaced blogs as the social media platform with the highest market share in China only in 2010. As in the previous section, our data period ends in December 2022

As described earlier for the calculation of the quarterly output gap, we should choose to extract and analyse information related to both employment and capital stock embedded in social media. However, the information posted by the public in social media is usually routine, colloquial and unprofessional, does not involve much discussion of the capital stock. Therefore, we focus on extracting employment-related information. Reference to the Chinese Social Media Dictionary published by Tsinghua University and China Knowledge Internet (CNKI), we selected the following keywords as the basis for filtering relevant texts, as Table 4.5 shown.

Table 4.5: Keywords related to employment

Translation in EN	Keyword in Chinese
Looking for a job	找工作, 寻职, 找活干, 求职, 应聘, 介绍工作
Lose current job	炒鱿鱼, 被裁, 失业, 裁员, 丢了工作

The texts screened by keywords were further cleaned. Possible employment agencies as well as advertising messages were removed by setting a repetition rate criterion to exclude highly similar advertising texts. As a result, we obtained the number of expressions of the population about the need for employment and job losses. This series is a time series, with a frequency of months, expressing changes in the employment gap as perceived by the public, which we express as SMEI (Social Media Employment Information). Finally, we obtain a mixed-frequency dataset containing the computed quarterly output gap, as well as the monthly CCI, PMI, BI, GS, IPI, and SMEI.

### c) Model averaging

Bates & Granger's (1969) groundbreaking article "The combination of forecasts" appeared in the *Operations Research Quarterly*. They showed that the mean square error of a combined forecasting model is smaller than that of any of the individual models being combined, and so the study of model averaging took off. However, some scholars argue that the study of model averaging started earlier because the idea of model averaging was already used in the literature, but the concept of model averaging was not explicitly introduced. Clemen (1989), in a review of the literature, corrects the fact that the literature of Bates & Granger (1969) is often considered to be seminal. But in fact, slightly earlier, Crane & Crotty (1967) had already used the regression-combination forecasting technique. Zarnowitz (1967) reviewed several forecasting methods, and commented on the superiority of averaging the results for data analysis. Nonetheless, the literature of Bates & Granger (1969) was the impetus for the development of model averaging theory, and a wave of research on model averaging

was initiated by scholars such as Clemen (1986, 1989), Dickinson (1973, 1975) and Bunn (1975, 1977). In 1975, Bunn pointed out that model averaging maximises the use of data information by combining all the information contained in a single model, and Bopp (1985) again discussed the motivation for model averaging. The results of Newbold & Granger (1974), Makridakis & Winlker (1983) and others have also shown that model averaging outperforms single-model forecasting. In 1989, the *Journal of Forecasting*, the leading international journal on forecasting, published a special issue on model averaging, which not only illustrated the importance of model averaging in forecasting, but also pushed the research on model averaging to a new stage and rose to a new starting point. At the end of the 20th century, the research results of model averaging in the field of economic management were already very rich.

Yang (2013) established adaptive model averaging estimates from an information-theoretic perspective, such as the AFTER, ARM method, in which each individual model is related to the distribution of the data, and then the convex combination weight coefficients for model averaging are determined based on the joint distribution. The advantage of this modelling approach is that it allows the results of model averaging to approximate the optimal model being combined with the fastest convergence rate. In model averaging, the prior information of each individual model is considered from a Bayesian perspective, so the Bayesian model averaging approach (BMA) is a natural approach, see Hoeting (1999) for a review of the results. When the set of alternative single models is large, as in the case of all subregression models, the prior probability for each predictive model directly affects the Bayesian model estimate, and the prior probability determines to some extent the importance of a model in the average estimate, hence BMA is very sensitive to the prior probability. Therefore, if the alternative set of individual models are all reasonable models, BMA can provide a valid average estimate. In contrast to the Bayesian viewpoint, the frequency school of

thought, from which model averaging is built, is known as frequency model averaging, and is represented by studies such as Hjort & Claeskens (2003), Liang et al. (2011).

Rapach & Strauss et al. (2009) showed that a large number of regression combinations of single models gave poor results. Therefore, single model selection is of great importance in portfolio estimation. Single model selection refers to the screening or filtering of models prior to model averaging, hence the term model filtering.

Hereby, model averaging is a popular method for resolving model selection uncertainty and is one of the most important ways to improve forecasting. The two steps necessary to establish a model averaging method are: firstly, to select a single model set; and secondly, to optimise the weighting coefficients.

#### **i) Criteria for selecting single models**

All models are incorrect, but some are helpful, as stated by Box (1976). In model selection and analysis, our task is to choose among a large number of incorrect models the model that best reveals the pattern of the data. When performing theoretical research, it is typical to make some ideal model assumptions, like using a normal linear model when there are actually a number of other models that may be used instead. The set of other models may include the real model, assuming that the genuine model has finite dimensions. The set of alternative models is unlikely to include the genuine model, though, if the true model has infinite dimensions. Therefore, before choosing a model, we must confirm the standards for evaluating model selection. In general, we select the consistency criterion and asymptotic validity criterion.

Asymptotically effective criterion: If a model selection criterion can asymptotically select the model with the smallest mean square error, then it is called an

asymptotically effective selection criterion.

Consistency criterion: If a model selection criterion can select the true model with probability 1 asymptotically, then it is called a selection criterion with consistency.

Linear regression models are the basis of statistical modelling and this section describes the model selection criteria commonly used in linear regression analysis. Assuming that the model generating the data is  $g(y)$ .  $p$  is the number of independent variables, and the modelling approach is  $f(y|\theta)$ .  $p^*$  is the number of factors in the alternative model, and the set of all alternative modelling methods can be expressed as:

$$C(p^*) = \{f(y|\theta_{p^*}) | \theta_{p^*} \in \theta(p^*), \quad p^* \leq (p + 1)\} \quad (4.21)$$

Assuming the corresponding regression model of  $f(y|\theta)$ :

$$y = X\beta + \epsilon, \quad \epsilon \sim N_n(0, \sigma^2 I) \quad (4.22)$$

where  $y$  is an  $n \times 1$  dimensional vector of observations.  $\epsilon$  is the  $n \times 1$ -dimensional error vector.  $X$  is the  $n \times p$ -dimensional full-rank design array.

The model selection criterion is a measure to evaluate the relationship between the goodness of fit and the complexity of a model, generally a smaller criterion value corresponds to a better performing model, and the model with the smallest information criterion value among the alternative models is called the "optimal model". The most widely used are the AIC (Akaike information criterion) and BIC (Bayesian information criterion) model selection criteria. There are also some other information criteria such as AICc (modified AIC), TIC (Takeuchi information criterion),  $C_p$  (Mallows' conceptual predictive statistic), PRESS (the predictive sum of squares statistics), MDI (minimum description length), are used in model comparison analysis.

For the fitted model  $f(y|\hat{\theta}_{p^*})$ ,  $p^*$  is the number of parameters in the model. Then, in a

regression model containing  $p^*$  factors, there are  $\binom{n}{p^*}$  numbers of possible models, denoted as  $(y|\hat{\theta}_{p^*})$ . Then AIC and BIC can be defined as follows:

$$AIC_{p^*} = -2f(y|\hat{\theta}_{p^*}) + 2p^* \quad (4.23)$$

$$BIC_{p^*} = -2f(y|\hat{\theta}_{p^*}) + \ln(n)p^* \quad (4.24)$$

Where  $f(y|\hat{\theta}_{p^*})$  represents the likelihood function (or goodness of fit). As the complexity of the model  $p^*$  increases, the fit or approximation error to the data becomes smaller and therefore the goodness of fit becomes smaller, but the penalty term  $2p^*$  and  $\ln(n)p^*$  will become larger. The choice of the optimal model for AIC and BIC is therefore a search for a balance between goodness of fit and model complexity that minimises the value of the criterion.

The advantages of AIC are: firstly, there is no need to assume that the model to be compared contains the 'real model' or the 'correct model'; secondly, AIC can be used to compare non-embedded models; thirdly, AIC can compare models that follow different distributions. However, the use of AIC has some drawbacks: firstly, when there are many alternative models, the AIC values of some models may be very close to each other, which means that the "optimal model" is ambiguous; secondly, the application of AIC requires large samples, especially for complex models. Shibata (1980, 1981) showed that AIC is asymptotically valid, but is not a consistent estimate. BIC is a strong competitor to AIC in that it selects the model with the highest posterior probability in a large sample, and its choice depends on the data being modelled. BIC also has the second and third advantages of AIC, as well as its disadvantages. However, BIC selects the true model with probability 1, so it must be assumed that the true model belongs to the set of alternative models. BIC and AIC do not have the same goodness of fit because  $\ln(n) > 2$  when  $n > 8$ , so BIC has a larger penalty than AIC and

prefers a model with less complexity to AIC. Given that the dataset we use has 6 indicators, the BIC criterion are more suitable to be used for model selection. The first 3 optimal combinations of variables selected based on the BIC criterion are given as Table 4.6.

Table 4.6: Variables selection

Variables Name	BIC
CCI, PMI, BI, GS, IPI, SMEI	19.83860255
CCI, PMI, GS, IPI, SMEI	18.44168972
PMI, BI, GS, IPI, SMEI	18.01891236

## ii) Criteria for selecting weights for model averaging

For the selection criteria of the weights in the model average, we chose to use the Jackknife criterion proposed by Hansen (2012). The main feature of this method is that it includes the case of heteroskedasticity  $\Omega = \text{diag}(\sigma_1^2, \dots, \sigma_n^2)$ . The Jackknife criterion can be expressed as follows:

$$J_m(w) = w' \hat{e}' \hat{e} w \quad (4.25)$$

Of which:

$\hat{e} = (\hat{e}_1, \dots, \hat{e}_p)$ ,  $\hat{e}_p = y - \hat{\mu}_{(p)}$ .  $\hat{\mu}_{(p)} = [D_{(p)}(P_{(p)} - I_n) + I_n]y$ .  $D_{(p)}$  is a diagonal matrix whose i-th diagonal element is  $(1 - h_{(p)ii})^{-1}$ , and  $h_{(p)ii}$  is the i-th diagonal element of  $P_{(p)}$ . Then:

$$\hat{w}_J = \text{argmin}_{w \in H_n} J_n(w) \quad (4.26)$$

The main rationale for using JMA estimation is that it is asymptotically optimal under certain reasonable conditions, and this optimality holds when the random error term is heteroscedastic or even serially correlated.

## iii) Model averaging result

We chose 6 frequently employed individual prediction approaches to conduct our model

averaging analysis. The chosen models consist of the Back Propagation (BP) neural network model, Random Forest (RF) model, Radial Basis Function (RBF) network model, Convolutional neural network (CNN) model, Long-Short Term Memory (LSTM) model, and LIBSVM. Figures 4.10 and 4.11 depict the result of estimating using an individual model and the benefit of estimation produced using model averaging, respectively.

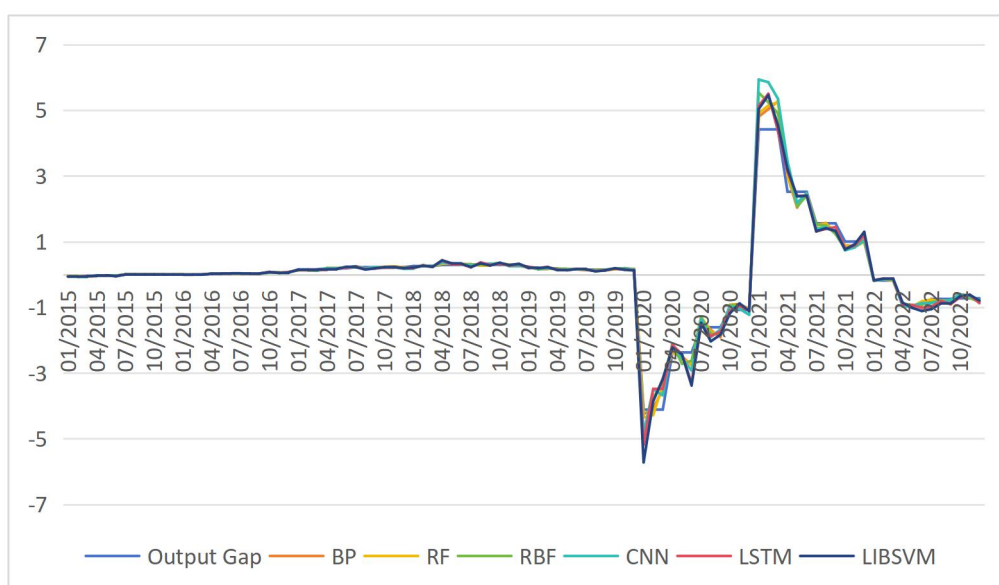


Figure 4.10: Estimation from individual models

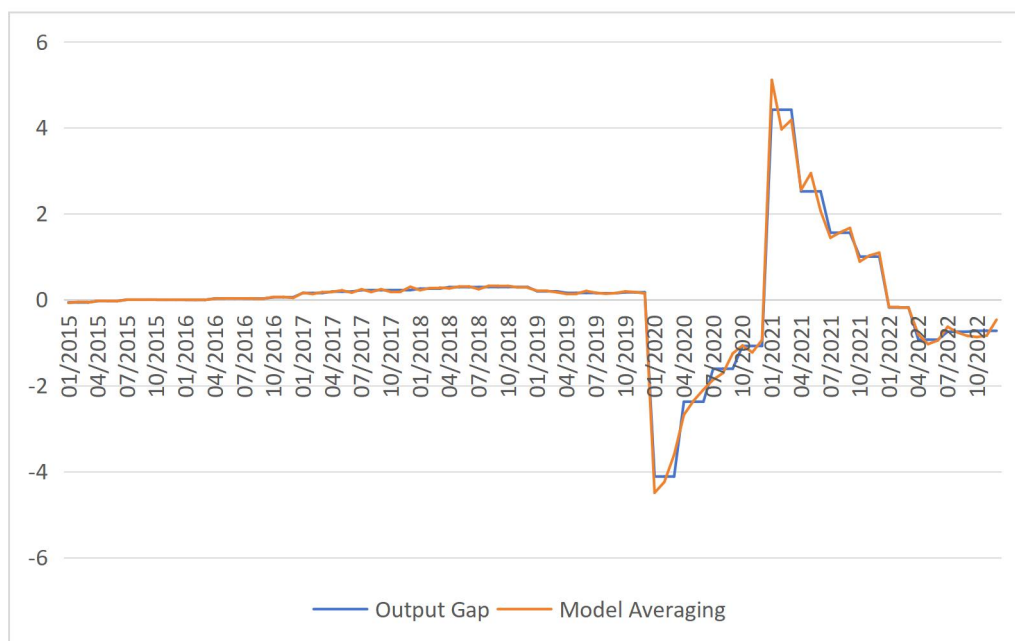


Figure 4.11: Estimation after model averaging

Table 4.7 illustrates the weights assigned to each model in the model average.

Table 4.7: Weight distribution of model averaging

Model	MSE	Weight
BP	0.088600112	0.077765034
RF	0.012494022	0.553806507
RBF	0.065897971	0.097839439
CNN	0.053668095	0.116943276
LSTM	0.166681303	0.039881545
LIBSVM	0.059247394	0.113764199

It is evident that the Random Forest algorithm makes the largest contribution to the measuring of the monthly output gap, with Convolutional Neural Networks and LibSVM following closely behind. We believe the model averaging technique is in fact more ideal for assessing the accuracy of the monthly output gap, given that the RF algorithm, which makes the largest contribution, only takes up roughly 55% of the total. That is, Model averaging yields results that are more valuable than those obtained through the Random Forest algorithm, the most prominent independent estimation method.

#### 4.2.4 Impulse Response Analysis of unconventional monetary policy

After obtaining the required dataset, we logarithmised the data in it based on the magnitude of data, including M2, Real Estate Prices, Stock Prices, Bond Prices, Total Social Financing, Targeted Lending, SLF, and MLF. among them, the targeted lending and SLF because of the existence of 0 values, so we added 1 to all the values and then took the natural logarithm of them. Table 4.8 illustrates the descriptive statistics of the indicators that were applied.

Table 4.8: Descriptive statistics

	<b>OUTPUTGAP</b>	<b>CPI</b>	<b>NUSCNY</b>	<b>LN2</b>	<b>LNTSL</b>	<b>SHIBOR</b>	<b>LNREP</b>
Mean	0.008690444	0.157291667	6.657765625	12.12664768	7.523464964	2.935851	9.069278788
Median	0.096555945	0.1	6.6559	12.12607432	7.516583384	2.768750	9.09372199
Maximum	5.109996157	1.6	7.1769	12.49287465	8.7284099	5.083300	9.308332223
Minimum	-4.494697852	-1.2	6.1136	11.73022012	6.171940673	1.314000	8.792759777
Std. Dev.	1.364019906	0.510674434	0.28061554	0.211800544	0.54398025	0.825453	0.13954337
Observations	96	96	96	96	96	96	96
	<b>LN2P</b>	<b>LN2B</b>	<b>RUSCNY</b>	<b>LN2LF</b>	<b>LN2MLF</b>	<b>LN2TL</b>	<b>FEMI</b>
Mean	8.110627773	5.142131186	7.978083187	7.513269273	14.94897495	0.754500704	39.7222114
Median	8.110370051	5.138260958	8.001216996	9.145538944	15.24437802	0	38.3584727
Maximum	8.482421606	5.291141683	10.0131659	12.0435596	15.50190951	2.984563524	86.4880949
Minimum	7.867634096	4.988185165	6.668712558	0	12.84792653	0	0.9845337
Std. Dev.	0.106467717	0.087435268	0.711286176	3.775797749	0.685086919	1.011445442	24.9218757
Observations	96	96	96	96	96	96	96

### 1) Unit root test and ADF test

The establishment of TVP-SV-VAR model requires that all the time series are smooth, i.e., the mean, variance and self-covariance of the time series do not depend on the time  $t$ . There are many methods to test whether the time series are smooth, and we chose the AR root test to test the smoothness of the time series. The test results are shown in Figure 4.12, all autoregressive (AR) eigenvalues reside within the unit circle, demonstrating that the TVP-SV-VAR system meets the stability condition. This implies that the model's impulse response function exhibits exponential decay over time instead of divergence, thereby confirming that the impact effect is transient and that the model structure is statistically robust.

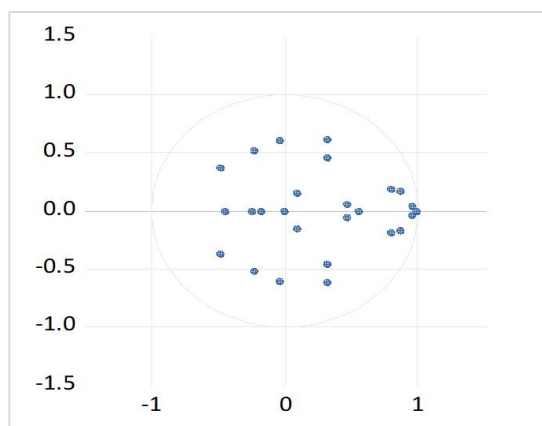


Figure 4.12: AR root test

In addition, we also performed an ADF test to confirm the stationary of the series. The result is shown in Table 4.9.

Table 4.9: ADF test for TVP-SV-VAR model

Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob. **	Cross-section s	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu $t^*$	-1.25976	0.0038	14	1309
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-4.20387	0.0000	14	1309
ADF - Fisher Chi-square	100.703	0.0000	14	1309
PP - Fisher Chi-square	145.318	0.0000	14	

\*\* Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution.

All other tests assume asymptotic normality.

The results demonstrate that the time series we created satisfies the requirements of VAR-like models since both the AR root test and the ADF test were passed.

## **2) Bai-Perron structural break test**

As the results of our analysis of the Covid-19 shock using the CGE model show, the impact of Covid-19 on China's economy is all-encompassing, and we need to determine whether the system of influence of the four monetary policy instruments, SLF, MLF, TL and FEMI, on China's economy has been disrupted to ensure that we can accurately compare the effectiveness of these three instruments before and after the epidemic. Therefore, we need to conduct a structural break test (Bai-Perron test, or called Multiple break test).

Table 4.10: Break point test result

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Current breakpoint calculations:

Multiple breakpoint tests

Bai-Perron tests of L+1 vs. L sequentially determined breaks

Included observations: 96

Breaking variable... LNSLF LNMLF LNTLF FEMI

Break test options: Trimming 0.15, Max. breaks 5, Sig. level 0.05

---

Sequential F-statistic determined breaks:			1
Break Test	F-statistic	Scaled F-statistic	Critical Value**
0 vs. 1 *	21.59408	64.78224	13.98
1 vs. 2	1.631197	4.893592	15.72

---

Significant at the 0.05 level.

\*\* Bai/Perron (Econometric Journal, 2003) critical values.

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Break dates:

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	Sequential	Repartition
1	2021M02	2021M02

---

The results of the test are shown in Table 4.10. Upon testing, a singular breakpoint was identified inside our chosen timeframe, happening in February 2021, at the 95 percent confidence level. During the apex of the Covid-19 outbreak, specifically from January to March 2020, there was no substantial alteration in the interplay between macroeconomic and monetary policy in China.

### 3) Impulse Response Analysis

In practice, because the vector autoregressive model is a non-theoretical model, it does

not need to make any a priori constraints on the variables. Therefore, when analyzing the vector autoregressive model, instead of analyzing how a change in one variable affects another variable, the dynamic impact on the system is analyzed when an error term changes, or when the model is subject to some kind of shock. This method of analysis is called the impulse response function method (IRF).

Prior to performing an IRF analysis with the TVP-SV-VAR model, it is essential to identify various time points that correspond to different economic cycles necessitating differentiation. This section selects  $t=13$  (January 2016) to illustrate the period of intensified interest rate liberalization and the examination of structural instruments. In October 2015, the People's Bank of China removed the cap on deposit interest rates, thereby achieving nominal interest rate liberalization. In January 2016, MLF operations were established as routine, and the Macro Prudential Assessment (MPA) was implemented for the first time, indicating a transition in the policy framework from a quantity-driven approach to a hybrid of interest rate corridors and structural instruments. This time point represents the initial phase of PSL expansion and MLF serving as the foundation for medium-term policy interest rates.

$t=37$  signifies the culmination of financial deleveraging and the shift towards unconventional monetary policy. In 2017, the draft Asset Management Regulations were published, and in January 2018, the new regulations regarding commercial bank equity pledges were officially enacted, resulting in a significant return of non-standard assets to the balance sheet. The PBOC simultaneously introduced targeted instruments, including the targeted RRR cut for inclusive finance initiated in September 2017, to mitigate the credit contraction resulting from deleveraging. This phase emphasized the transition in structural instruments from remedying deficiencies (special PSL for slum renovation) to mitigating risks (enhancing liquidity

support for small and medium-sized banks).

t=67 denotes the phase of reconstructing the Covid-19 crisis response and policy framework. By June 2020, the anti-epidemic re-lending quota had been predominantly allocated, and from July onwards, the policy emphasis transitioned to instruments directly aimed at the real economy, such as the inclusive small and micro enterprise loan deferral support instrument. This timing aligned with the inflection point of the economic V-shaped rebound, as GDP growth shifted from -6.8% to 3.2% in the second quarter. This marked the PBOC's transition from emergency easing to a new phase of moderate aggregate policy with a structural emphasis. Therefore, this period is essential for assessing unconventional monetary policy.

Our impulse response results and analysis for each model are shown below.

#### **a) Target-Oriented Analysis**

##### **i) Output Gap target**

Prior to analyzing the impulse response results, it is essential to examine the parameter estimates to confirm MCMC convergence and to verify that the confidence intervals and power factors satisfy the necessary criteria. Table 4.11 presents the parameter estimation derived from the impulse response analysis of the Output Gap target.

Table 4.11: Parameter estimation for Output Gap target<sup>27</sup>

Parameter	Mean	Stdev	95%U	95%L	Geweke	Inef.
sb1	0.0023	0.0003	0.0018	0.0029	0.189	5.01
sb2	0.0025	0.0003	0.0018	0.0028	0.059	9.59
sa1	0.0057	0.0018	0.0034	0.0102	0.009	39.06
sh1	1.0423	0.2497	0.7532	1.6948	0.381	86.58
sh2	0.0055	0.0017	0.0034	0.0098	0.203	35.47

Table 4.11 demonstrates that, at the 95% confidence level, all Geweke estimates are below 1.96, signifying convergence of the Markov chain to a stationary distribution and reliability of the posterior sampling results for the parameters. Additionally, all Inef (Ineffectiveness Factor) estimates are below 100, confirming that the MCMC sampling efficiency is adequate and that the posterior samples are suitable for statistical inference (Koop, 2020).

<sup>27</sup> Referring to Nakajima (2011), the model settings in this section establish the random volatility at 1, specifically  $\sigma^2 = 1$ , resulting in the exclusion of the sa2 indicator from the parameter estimation output.

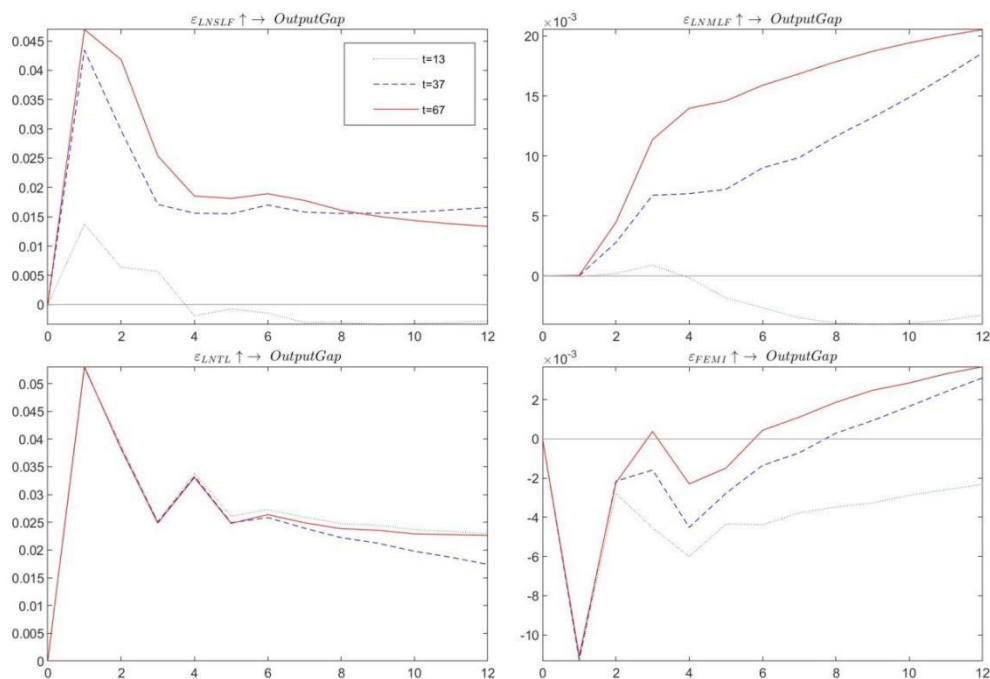


Figure 4.13: IRF result for Output Gap

Figure 4.13 illustrates that following a 1-unit positive shock to each of the four unconventional monetary policy instruments, omitting FEMI for foreign exchange reserves, the other three instruments demonstrate efficacy in addressing the output gap. Figure 4.13 indicate that all three unconventional monetary policy instruments, with the exception of the exchange rate instrument represented by FEMI, demonstrate a significant positive impact on the output gap following the Covid-19 outbreak, subsequent to a 1-unit positive shock applied to each instrument. Both SLF and TL demonstrate significant and swift effectiveness, achieving their maximum impact in Period 1 (0.0471, [0.0061,0.0881] and 0.0555, [0.0279,0.0831] respectively). The effectiveness of both diminishes considerably in the medium to long term, stabilizing after Period 5 (0.0206, [-0.0302,0.0713] and 0.0292, [-0.0025,0.0608] respectively) and gradually expiring in subsequent periods. In contrast to the other two, the MLF demonstrates a rapid increase in effectiveness after Period 1 (0, [0,0]), with a gradual rise observed in the medium to long term after Period 4 (0.0146, [-0.0081,0.0374]). The

FEMI demonstrates a notable negative effectiveness in the short term, accompanied by a gradual yet statistically insignificant positive increase in effectiveness starting from Period 4. To optimize the output gap, the PBOC should increase the release of SLF and MLF, enhance targeted microfinance for tertiary SMEs, and contemplate deregulating foreign exchange reserves.

The effectiveness of TL among the four unconventional monetary policy instruments has shown consistent results throughout the data period. SLF and MLF exhibited low effectiveness initially following the establishment of China's unconventional monetary policy instruments. However, they showed significant effectiveness prior to the Covid-19 outbreak and demonstrated enhanced targeting in the aftermath of the pandemic. The effectiveness of MLF has significantly improved post-outbreak, suggesting that the regulation of short- and medium-term liquidity has been more effective following the outbreak. The effectiveness of FEMI has shown some improvement following the Covid-19 outbreak; however, it remains insignificant, suggesting that further enhancements in the foreign exchange control measures by the PBOC are necessary.

In summary, SLF and TL demonstrate superior short-term optimization of China's output gap following the Covid-19 outbreak, whereas MLF exhibits enhanced medium-term regulation during the same period. The PBOC may evaluate the increased utilization of medium-term lending facilities to enhance production in future policy decisions.

## **ii) Inflation target**

Table 4.12: Parameter estimation for Inflation target

Parameter	Mean	Stdev	95%U	95%L	Geweke	Inef.
sb1	0.0023	0.0003	0.0018	0.0029	0.223	4.90
sb2	0.0023	0.0003	0.0018	0.0029	0.499	6.12
sa1	0.0055	0.0015	0.0034	0.0092	0.490	29.23
sh1	0.0055	0.0015	0.0034	0.0092	0.596	28.20
sh2	0.0057	0.0016	0.0034	0.0099	0.224	29.98

Table 4.12 presents the parameter estimation derived from the impulse response analysis of the Inflation target, it also demonstrates that, at the 95% confidence level, the posterior samples are reliable for the estimation and are suitable for statistical inference.

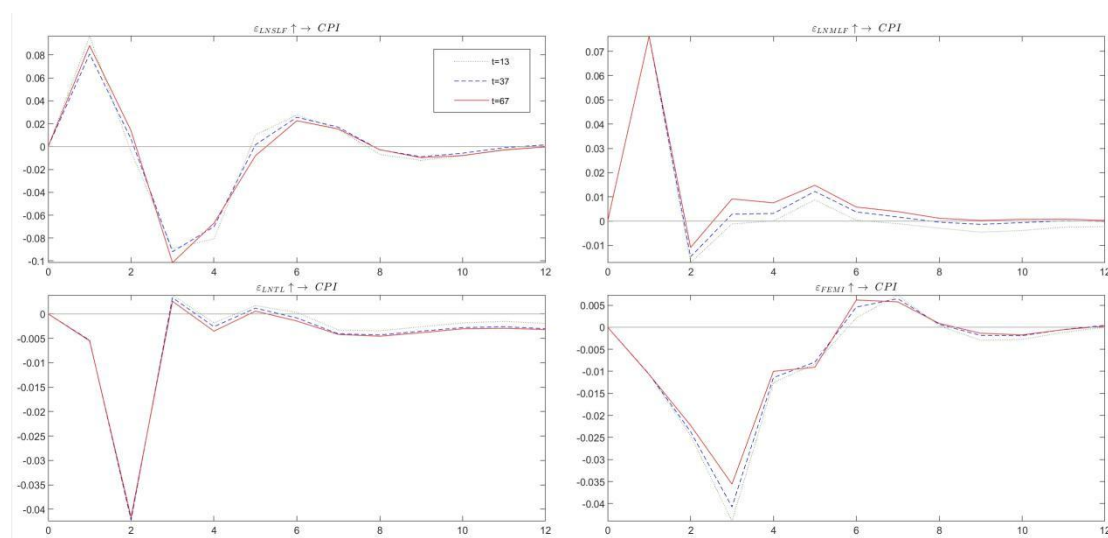


Figure 4.14: IRF result for CPI

Figure 4.14 indicates that following a 1-unit positive shock to the four unconventional monetary policy instruments, in the short term, SLF and MLF contribute to currency depreciation, whereas TL and FEMI effectively reduce inflation following the application of 1 unit of positive shocks, respectively. In the medium term, the impacts of MLF and TL on the price level decrease quickly, whereas SLF demonstrates the

most pronounced dampening effect on inflation following Period 2 and reach the negative peak at Period 3 (-0.0995, [-0.1653,-0.0337]) . TL demonstrates its ability to curb inflation in the short term, with relatively rapid effectiveness, reaching its peak at Period 2 (-0.0458, [-0.0765,-0.0150]), but its peak absolute effectiveness is relatively weaker than that of SLF. FEMI does not significantly dampen inflation compared to SLF in the medium term and only reach the negative peak at Period 3 (-0.0358, [-0.0899,0.0184]), and ceases to exhibit a dampening effect after Period 6. Ultimately, none of the four categories of unconventional monetary policy instruments demonstrate a significant impact on inflation over the long term. The impact of the four types of policy instruments on inflation remained largely consistent throughout the data period. The operation of tertiary SMEs and forex trading is more appropriate for addressing China's inflation issue, while a reduced share of MLF may also be considered in the short term.

### iii) Exchange Rate target

Table 4.13 : Parameter estimation for Exchange Rate target

Parameter	Mean	Stdev	95%U	95%L	Geweke	Inef.
sb1	0.0023	0.0003	0.0018	0.0029	0.460	5.07
sb2	0.0023	0.0003	0.0018	0.0025	0.577	6.80
sa1	0.0055	0.0016	0.0034	0.0095	0.358	27.50
sh1	0.0053	0.0014	0.0034	0.0087	0.006	25.34
sh2	0.0055	0.0015	0.0034	0.0091	0.923	20.24

Table 4.13 presents the parameter estimation derived from the impulse response analysis of the Exchange Rate target, it also demonstrates that, at the 95% confidence level, the posterior samples are reliable for the estimation and are suitable for statistical inference.

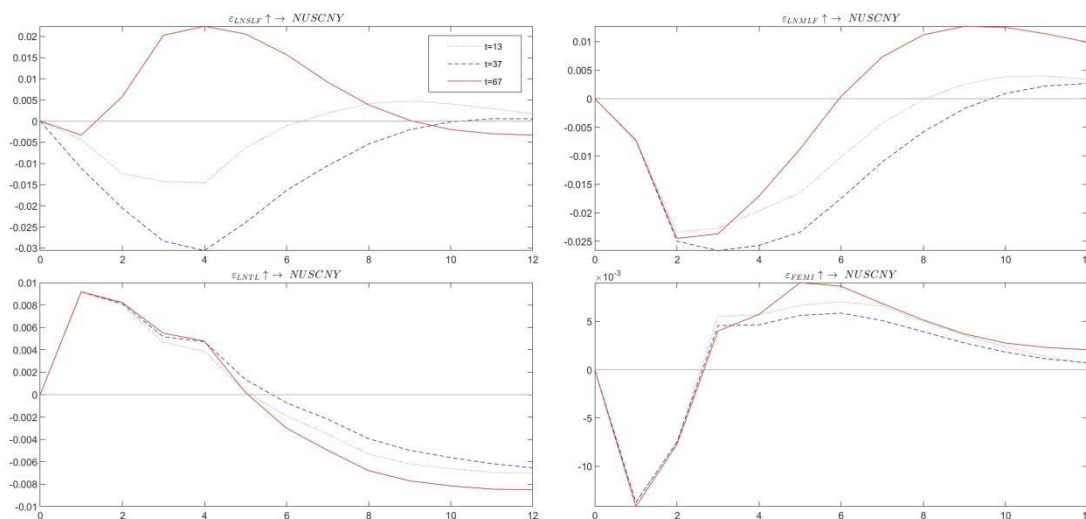


Figure 4.15: IRF result for Nominal USDCNY exchange rate

Figure 4.15 illustrates that following the application of a positive shock of 1 unit each, MLF and FEMI effectively mitigate CNY depreciation in the short term, whereas TL demonstrates a negative impact during the same period. The SLF effect stimulates overall CNY depreciation, though it demonstrates a weak dampening effect in the short term but reach the positive peak at Period 4 (0.0224, [-0.0091,0.0539]). In the medium to long term, the performance of the three other monetary policy instruments, excluding the SLF, contrasts with their short-term performance. The TL demonstrates a dampening effect on CNY depreciation following Period 5, and the effectiveness continues growing until Period 11 (-0.0088, [-0.0189,0.0184]), whereas the MLF and FEMI demonstrate the dampening effect on the depreciation of the CNY in short-term and reach the negative peak at Period 2 (-0.0246, [-0.0410,-0.0082]) and Period 1 (-0.0142, [-0.0239,-0.0045]), respectively. However, both MLF and FEMI indicate a stimulative effect on CNY compilation after Period 6 and Period 3, which suggest that they may not suitable to be considered as the sustained selection. To achieve the target of mitigating local currency depreciation, the PBOC may contemplate increasing the issuance of MLF in the short term, while reducing the proportion of SLF, and

employing both TL and FEMI policy instruments concurrently based on effectiveness trends.

The trends in the effects of MLF, TL, and FEMI exhibit considerable similarity throughout the data period, with a notable increase in MLF's impact following Period 2, particularly in the post-epidemic period. In contrast, SLF demonstrates differing medium- and long-term utility concerning Covid-19. An increase in the SLF, functioning as a short-term liquidity adjustment instrument, generally results in a decrease in the short-term cost of funds in the market. This leads to a rise in CNY asset yields compared to US dollar assets, thereby narrowing the inverted US-China interest rate differential and attracting foreign capital inflows, which stimulates CNY appreciation. Following the Covid-19 outbreak, SLF assumed a distinct role within the Chinese economy, adapting to a markedly different economic context. Initially, regarding policy targets, the PBOC clarified that the focus shifted to risk prevention following the Covid-19 outbreak. The current frequent application of SLF, combined with easing measures like interest rate reductions, has heightened market apprehension regarding economic downturns and has further solidified public expectations for a depreciation of the CNY (Zeng, 2024). The divergence of market confidence is likely a contributing factor. Prior to the epidemic, the SLF functioned as a ceiling instrument within the interest rate corridor, primarily influencing the exchange rate through the interest rate transmission mechanism. Post-epidemic, structural contradictions within the economy, such as corporate debt backlog and weak domestic demand, diminished the transmission efficiency of monetary policy. In a high-leverage environment, funds released through easing policies were predominantly allocated to debt servicing rather than investment, resulting in reduced sensitivity of the exchange rate to liquidity expansion (Wang, 2018). The substantial increase in the scale of SLF operations following the epidemic indicates heightened liquidity pressures on financial

institutions. The market is expected to perceive this as an indication of financial system vulnerability rather than merely liquidity management, consequently leading to a further decline in the CNY exchange rate. In conclusion, external shocks warrant consideration; following Covid-19, the Federal Reserve's aggressive interest rate hikes resulted in a persistent inversion of the US/China interest rate differentials, a trend further intensified by China's accommodative monetary policy prioritizing domestic needs. The widening spread between US and China's 10-year treasury bonds has led to a decline in the relative attractiveness of CNY assets, resulting in accelerated capital outflows through portfolio investment, a significant factor contributing to the depreciation. This contrasts sharply with the relatively closed capital account and stable spread environment in China prior to the epidemic. Concurrently, increasing global risk aversion has intensified the strength of the US dollar. The market perceives the expansion of instruments like the SLF as indicative of rising risk premiums for CNY assets, which further diminishes the impact of the exchange rate channel.

### **b) Transmission Channel-Oriented Analysis**

A discussion of individual unconventional monetary policy instruments must be accompanied by an examination of the transmission channels of monetary policy. Following our examination of the PBOC's monetary policy framework in the preceding section, alongside Yi Gang's statements from 2020 and 2021, the transmission mechanisms of monetary policy in China post-Covid-19 include the traditional credit channel, the interest rate channel, the price channel, and the exchange rate channel, which has garnered heightened focus in recent years. We analyze the effectiveness of the four channels on monetary policy targets to identify the channels most suited to the contemporary Chinese economic system. Based on our analysis of China's monetary policy system, we have identified the following representative variables for the indicators associated with the four channels. The broad money supply (M2) and total

social financing (TSL) are associated with the credit channel. The Shanghai Interbank Offered Rate (SHIBOR) is associated with the interest rate channel. Real Estate Prices (REP), Stock Prices (SP), and Bond Prices (BP) are associated with the price channel. The real exchange rate of the US dollar relative to the CNY (RUSCNY) aligns with the exchange rate channel.

### i) Credit channel

Table 4.14 : Parameter estimation for Credit channel

Parameter	Mean	Stdev	95%U	95%L	Geweke	Inef.
sb1	0.0023	0.0003	0.0018	0.0029	0.042	7.13
sb2	0.0023	0.0003	0.0018	0.0029	0.002	4.21
sa1	0.0057	0.0017	0.0034	0.0098	0.107	33.74
sh1	1.1420	0.2598	0.7330	1.7507	0.392	87.47
sh2	0.0055	0.0015	0.0034	0.0092	0.136	20.39

Table 4.14 presents the parameter estimation derived from the impulse response analysis of the Credit channel, it also demonstrates that, at the 95% confidence level, the posterior samples are reliable for the estimation and are suitable for statistical inference.

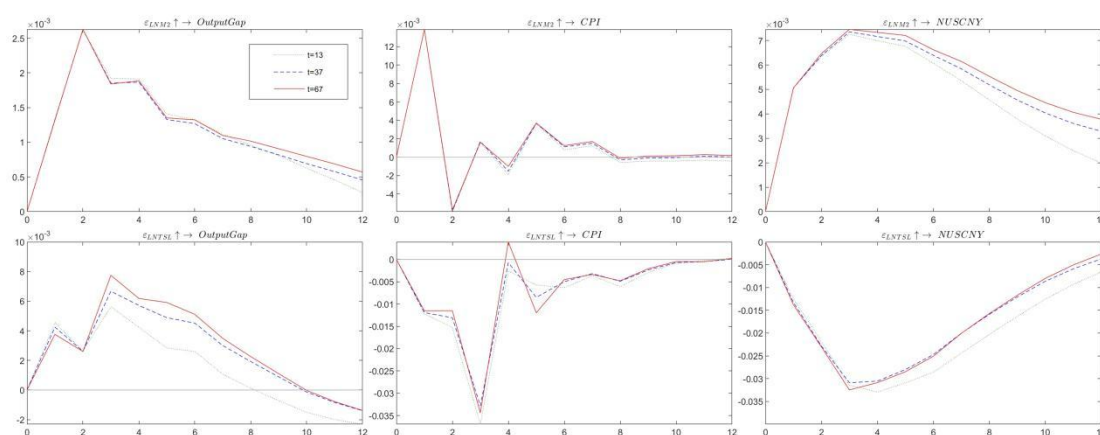


Figure 4.16: IRF result for Credit channel

Figure 4.16 illustrates that both M2 and TSL demonstrate considerable effectiveness in optimizing the output gap in the short run following a 1-unit positive shock, with their impact gradually diminishing after reaching their peaks in Period 2 (0.0027, [-0.0022,0.0076]) and Period 3 (0.0078, [-0.0029,0.0184]), respectively. The effectiveness of M2 remains persistent and continues to demonstrate positive effects beyond Period 12. The short-term impact of TSL is significantly greater, exhibiting peak effectiveness approximately three times that of M2. The credit channel's effectiveness exhibits a consistent trend across the data period, with M2 demonstrating a minimal increase in effectiveness, whereas TSL experiences a significant rise in both peak effectiveness and persistence as the data period advances. The credit channel has consistently demonstrated significant effectiveness in stimulating output.

In the context of price stabilization, positive shocks to M2 are ineffective, as they tend to increase inflation in the short term and reach the positive peak at Period 1 (0.0144, [-0.005,0.0293]), and contribute minimally to the long-term target as it reach the negative peak at Period 2 with only -0.0061 ([-0.0235,0.0113]), and cannot remain the effect. The TSL has demonstrated a significant dampening effect on prices in the short term and reach the negative peak at Period 3 (-0.0347, [-0.0859,0.0166]), also has sustained this effect in the medium to long term. The credit channel exhibits a consistent effectiveness trend throughout the data period, with TSL demonstrating a marginal increase in volatility during this period. The credit channel's effectiveness in controlling inflation is primarily achieved through the TSL, whereas traditional M2 contributes minimally to the inflation target.

The effectiveness of the credit channel in regulating the exchange rate is a complex issue. The two representative variables exhibit opposing effects on the exchange rate.

M2 accelerates the depreciation of the CNY in the international market, whereas TSL mitigates the weakening of the CNY's exchange rate by more than four times its peak impact. M2 reached its peak in Period 5 (0.0079, [-0.0019,0.0177]) when TSL reached its peak in Period 3 (-0.0326, [-0.0530,-0.0122]), and both are subsequently declined, with the TSL diminishing at a faster rate, yet still mitigating M2 depreciation pressure in absolute terms until Period 12. The trends in the effectiveness of M2 and TSL remain relatively stable over the data period. However, the dampening effect of TSL on depreciation diminishes, while M2's influence on depreciation increases in the medium to long term. The results indicate a diminishing effectiveness of the credit channel within China's monetary policy framework, highlighting the necessity for the PBOC to expedite the systemic optimization of monetary policy to decrease dependence on this channel.

## ii) Interest rate channel

Table 4.15 : Parameter estimation for Interest rate channel

Parameter	Mean	Stdev	95%U	95%L	Geweke	Inef.
sb1	0.0023	0.0003	0.0018	0.0029	0.762	4.26
sb2	0.0023	0.0003	0.0018	0.0029	0.891	4.03
sa1	0.0057	0.0017	0.0035	0.0100	0.004	39.56
sh1	1.1651	0.2268	0.7861	1.6535	0.850	61.52
sh2	0.0055	0.0016	0.0033	0.0094	0.630	26.34

Table 4.15 presents the parameter estimation derived from the impulse response analysis of the Interest rate channel, it also demonstrates that, at the 95% confidence level, the posterior samples are reliable for the estimation and are suitable for statistical inference.

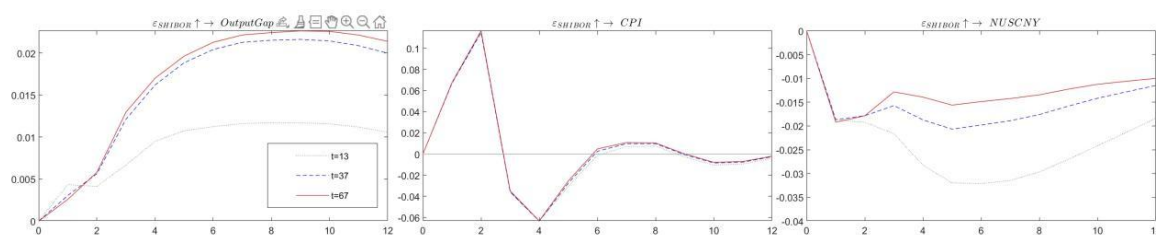


Figure 4.17: IRF result for Interest rate channel

Figure 4.17 illustrates that the effectiveness of SHIBOR, serving as a proxy for the interest rate channel, demonstrates markedly different trends in effectiveness across the three policy targets following a 1-unit positive shock. The effectiveness of SHIBOR in optimizing the output gap is limited in the short run, but increases throughout the period, demonstrating significant effectiveness in Period 6 (0.0212, [-0.0013,0.0437]), peaking in Period 9 (0.0226, [-0.0025,0.0477]), and remaining elevated thereafter. SHIBOR effectively mitigates CNY depreciation in the short term for the purpose of exchange rate stabilization, with peak effectiveness observed in Period 1 (-0.0193, [-0.0305,-0.0081]). Concurrently, SHIBOR demonstrated a notable dampening effect over the long term.

Nevertheless, regarding the policy target of price suppression, the interest rate channel exhibited suboptimal performance. In the short term, SHIBOR rapidly contributed to the decline in the price level, began to decline sharply after reaching its peak in Period 2 (0.1170, [0.0616,0.1723]), and rapidly transferred to exhibited the most significant dampening effect on the price level in Period 4 (-0.0609, [-0.1024,-0.0194]), but subsequently appeared to nearly lose its influence in Period 6. The maximum dampening effect of SHIBOR on the price level did not counterbalance the peak of the negative effect. Consequently, it is deemed imprudent to regulate the price level through the interest rate channel within the context of China's monetary policy and economic framework.

The influence of the interest rate channel on the output gap has significantly intensified throughout the data period, with its peak effectiveness improving by over 100% following the onset of Covid-19, in comparison to the period when unconventional monetary policy was initially implemented. This is likely attributable to the gradual improvement of China's financial markets for SMEs over the period, alongside a significant increase in financial market participation by the productive sector. China's inclusive SME loan balances have demonstrated consistent growth from the first quarter of 2017 (CNY 7.8 trillion) to the fourth quarter of 2022 (CNY 29.1 trillion), with the exception of a year-on-year decline in the fourth quarter of 2019. The dampening effect of the interest rate channel on CNY depreciation is decreasing. SHIBOR serves as an indicator of the interest rate channel, representing the supply and demand dynamics of funds within the interbank market. Higher interest rates typically attract foreign capital inflows, resulting in an appreciation of the local currency exchange rate. Conversely, lower interest rates may lead to the depreciation of the local currency. The diminished impact of SHIBOR on local currency depreciation can be linked to the reduction in the interest rate differential between the United States and China. Since 2015, the People's Bank of China has implemented a loose monetary policy to support the real economy, resulting in a generally lower level of SHIBOR. The Federal Reserve initiated a period of rate increases during this period, implementing nine cumulative hikes from late 2015 to 2018, while the interest rate spread between the US and China progressively diminished. The narrowing of the spread diminished the direct influence of SHIBOR on the exchange rate. Following the Covid-19 outbreak, the Federal Reserve raised interest rates to address inflation, whereas the People's Bank of China opted to stimulate the economy through interest rate cuts. This divergence contributed to the inversion of the spread, diminishing the appeal of CNY assets, and the moderating influence of SHIBOR was once again overshadowed by external spread factors.

## iii) Asset price channel

Table 4.16 : Parameter estimation for Asset price channel

Parameter	Mean	Stdev	95%U	95%L	Geweke	Inef.
sb1	0.0023	0.0003	0.0018	0.0028	0.0027	9.13
sb2	0.0023	0.0003	0.0018	0.0029	0.084	4.80
sa1	0.0057	0.0018	0.0035	0.010.	0.550	30.42
sh1	1.1719	0.1650	0.8382	1.5073	0.008	43.41
sh2	0.0056	0.0016	0.0033	0.0096	0.923	28.09

Table 4.16 presents the parameter estimation derived from the impulse response analysis of the Asset price channel, it also demonstrates that, at the 95% confidence level, the posterior samples are reliable for the estimation and are suitable for statistical inference.

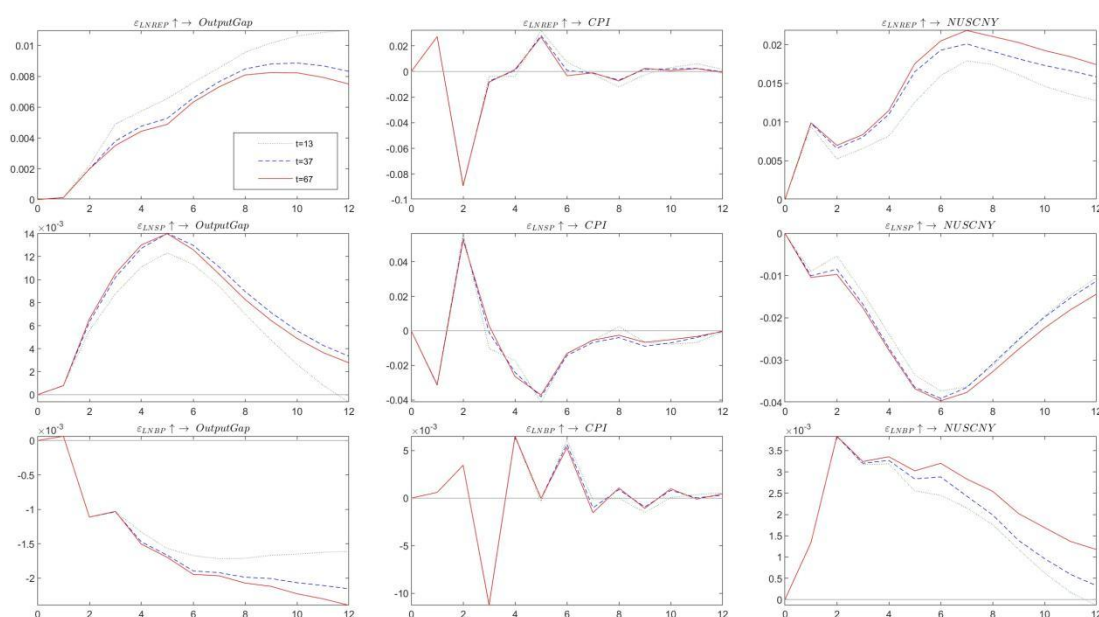


Figure 4.18: IRF result for Price channel

Figure 4.18 illustrates that the impact of property price levels on the output gap is both long-term and gradual, peaking at a relatively low level with minimal hysteresis after

a 1-unit positive shock. Conversely, stock prices exhibit superior performance compared to real estate prices in the short to medium term, reaching a peak in Period 5 (0.0143, [0.0043,0.0243]) that is markedly higher than the peak associated with real estate prices which reach its peak at Period 8 (0.0084, [-0.0038,0.0205]). In the medium to long term, the SP's capacity to optimize the output gap remains limited but continue upperforms in comparison to the REP until Period 9, and subsequent performance is not as good as REP. The influence of the bond price level on the output gap is contrary to the previous two factors, as a higher bond price tends to widen the output gap and further enhances its negative effectiveness. Furthermore, REP exhibits a significant dampening effect on the price level in the short term, reach the negative peak at Period 2 (-0.0894, [-0.1249,-0.0593]). However, this effect diminishes rapidly and approaches 0 right at Period 3, demonstrates serious lack of sustainability. BP's impact on the price level varies similarly to that of REP. However, its overall effect remains minimal, only show its strongest inhibitory effect at Period 3 (-0.0114, [-0.0192,-0.0036]), and quickly rebounded and stimulated price increases, followed by volatility and convergence to long-term ineffectiveness. The impact of the SP on the price level is limited, inducing short-term inflation while exhibiting minimal significance in the medium and long term. Specifically, SP exhibited a minimal impact on price level suppression in Period 1 (-0.0316, [-0.0745,0.0113]), but subsequently demonstrated an opposing effect, peaking in Period 2 (0.0526, [0.0076,0.0976]), followed by a secondary rebound in Period 3 (-0.0382, [-0.0761,-0.0003]), ultimately achieving its maximum effect on price suppression. In later periods, the suppressing effect diminished progressively, nearing 0 by Period 8. Regarding the exchange rate control target, only the SP demonstrates a dampening effect on CNY depreciation, with its influence increasing in the short term until it peaks in Period 6 (-0.0412, [-0.0708,-0.0115]), after which it gradually declines. Additionally, its effectiveness appears limited in the medium to long term.

The influence of property prices on China's economy has been a prominent subject of discourse in academic circles since the country's substantial investment in infrastructure and the real estate sector in 2009. Initial discussions indicated that the real estate sector plays a significant role in short-term GDP growth by stimulating the construction industry, which subsequently fosters the development of over 50 related industries both upstream and downstream (Du, 2013; Cheng, 2013; Fan, 2014). However, discussing solely the stimulation of output is one-sided and biased. The cooling of China's property sector, coupled with government policies aimed at curbing property prices, has led to increased scholarly attention on the adverse effects of property prices on consumption and their negative implications for the real economy. An opinion piece published in 2018 by People's Daily indicated that a 100 percent increase in real estate prices correlates with a decrease of approximately 5 percent in total corporate tax revenue as a percentage of total industrial assets (Huang, 2018). Du's (2017) study utilizing panel data from 172 prefecture-level cities indicates that an increase in real estate prices significantly reduces the average propensity to consume among residents. This effect is further intensified by a high proportion of potential homebuyers and the underdeveloped state of real estate finance. Consequently, it is insufficient to conclude that the real estate price level optimizes the output gap based solely on the results of the impulse response analysis. Considering the definition of the output gap, we believe that the optimising effect of real estate price levels on the output gap is more likely to be manifested not in the enhancement of actual output, but in the suppression of potential output. Referring to the property bubble in Japan and the subprime crisis in the US, the reliance on property-led output growth will eventually lead to systemic risks. Robert Shiller's feedback loop theory also argues that an irrational rise in property prices can easily lead to the bursting of an economic bubble. Therefore, although rising property prices may stimulate short-term output at a particular stage, their long-term dampening effect is more significant and systemic

risk, which is realised through multiple channels such as consumption disincentives, cost transmission and structural distortions.

The trend in the effectiveness of the price channel on the various policy targets did not change significantly throughout the data period. In terms of absolute impact, the effectiveness of the price channel on the target of optimising output declined by about one-third overall over time, while for the target of price stabilisation there was little change. For the target of suppressing the exchange rate, on the other hand, the negative impact of property and bond prices has increased year on year, while the positive impact of stock prices has been decreasing year on year. Fang (2016) discusses the ongoing depreciation of the CNY in 2016, suggesting that the PBOC will implement 'disguised interest rate hikes' to mitigate asset bubbles while pursuing deleveraging in the financial market. However, this approach may undermine the price channel amid external turbulence, such as a stronger U.S. dollar. The PBOC has implemented a moderately accommodative monetary policy to enhance domestic demand post-Covid-19, while simultaneously pursuing deleveraging in financial markets<sup>28</sup>, potentially increasing the risk of capital outflows. In the current economic environment, all three price channels have concurrently been influenced by various policies. The Political Bureau of the Communist Party of China (CPC) Central Committee meeting identified 'stabilising the property market and stock market' as a continuous economic target for the period from 2020 to 2023. The current adjustments in the property market have resulted in a decrease in residents' wealth, which in turn impacts consumption intentions and capital flows. The downward pressure on the property market has diminished its role as an asset price stabilizer, potentially increasing the risk of capital outflows indirectly. The volatility of China's stock market has risen in recent years (Yu, 2023), and the uncertainty regarding a transition in portfolio

<sup>28</sup> Yi Gang, then governor of the People's Bank of China, public statements in 2024.

investment from net outflows to net inflows is also increasing. Despite the emergence of supportive forces in emerging stock markets, including artificial intelligence platforms (e.g., AliCloud, Deepseek) and new social media channels (e.g., TikTok), investor confidence remains significantly affected (Liu, 2023). This situation has resulted in intensified capital flows and subsequent pressures on exchange rates. Bond yields, exemplified by the 10-year Treasury bond, have experienced a significant decline since 2014, decreasing from 4.6 percent to 2.4 percent by 2024. The persistent decrease in domestic bond yields has resulted in an expansion of the domestic and foreign spread inversion, subsequently diminishing the appeal of CNY assets. Consequently, outflows from the financial account may emerge as the primary driver of depreciation. Furthermore, following the outbreak of Covid-19, the PBOC's monetary policy transitioned to a moderate easing stance, resulting in a decline in the policy rate. The central bank's communications have consistently indicated an expectation of further interest rate reductions. This is expected to further lower bond yields and intensify capital outflows, resulting in additional pressure on the CNY exchange rate.

#### iv) Exchange rate channel

Table 4.17 : Parameter estimation for Exchange rate channel

Parameter	Mean	Stdev	95%U	95%L	Geweke	Inef.
sb1	0.0023	0.0003	0.0018	0.0028	0.534	3.92
sb2	0.0023	0.0003	0.0018	0.0029	0.003	6.22
sa1	0.0055	0.0015	0.0034	0.0092	0.526	30.04
sh1	1.1662	0.2260	0.7757	1.6371	0.179	73.75
sh2	0.0055	0.0015	0.0034	0.0094	0.327	20.37

Table 4.17 presents the parameter estimation derived from the impulse response analysis of the Exchange rate channel, it also demonstrates that, at the 95% confidence level, the posterior samples are reliable for the estimation and are suitable for

statistical inference.

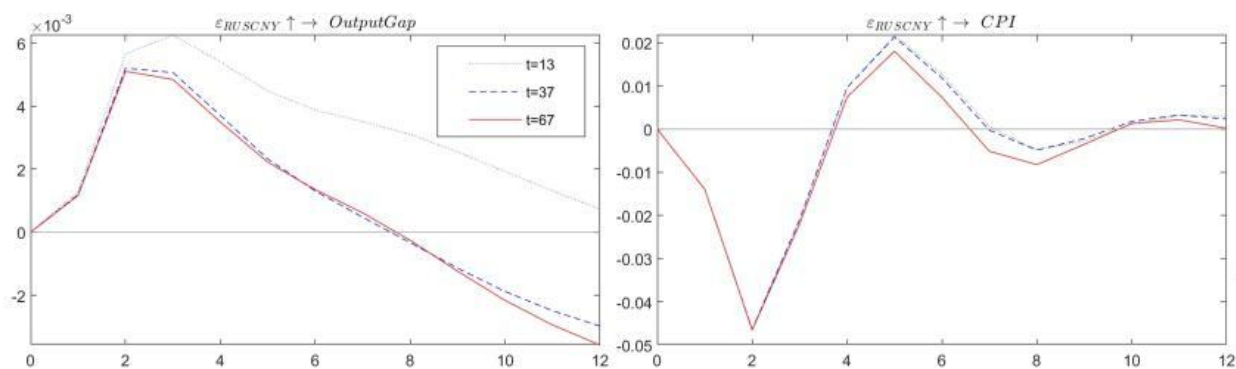


Figure 4.19: IRF result for Exchange rate channel

Figure 4.19 illustrates that the real USD-CNY exchange rate has a positive but insignificant effect on the output gap in the short run following a 1-unit positive shock, reaching a peak at Period 2 (0.0052, [0.0005,0.0098]). The weak optimizing effect is not enduring, diminishing rapidly from Period 2 and becoming negative from Period 8, remaining consistently low thereafter. The real USD-CNY exchange rate exhibits a notable dampening effect on the price level in the short run, reaching its peak at Period 2 (-0.0471, [-0.0734,-0.0208]). The impact of the exchange rate on the price level is temporary, diminishing after Period 2 and approaching 0 by Period 10.

The influence of the real USD-CNY exchange rate on the price level remains relatively stable over the data period, exhibiting only a minor dampening effect in the short to medium term from Period 4 to Period 10. The effect of the nominal exchange rate on optimizing the output gap significantly declines over time. The observed variation in periods is primarily attributed to the reduced sensitivity to exchange rates and the gradual decoupling of U.S.-China trade relations.

Post-2014, China's export structure underwent a gradual transformation towards high

value-added products. The diminished sensitivity of high value-added industries to fluctuations in exchange rates reduced the marginal effect of exchange rate adjustments on export volumes. A comparable instance to this phase is that Japan's high value-added exports exhibited resilience following the Plaza Accord, and the appreciation of the exchange rate did not substantially diminish total exports. The growth model of the Chinese economy has transitioned from being export-led to being driven by domestic demand. Also post-2014, consumption's contribution to GDP growth surpassed that of investment and exports. Additionally, the elongation of the transmission chain for exchange rate adjustments to domestic demand, coupled with a reduction in short-term stimulus effects, diminished exchange rate sensitivity.

The US-China trade war has altered the cost structure and demand elasticity of China's export commodities due to tariffs and restrictions on technology exports. Monetarist exchange rate theory posits that the exchange rate's influence on trade is contingent upon the effectiveness of price transmission. Trade wars result in tariff costs being partially borne by both exporters and importers, thereby diminishing the direct effect of exchange rate fluctuations on export volumes. In this context, Chinese exporters circumvent tariffs by relocating the industrial chain, such as moving the assembly process to Southeast Asian countries, thereby rendering 'Made in China' effectively as 'Made along the Belt and Road'. This may result in a disruption of the transmission mechanism of exchange rate adjustments to exports, thereby influencing the efficacy of the exchange rate channel. The decoupling of supply chains weakens economic elasticity, potentially influencing the marginal effect of exchange rate adjustments on the output gap. The 'de-Chinisation' policy implemented by the United States has compelled China to expedite the development of its internal period. China's domestic demand growth has notably fallen short of the decline in external demand, resulting in a diminished marginal impact of exchange rate depreciation on

output stimulation. Since 2014, the proportion of processing trade in China has consistently decreased, whereas general trade exhibits lower sensitivity to exchange rate fluctuations, thereby diminishing the short-term optimization effect of the exchange rate channel (Li, 2018; Shen, 2023).

#### **4.2.5 TVP-SV-VAR Sector Conclusion**

Post-Covid-19, the PBOC's unconventional monetary policy instruments primarily focus on three targets: optimizing the output gap, mitigating exchange rate volatility, and controlling inflation. The transmission channels involved include credit, interest rates, prices, and exchange rates, with varying effectiveness depending on the specific target pursued. Impulse response analysis allows for a summary of the effectiveness of each instrument across various targets as outlined below.

The policy targets indicate that SLF and TL exert a rapid and substantial optimizing effect on the output gap post-epidemic, reaching a peak in Period 1, followed by a decline in effectiveness over the medium to long term. The moderating effect of MLF progressively increased from Period 1 and continued to rise in the medium to long term. FEMI exhibits a short-term suppression of output, transitioning to a slightly positive trajectory in the medium term. We assert that liquidity support can be enhanced via the Standing Lending Facility (SLF) and the Medium-term Lending Facility (MLF), with an emphasis on targeted lending for tertiary small and medium-sized enterprises (SMEs). In the context of a complex international trade environment, the PBOC must manage foreign exchange reserves with greater prudence to mitigate short-term negative shocks.

To achieve exchange rate stabilization, MLF and FEMI can be utilized to effectively

mitigate short-term CNY depreciation, whereas SLF may provide short-term relief but intensifies depreciation pressures in the medium to long term. The immediate adverse impact of TL transitions into a mitigating effect over the medium to long term. The SLF operation is perceived by the market as an indicator of financial system vulnerability post-epidemic, compounded by the inverted US-China interest rate spread and capital outflow pressures, which have diminished its exchange rate adjustment function. In the short term, priority should be assigned to the utilization of MLF, while reducing the scale of SLF and dynamically adjusting the combination of TL and FEMI to achieve a balance between long- and short-term effects.

To address inflation, TL and FEMI can effectively reduce it in the short term, whereas SLF and MLF tend to worsen inflation in the short term. In the medium term, SLF exhibits the most significant effect on suppressing inflation. In the long-term utility perspective, none of the instruments demonstrates a significant impact. Consequently, it is essential to increase reliance on TL and FEMI to mitigate inflation, while in the short term, reducing MLF injections may help prevent excess liquidity from driving up prices.

Both types of credit channels effectively stimulate output in response to the output gap, with TSL demonstrating a more pronounced short-term effect (reaching up to three times M2), while M2 exhibits greater persistence. In contrast, TSL exhibits a dampening effect on inflation in the short term, whereas M2 promotes an increase in the inflation rate. In the context of exchange rate stabilization, M2 contributed to the depreciation of the CNY, whereas TSL remained subdued. The impacts of these factors have fluctuated throughout the period, indicating a gradual decline in the effectiveness of the credit channel. It is essential for the PBOC to further optimize its credit structure, decrease reliance on traditional M2, and enhance TSL's targeted support for

the real economy.

The optimization of the output gap through SHIBOR in the interest rate channel has significantly increased in the medium to long term, with peak effectiveness rising by more than 100% during the post-epidemic period. The primary reason for this is the advancement of financial inclusion and heightened market participation. SHIBOR induced short-term inflation while exhibiting a limited dampening effect in the medium term, indicating its inadequacy as an inflation-suppressing instrument. Furthermore, SHIBOR mitigated CNY depreciation in the short term; however, the inverted US-China interest rate differential diminished its long-term impact. We contend that the interest rate channel is more effective for optimizing output, while the PBOC should prioritize the coordination of domestic and foreign interest rate policies to mitigate the impact of spread inversion on the exchange rate channel.

In the context of the price channel, property prices may gradually optimize the output gap over the long term, albeit with associated risks. Equity prices have demonstrated effectiveness in the short term, whereas bond prices have contributed to the widening of the output gap. In the short term, property prices exhibit a more pronounced dampening effect on inflation. The observed trend in the output gap suggests that real estate prices may enhance output in the short term; however, they concurrently suppress consumption and investment, potentially leading to systemic risk. As uncertainty escalates in China's international trade relations amid volatility, the stock market has experienced increased fluctuations, which may further undermine the stability of capital flows and result in a relative decline in the capacity to regulate the exchange rate. Consequently, it is recommended that the PBOC refrain from excessive dependence on real estate stimulus, enhance management of stock market expectations, mitigate the risk of asset price bubbles, and exercise caution in the use of

price channels until financial markets attain a sufficient level of stability.

The exchange rate channel exhibits a limited short-term impact on the optimization of the output gap, which is further diminished by alterations in the external environment, including the structural transformation of the economy (increased proportion of high value-added exports, enhanced domestic demand) and the decoupling of US-China trade. The depreciation of the exchange rate may temporarily reduce inflation; however, this effect diminishes rapidly over time. Consequently, it is posited that while Yi Gang emphasized the importance of the exchange rate channel in his recent speech, the PBOC must further investigate the synergistic relationship between exchange rate policy and industrial upgrading, as well as improve the domestic period's buffering effect on the exchange rate.

This section presents a framework that effectively addresses three significant shortcomings of traditional models. First, this section distinguishes itself by identifying the specific roles of each channel through channel decomposition, offering a mechanistic explanation, in contrast to traditional models that merely reveal the correlation between monetary policy instruments. Secondly, when monetary policy instruments produce counteracting effects via various channels, direct discussions may fail to capture their actual significance. Quantitative monetary policy instruments enhance the liquidity of local government bonds directly; however, they may also induce arbitrage transactions through the interest rate channel, which can weaken the improvements in liquidity. This framework enables the isolation of net effects. Also, as the PBOC's regulatory emphasis has progressively transitioned from monetary policy instruments to channel operations (e.g., LPR reform), this framework can offer evidence of channel efficiency to guide the selection of monetary policy instruments.

In conclusion, the empirical findings indicate that the PBOC has the capacity to dynamically adjust its instrument mix to achieve various policy targets. SLF and MLF are employed to stimulate short-term output; MLF is utilized for medium to long-term targets, whereas the stabilization of exchange rates necessitates the synergy of MLF and FEMI. Inflation control emphasizes TL and FEMI. The PBOC should prioritize enhancing the effectiveness of its channels. For instance, diminish dependence on the credit channel and enhance the medium- to long-term function of the interest rate channel. Enhance the inclusive financial system to improve the efficiency of interest rate transmission. Mitigate potential risks within the price channel, among other factors. In light of the uncertainty surrounding the global trade environment, the PBOC should prioritize the external context and formulate appropriate responses. Coordinate domestic and foreign monetary policies to mitigate the effects of inverted US-China interest rate differentials. Mitigate the effects of trade wars on the exchange rate mechanism by implementing industrial chain diversification, among other strategies. The PBOC should collaborate with government-initiated structural reforms aimed at decreasing reliance on exports and real estate, thereby strengthening economic resilience in response to the diminishing marginal effects of unconventional policies. The PBOC must achieve a balance among instrument innovation, channel optimization, and structural reforms to improve the precision and sustainability of unconventional monetary policy.

It should be noted that during the Covid-19 pandemic, conventional monetary policy instruments in China, including the reserve requirement ratio and open market operation interest rates, reached their operational limits, resulting in a significant decline in transmission efficiency. Consequently, unconventional monetary policy became the primary regulatory instrument. In this context, the TVP-SV-VAR model employed in this study did not independently account for conventional monetary policy

for two reasons. The structural transformation of China's monetary policy framework has diminished the effectiveness of traditional monetary policy instruments. Before 2020, the policy options for conventional instruments had already diminished considerably. Following the pandemic's onset, the People's Bank of China explicitly transitioned to a framework that prioritizes structural instruments over aggregate instruments (Yi Gang, 2020), relegating conventional instruments to a supplementary role. Secondly, China's unconventional monetary policy framework is characterized by precise targeting and fiscal coordination, resulting in operational detachment from traditional monetary policy instruments. In the context of instrument independence, unconventional monetary policy instruments are administered via distinct quotas and separate accounting by the central bank, with fund flows limited by credit assessments, resulting in a dual-track system alongside conventional monetary policy instruments. Considering transmission channel utilization, the incorporation of transmission channels allows the channel decomposition function of TVP-SV-VAR to independently quantify the transmission efficiency of unconventional monetary policy, specifically in identifying credit supply shocks, without the need for conventional monetary policy as a control variable.

### **4.3 Systemic Effectiveness of Unconventional Monetary Policy**

When analysing the efficiency of unconventional monetary policy using a VAR-type model, it is important to consider the interactions between different monetary policy elements. This is necessary to avoid overlooking the effects of utilising many instruments together.

Section 4.2 examines the efficacy of a solitary unconventional monetary policy.

Frequently, unconventional monetary policies are conducted in conjunction, exerting control over the real economy by influencing the quantity of money or interest rates. When utilising a VAR-type model to analyse the effects of the policy mix, it is typically necessary to establish a policy component to represent it. Nevertheless, there is a debate regarding whether the establishment of a policy component will obscure the examination of the function of specific instruments. The Dynamic Stochastic General Equilibrium (DSGE) model enables us to introduce shocks to the intermediary indicators, specifically quantity (money) shocks and interest rate shocks, in order to analyse the effectiveness of the policy combination. Furthermore, the exclusion of expectation management from the TVP-SV-VAR model arises from the limited research and application of this concept in China. The DSGE model, which incorporates policy expectations in this section, can effectively address this gap and highlight the significance of expectation management.

### **4.3.1 DSGE model**

The DSGE model is a fundamental research paradigm in contemporary mainstream macroeconomic theory. It not only holds a dominant position in the academic area, but also plays a significant role in policy analysis and economic forecasting conducted by central banks.

The DSGE model is characterised by 3 primary attributes, as indicated by its name:

- 1) **Dynamic:** The model allows each economic agent to solve the intertemporal optimisation issue based on their preferences, technology, restrictions, and other factors. This enables the exploration of how macroeconomic variables evolve over time in a dynamic manner.

2) Stochastic: The model incorporates many external random disturbances, such as shocks to total factor productivity, labour supply, monetary policy, etc., to represent the different uncertainties present in the actual economy.

3) General Equilibrium: The model refers to a situation where all markets in the model are simultaneously cleared, allowing for the examination of the interrelationships and interactions between economic agents and variables.

Conventional econometric models possess several drawbacks that are difficult to overlook. For instance, the model does not incorporate the optimal behavioural choices made by economic individuals and lacks a theoretical foundation rooted in microeconomics. Microeconomic analysis and macroeconomic analysis are currently distinct and lack cohesive integration. The model typically employs static or adaptive expectations, rather than rational expectations, which in turn impact the simulation results and policy analysis of the model. Typically, it is a model that lacks structural elements and is thus susceptible to Lucas' critique. DSGE models, unlike other models, provide theoretical rigour and consistency. They also incorporate explicit structural elements in their modelling framework, making them ideal for policy analysis (Liu, 2008).

DSGE models provide 3 primary functions: story-telling, policy experiments, and economic forecasting (Del Negro & Schorfheide, 2013). All three are mutually reinforcing and indivisible. Story-telling involves creating accurate theoretical models to examine the connections and interactions among economic variables. In order to assess the effects of various economic policies on real economic performance, policy experiments must be based on robust models. Evaluating the accuracy of economic

forecasting is a crucial factor in determining the effectiveness of a model. Enhanced economic forecasting technologies enable central banks and governments to promptly detect economic issues and implement suitable measures to effectively stabilise the economy.

### **4.3.2 DSGE model constructs considering policy expectations**

In the preceding discussion, we highlighted that one of the key targets of unconventional monetary policy is to regulate interest rate expectations and inflation expectations. However, usually these targets are accomplished by actions like providing direction about future actions, and these forms of communication are challenging to represent in a sequence of data points. One often used method is event analysis, which examines the effect on expectations after the central bank implements specific forward guidance actions. However, we would prefer a more unbiased and measurable approach to analyse the efficiency of unconventional monetary policy in this context. Thus, we opt to construct a DSGE model that incorporates policy expectations.

Referring to the analytical approach of the studies by Smets and Wouters (2007) and Gomes et al. (2017), we theoretically modelled the four-sector DSGE considering policy expectations, price stickiness and other factors as following. The DSGE model was established because it better reflects the features of the Chinese economy, which is why these two studies were cited. For instance, the tightness of the labor market and the high savings and consumption inertia setting reflect the features of the Chinese economy in the household sector. Given that certain industries are subject to price guidance by the Chinese government, the concept of price stickiness in the producer

sector is also somewhat appropriate. For instance, China typically lags behind international markets in pricing adjustments for refined oil products. Furthermore, the establishment of policy norms is more consistent with China's practical inclination for integrating fiscal intervention with its two-track monetary policy.

### 1) Private households

For a private household labelled  $H \in (0,1)$  in the economic system its target at any point in time is to maximise a utility function of the following form:

$$E_0 \sum_{t=0}^{\infty} \beta^t U_t^H \quad (4.27)$$

In the above equation,  $\beta$  denotes the discount factor,  $U_t^H$  is the utility of private household  $H$  in period  $t$  and can be expressed as:

$$U_t^H = \varepsilon_t^s \left( \frac{1}{1-\sigma_e} (C_t^H - H_t)^{1-\sigma_e} + \frac{\varepsilon_t^m}{1-\sigma_m} \left( \frac{M_t^H}{P_t} \right)^{1-\sigma_m} - \frac{\varepsilon_t^l}{1+\sigma_l} (L_t^H)^{1+\sigma_l} \right) \quad (4.28)$$

In the above equation,  $C_t^H$  is the consumption of private household  $H$ , and the consumption habit  $H_t$  can be expressed as  $H_t = hC_{t-1}^H$ .  $M_t^H$  is the nominal money holdings,  $P$  denotes the price level,  $L_t^H$  denotes the labour paid by private households in exchange for rewards,  $\sigma_c^{-1}$  is the intertemporal elasticity of substitution of consumption,  $\sigma_m^{-1}$  denotes the parameter of the elasticity of demand for money, and  $\sigma_L^{-1}$  denotes the parameter of the elasticity of supply of labour in households. The three shocks included in the above equation are fluctuations in the discount factor  $\varepsilon_t^B$ , fluctuations in the demand for money  $\varepsilon_t^m$ , and fluctuations in the supply of labour  $\varepsilon_t^l$ , and all satisfy the following AR(1) form:

$$\begin{aligned} \ln \varepsilon_t^B &= \rho_B \ln \varepsilon_{t-1}^B + \eta_{B,t}, \quad \eta_{B,t} \text{i.i.d.} N(0, \tilde{\sigma}_B^2) \\ \ln \varepsilon_t^m &= \rho_m \ln \varepsilon_{t-1}^m + \eta_{m,t}, \quad \eta_{m,t} \text{i.i.d.} N(0, \tilde{\sigma}_{mt}^2) \\ \ln \varepsilon_t^l &= \rho_l \ln \varepsilon_{t-1}^l + \eta_{l,t}, \quad \eta_{l,t} \text{i.i.d.} N(0, \tilde{\sigma}_l^2) \end{aligned} \quad (4.29)$$

With  $B_t^H$  denoting the risk-free financial asset held by  $H$ ,  $b_t$  its price,  $Y_t^H$  the income of private household  $H$ , and  $I_t^H$  and  $T_t^H$  its investment and tax payments, respectively,

the constraint equation used to solve the above two equations is expressed as:

$$C_t^H + b_t B_t^H / P_t + M_t^H / P_t + I_t^H + T_t^H = (M_{t-1}^H + B_{t-1}^H + Y_t^H) / P_t \quad (4.30)$$

The left-hand side of the above equation represents the total expenditure of household  $H$  in period  $t$ , and the corresponding right-hand side represents the increase and stock of wealth in the current period, and the income  $Y_t^H$  can be expressed as:

$$Y_t^H = (W_t^H L_t^H + A_t^H) + (r_t^k z_t^H K_{t-1}^H - \Psi(z_t^H) K_{t-1}^H) + Div_t^H \quad (4.31)$$

From the above equation,  $Y_t^H$  can be found to depend on household labour income  $W_t^H L_t^H$ , income from risk-free securities  $A_t^H$ , return on physical capital rentals  $r_t^k z_t^H K_{t-1}^H - \Psi(z_t^H) K_{t-1}^H$  after deducting the variable costs of capital inputs, and dividends  $Div_t^H$ , where  $z_t^H$  denotes the capital utilisation rate.

When the level of the nominal market interest rate is denoted by  $R_t = b_t^{-1}$ , the first-order condition for maximisation in equations 4.27 and 4.30 can be expressed as:

$$E \left[ \beta \frac{\lambda_{t+1} R_t P_t}{\lambda_t P_{t+1}} \right] = 1 \quad (4.32)$$

where  $\lambda_t = \varepsilon_t^B (C_t - H_t)^{-\sigma_e}$ . Assuming that the private household is the price-setter of labour in the economic system, and that the probability that it will change the price of labour in each period is  $1 - \xi_w$ , such that the private household  $H$  adjusts the price of labour to  $\tilde{w}_t^H$  at time  $t$ , and assuming that the coefficient of adjustment of wages to fluctuations in the price level is  $\gamma_w$ , then:

$$W_t^H = \left( \frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_w} W_{t-1}^H \quad (4.33)$$

For the coefficient  $\gamma_w$ , when  $\gamma_w = 0$ , the household sector does not adjust wages in response to price fluctuations, and when  $\gamma_w = 1$  it adjusts wages accordingly to the price fluctuations of the previous period. Under equation 4.30, private households adjust their labour supply to maximise equation 1, and their demand function can be expressed as:

$$L_t^H = \left( \frac{W_t^H}{W_t} \right)^{\frac{1+\lambda_{w,t}}{\lambda_{w,t}}} L_t \quad (4.34)$$

In equation 4.34,  $L_t$  denotes the aggregate labour demand in the economy,  $\lambda_{w,t}$  is the volatility variable of labour remuneration,  $W_t$  is the level of remuneration in the economy in the aggregate form,  $L_t$  and  $W_t$  can be expressed as:

$$L_t = \left[ \int_0^1 (L_t^H)^{\frac{1}{1+\lambda_{w,t}}} dH \right]^{1+\lambda_{w,t}} \quad (4.35)$$

$$W_t = \left[ \int_0^1 (W_t^H)^{-1/\lambda_{w,t}} dH \right]^{-\lambda_{w,t}} \quad (4.36)$$

Also combining equations 4.27, 4.30 and 4.33, the optimal path of labour compensation adjustment can be described as:

$$\frac{\tilde{w}_t}{P_t} E_t \sum_{i=0}^{\infty} \beta^i \xi_w^i \left( \frac{P_t/P_{t-1}}{P_{t+i}/P_{t+i-1}} \right)^{\gamma_w} \frac{L_{t+i}^H}{1+\lambda_{w,t+i}} \frac{\partial U_{t+i}^H}{\partial C_{t+i}^H} = E_t \sum_{i=0}^{\infty} \beta^i \xi_w^i L_{t+i}^H \frac{\partial U_{t+i}^H}{\partial L_{t+i}^H} \quad (4.37)$$

Equation 4.37 indicates that the marginal returns of the household sector after adjusting labour remuneration can cover the marginal consumption expenditure of the household. Combined with equation 4.36, the level of remuneration in the economic system can be expressed as:

$$(W_t)^{-1/\lambda_{w,t}} = \xi_w \left( W_{t-1}^{-1/\lambda_{w,t}} (P_{t-1}/P_{t-2})^{-\gamma_w/2\lambda_{w,t}} \right) + (1 - \xi_w) \tilde{w}_t^{-1/\lambda_{w,t}} \quad (4.38)$$

In the vicinity of the steady state, the labour requirements supplied by private households, corrected for labour prices based on price factors, are equal to the demand of intermediate firms, and the log-linearized equations for consumption behaviour  $C_t$ , labour demand  $L_t$ , and the level of real wages  $w_t$  can be expressed as<sup>29</sup>:

$$\hat{C}_t = \frac{h}{1+h} \hat{C}_{t-1} + \frac{1}{1+h} E_t \hat{C}_{t+1} - \frac{1-h}{(1+h)\sigma_c} (\hat{R}_t - E_t \hat{\pi}_{t+1}) + \frac{1-h}{(1+h)\sigma_c} (\hat{\xi}_t^B - E_t \hat{\xi}_{t+1}^B) \quad (4.39)$$

$$\hat{L}_t = -\hat{w}_t + (1 + \Psi) \hat{r}_t^k + \hat{K}_{t-1} \quad (4.40)$$

$$\hat{w}_t = \frac{1}{1+\beta} \{ \beta E_t \hat{w}_{t+1} + \hat{w}_{t-1} + \beta E_t \hat{\pi}_{t+1} - (1 + \beta \gamma_w) \hat{\pi}_t + \gamma_w \hat{\pi}_{t-1} - \frac{\lambda_{w,t}(1 - \beta \xi_w)(1 - \xi_w)}{[\lambda_{w,t} + (1 + \lambda_{w,t})\sigma_t] \xi_w} \left[ \hat{w}_t - \sigma_t \hat{L}_t - \frac{\sigma_c}{1-h} (\hat{C}_t - h \hat{C}_{t-1}) - \hat{\xi}_t^l \right] \} \quad (4.41)$$

In the steady state deviation equation for consumption behaviour, the variable  $\pi_t$

<sup>29</sup> The symbol  $\hat{\cdot}$  is added to the variable to indicate its logarithmic deviation from the steady state, the same as below.

denotes inflation.  $\widehat{R}_t$  changes in the opposite direction to  $\widehat{C}_t$ , suggesting that an increase in  $\widehat{R}_t$  will cause private households to save more and thus spend less on consumption, which is in line with our expectation. When  $h = 0$ , equation 4.39 can be reduced to a general consumption equation. In equation 4.40,  $\Psi^{30}$  is a constant. From the expression  $\widehat{L}_t$  for the steady state deviation of labour demand, it is easy to see that labour demand is negatively correlated with real wages and positively correlated with the level of capital, which is in line with the relevant economic theories.

## 2) Producers

In an economic model with many monopolistically competitive intermediaries and perfectly competitive final goods producers, we assume that the final goods production function is as:

$$Y_t = \left( \int_0^1 (y_t^j)^{1/(1+\lambda_{p,t})} dj \right)^{1+\lambda_{p,t}} \quad (4.42)$$

In equation 4.42,  $y_t^j$  denotes the output of intermediate good  $j$ ,  $\lambda_{p,t}$  is the price volatility variable, and the vendor cost minimisation problem can be formulated as:

$$y_t^j = (p_t^j / P_t)^{\frac{1+\lambda_{p,t}}{\lambda_{p,t}}} Y_t \quad (4.43)$$

where  $p_t^j$  denotes the price of intermediate good  $j$ . Since we assume that the final good in the model is in a perfectly competitive market,  $P_t$  can be described as:

$$P_t = \left( \int_0^1 (p_t^j)^{\frac{1}{\lambda_{p,t}}} dj \right)^{-\lambda_{p,t}} \quad (4.44)$$

We assume that households in the economic system lease physical capital from producers at a price  $r_t^k$ , and can realise further capital gains by making additional investments  $I_t^{31}$ . The amount of capital in the economic system can be expressed as:

$$K_t = K_{t-1}(1 - \delta) + (1 - S(\varepsilon_t^I I_t / I_{t-1})) I_t \quad (4.45)$$

<sup>30</sup> The expression for the derivation of the constant  $\Psi$  can be found in Christiano et al. (2001).

<sup>31</sup> Assuming that investment in the household sector can have an impact on the capital utilisation rate.

In equation 4.45,  $\delta$  denotes the capital depreciation rate.  $S(\cdot)$  is a function of variable  $I_t/I_{t-1}$ <sup>32</sup>, which takes the value of 0 near the steady state of the economy, and  $\varepsilon_t^I$  is set to be a shock of the form  $AR(1)$  that satisfies:

$$\ln \varepsilon_t^I = \rho_t \ln \varepsilon_{t-1}^I + \eta_{t,t}, \quad \eta_t, \text{i.i.d.} N(0, \tilde{\sigma}_t^2) \quad (4.46)$$

We assume that the demand for  $K$  by the intermediate goods producer is the same as the supply by the private household near the steady state of the economy. Based on equation 4.32, equation 4.45 and the first-order condition of profit maximisation for the producer, the following expression can be obtained:

$$Q_t = E_t \left( \beta \frac{\lambda_{t+1}}{\lambda_t} \left( Q_{t+1} (1 - \delta) + z_{t+1} r_{t+1}^k - \Psi(z_{t+1}) \right) \right) \quad (4.47)$$

$$Q_t S' \left( \frac{\varepsilon_t^I I_t}{I_{t-1}} \right) \frac{\varepsilon_t^I I_t}{I_{t-1}} + \beta E_t Q_{t+1} \frac{\lambda_{t+1}}{\lambda_t} S' \left( \frac{\varepsilon_{t+1}^I I_{t+1}}{I_t} \right) \frac{\varepsilon_{t+1}^I I_{t+1}}{I_t} = 1 \quad (4.48)$$

Then the production function for intermediate  $j$  can be expressed as a classic Cobb-Douglas function:

$$y_t^j = A_t \tilde{K}_{j,t}^\alpha L_{j,t}^{1-\alpha} - \Phi \quad (4.49)$$

In equation 4.46,  $\ln A_t = \rho_a \ln A_{t-1} + \eta_{a,t}$  is a technology shock that satisfies  $\eta_{a,t} \text{ i.i.d. } N(0, \tilde{\sigma}_a^2)$ .  $\alpha$  is a parameter for the proportion of inputs to  $\tilde{K}_{j,t}$ ,  $\tilde{K}_{j,s} = z_t K_{j,t-1}$  and  $L_{j,t}$  are inputs to the production of intermediate good  $j$ , and  $\Phi$  is a constant cost. Cost minimisation can be translated into the following conditions:

$$\frac{W_t L_{j,t}}{r_t^k \tilde{K}_{j,t}} = \frac{1-\alpha}{\alpha} \quad (4.50)$$

The marginal cost and profit of intermediate firm  $j$  are given by equations 4.51 and 4.52, respectively:

$$MC_t = \frac{1}{A_t} W_t^{1-\alpha} (r_t^k)^\alpha ((1-\alpha)^{-(1-\alpha)}) \quad (4.51)$$

$$\Pi_t^j = (p_t^j - MC_t) \left( \frac{p_t^j}{P_t} \right)^{\frac{1+\lambda_{p,t}}{\lambda_{p,t}}} Y_t - MC_t \Phi \quad (4.52)$$

We follow the classical setting of Calvo (1983) on price stickiness, such that the

<sup>32</sup> The exact form of the function can be found in Christiano et al. (2001).

probability of a producer's price adjustment is set to  $1 - \xi_p$ , and the first-order conditional expression arising from the optimal behaviour of the producer in terms of expenditure is:

$$E_t \sum_{i=0}^{\infty} \beta^i \xi_p^i \lambda_{t+i} \mathcal{Y}_{t+i}^j \left( \frac{p_t^j P_{t-1+i}}{P_{t-1} P_{t+i}} - (1 + \lambda_{p,t+i}) MC_{t+i} \right) = 0 \quad (4.53)$$

The price variable equation can be further recursively organised by combining equation 4.44 as:

$$P_t^{-1/\lambda_{p,t}} = \xi_p \left( \frac{P_{t-1}}{P_{t-2}} \right)^{-1/\lambda_{p,t}} + (1 - \xi_p) (p_t^j)^{-1/\lambda_{p,t}} \quad (4.54)$$

Let  $G_t$  denote government purchases, then output in equilibrium can be represented by the consumption demand of private households, the investment demand and the government's purchase demand:

$$Y_t = C_t + G_t + I_t + \Psi(z_t) K_{t-1} \quad (4.55)$$

The linearised equations for the variables investment  $I_t$ , capital  $K_t$ , inflation  $\pi_t$  and aggregate output  $Y_t$  near the steady state of the model can be expressed as:

$$\hat{I}_t = \frac{1}{1+\beta} (\hat{I}_{t-1} + \beta E_t \hat{I}_{t+1} + \varphi \hat{Q}_t - \beta E_t \hat{\varepsilon}_{t+1}^I + \hat{\varepsilon}_t^I) \quad (4.56)$$

$$\hat{K}_t = (1 - \delta) \hat{K}_{t-1} + \delta \hat{I}_{t-1} \quad (4.57)$$

$$\hat{\pi}_t = \frac{1}{1+\beta} \left\{ \beta E_t \hat{\pi}_{t+1} + \hat{\pi}_{t-1} + \frac{(1-\beta\xi_p)(1-\xi_p)}{\xi_p} [\alpha \hat{r}_t^k + (1-\alpha) \hat{w}_t - \hat{A}_t + \eta_t^p] \right\} \quad (4.58)$$

$$\hat{Y}_t = (1 - \delta\alpha - g) \hat{C}_t + \delta\alpha \hat{I}_t + g \varepsilon_t^G = \hat{A}_t + \alpha \hat{K}_{t-1} + \alpha \Psi \hat{H}_t^k + (1 - \alpha) \hat{L}_t \quad (4.59)$$

In equations 4.56 to 4.59<sup>33</sup>,  $g$  is the expenditure-output ratio near the steady state, and  $\varepsilon_t^G$  is the AR(1) form of the fiscal policy shock characterised by fluctuations in government purchases, specifically  $\ln \varepsilon_t^G = \rho_G \ln \varepsilon_{t-1}^G + \eta_{G,t}$ , and satisfying  $\eta_{G,t} \text{ i.i.d. } N(0, \tilde{\sigma}_G^2)$ .

### 3) Government sector

In our model, the function of the government sector is to provide money  $M_t$ , issue risk-free bonds  $B_t$  and pay interest  $R_t B_{t-1}$ , collect taxes  $T_t$  from private households

<sup>33</sup> The expression for the derivation of constant  $\varphi$  can be found in Christiano et al. (2001).

and make government purchases  $G_t$ . Then the expression for the government sector's revenue and expenditure is:

$$\frac{M_t - M_{t-1}}{P_t} + \frac{B_t}{P_t} + T_t = \frac{R_t B_{t-1}}{P_t} + G_t \quad (4.60)$$

It is important to emphasise that, under this arrangement, the PBOC lacks independence. The People's Bank of China, as the central bank of China, has thus far preserved its nominal and definitional independence, while effectively functioning as both policymaker and enforcer. This is determined by China's unique economic system and aligns with our prior discussion regarding the evolution of the PBOC.

#### 4) Monetary authority

We continue to follow the typical setting of a monetary policy rule, where the monetary authority adjusts different attributes of the policy instruments through a variety of policy instruments in response to fluctuations in the price and output levels in the economic system. Based on our research targets, we will set up the interest rate instrument equation and the monetary instrument equation in the model to identify the changes in the model's ability to fit the economic system and the changes in the policy instruments' regulation ability after the introduction of the policy expectation factor. In this chapter, we refer to the methodology of Zhuang (2018) to portray the modelling of the regulatory behaviour of China's monetary authority. Specifically, on the one hand the quantitative regulatory behaviour of China's monetary authority can be expressed by:

$$\begin{aligned} \hat{m}_t &= \sigma_c \sigma_{m_t}^{-1} (1 - h)^{-1} (\hat{C}_t - h \hat{C}_{t-1}) - \sigma_m^{-1} (\bar{R} - 1) \hat{R}_t \\ \hat{m}_t &= \hat{m}_{t-1} - \hat{\pi}_t + \hat{v}_t \\ \hat{v}_t &= \rho_v \hat{v}_{t-1} + \xi_t E_t \hat{\pi}_{t+1} + \xi_2 \hat{Y}_t + \hat{\varepsilon}_{M,t} \\ \hat{\varepsilon}_{M,t} &= \rho_M \hat{\varepsilon}_{M,t-1} + \eta_{M,t} \end{aligned} \quad (4.61)$$

In equation 4.61,  $\bar{R}$  is the steady-state interest rate level,  $v_t$  is the growth rate of money supply,  $\hat{\varepsilon}_{M,t}$  is the quantity shock to money,  $\rho_v$  is the growth rate smoothing parameter, the response coefficients of  $\hat{\pi}_{t+1}$  and  $\hat{Y}_1$  are  $\xi_1$  and  $\xi_2$ , respectively, and  $\sigma_m$  is the first-order lag parameter of the quantity-based policy shock. In order to be able to introduce expectations into the behaviour of the monetary authority, following the discussion in Gomes (2017) on the form in which shocks are modelled in the model, we assume that in equation 4.61 we have:

$$\eta_{M,t} = \eta_{M,t}^0 + \eta_{M,t-1}^1 + \dots + \eta_{M,t-n}^n \quad (4.62)$$

In equation 4.62,  $\eta_{M,t}^0$  is the part of the  $\eta_{M,t}$  decomposition presented in period  $t$ , i.e., unintended quantitative shocks, while  $\eta_{M,t-1}^1$ ,  $\eta_{M,t-2}^2$ , etc. are the pre- $t$  period factors, i.e., intended quantitative shocks.

On the other hand, the equation of interest rate regulation behaviour of our central bank can be expressed as:

$$\hat{R}_t = \lambda_1 \hat{R}_{t-1} + \lambda_2 (E\hat{\pi}_t \hat{\pi}_{t+1} - \pi_t) + \lambda_3 \hat{\pi}_t + \lambda_4 \hat{Y}_t + \hat{\varepsilon}_{R,t} \quad (4.63)$$

$$\hat{\varepsilon}_{R,t} = \rho_R \hat{\varepsilon}_{R,t-1} + \eta_{R,t} \quad (4.64)$$

Decompose  $\eta_{R,t}$  as:

$$\eta_{R,t} = \eta_{R,t}^0 + \eta_{R,t-1}^1 + \dots + \eta_{R,t-n}^n \quad (4.65)$$

We define the  $t$  period factor  $\eta_{R,t}^0$ , obtained after  $\eta_{R,t}$  is decomposed, as an unexpected shock to interest rate policy, and the corresponding  $\eta_{R,t-1}^1$ ,  $\eta_{R,t-2}^2$ , etc. as expected shocks.

### 4.3.3 Model interpretation

Within the framework of the aforementioned DSGE model, the impulse response function (IRF) is derived from the optimization behavior of microeconomic agents and the transmission mechanism of dynamic stochastic general equilibrium. The model's

structured design rigorously presents its relationship with unconventional monetary policy. This section will examine the effectiveness of combination monetary policy, necessitating an explanation of the logical derivation of the IRF within this model and its relationship to unconventional monetary policy.

The mathematical implementation of the IRF starts with the steady-state solution of the economic system, followed by the development of a state-space form using linearised behavioural equations, such as the household consumption Euler equation (Equation 4.39) and the firm pricing rule (Equation 4.58). Exogenous policy shocks, such as quantity shocks  $\hat{\varepsilon}_{M,t}$  or interest rate shocks  $\hat{\varepsilon}_{R,t}$ , induce a dynamic adjustment path in the system, which is illustrated by the impulse response function (IRF) under rational expectations. Essential steps in key derivation encompass:

① Systematic breakdown of anticipated elements. In this model, policy shocks are divided into unexpected components ( $\eta_{M,t}^{(0)}$ ,  $\eta_{R,t}^{(0)}$ ) and expected components (such as  $\eta_{M,t-6}^{(6)}$ ,  $\eta_{R,t-12}^{(12)}$ ). The latter is incorporated into the model using a lag operator (Equations 4.62 and 4.65) to reflect the PBOC's forward guidance, such as signal release in LPR reforms, despite the absence of definitive quantitative indicators, in shaping private sector expectations.

② Bayesian posterior estimation. Parameters of policy rules, including the expected inflation coefficient  $\xi_1$  for quantitative tools and the smoothing parameter  $\lambda_1$  for interest rate tools, are estimated using Chinese macroeconomic data from January 2005 to December 2022. IRF calculations utilize posterior distribution sampling to produce 90% confidence intervals, effectively delineating the boundaries of policy effects amid parameter uncertainty.

Furthermore, unconventional monetary policies have been integrated into the model, while preserving the distinctive features of China's monetary policy. For instance, quantity-based tools result in increased liquidity within the banking system due to the money supply equation (Equation 4.61). This increase subsequently enhances investment (Equation 4.56) and output (Equation 4.59) via the credit channel, thereby demonstrating its transmission mechanisms. Price-based tools experience a reduction in financing costs due to interest rate shocks, as described by the interest rate rule (Equation 4.63). This reduction stimulates intertemporal substitution in consumption (Equation 4.39) and influences inflation expectations (Equation 4.58). The distinction between including an expectation factor and excluding it in expectation management tools can substantiate its enhancing impact on policy effectiveness. Furthermore, the simultaneous integration of quantity-based and price-based monetary policies (Equations 4.61 and 4.63) illustrates China's approach to unconventional monetary policy coordination, which is marked by a division of labor, complementarity, and dynamic coordination.

Overall, this section establishes a robust connection between the DSGE model and China's unconventional monetary policy through three fundamental designs. The M2 growth rate is governed by a quantity rule, while the interest rate rule is responsive to SHIBOR, reflecting China's dual-pillar regulatory framework and illustrating specific policy rules. Secondly, shock decomposition offers a microfoundation for central bank forward guidance, with the lag order established through a Bayesian model comparison of endogenous parameters (Table 4.20) to illustrate a unique expectation mechanism. The IRF demonstrates characteristics of division of labor, validating the PBOC's asserted monetary policy operations and transformation strategy. This provides a theoretical foundation for optimizing policy combinations to identify effect

heterogeneity.

### 4.3.4 Data processing and parameter estimation

#### 1) Data selection and processing

Based on the structure of the DSGE model in the previous section and with reference to the publication of China's macroeconomic data, we select Output Gap, CPI, M2 growth rate and SHIBOR as the original data samples of  $Y_t$ ,  $\pi_t$ ,  $v_t$  and  $R_t$  in the model, with the sample interval from 2005M1 to 2022M12 and the frequency of monthly.

- i)  $Y_t$ : Refer to the monthly output gap obtained from our measure using the Model Averaging<sup>34</sup> method as the data sample  $Y_t$ .
- ii)  $\pi_t$ : We use CPI year-on-year data to proxy for fluctuations in  $\pi_t$ . Because of its more pronounced quarterly characteristics, we subject it to the X-12 treatment.
- iii)  $v_t$ : We use the monthly M2 growth to represent the change in  $v_t$ .
- vi)  $R_t$ : We characterise the trend of  $R_t$  based on the SHIBOR. Note that the SHIBOR indicator was only published from 2006M10 onwards. Therefore, for data from 2005M1 to 2006M9, we have chosen to use the interbank lending rate IBO1M instead.

<sup>34</sup> See section 4.2.3 and Appendix 1.

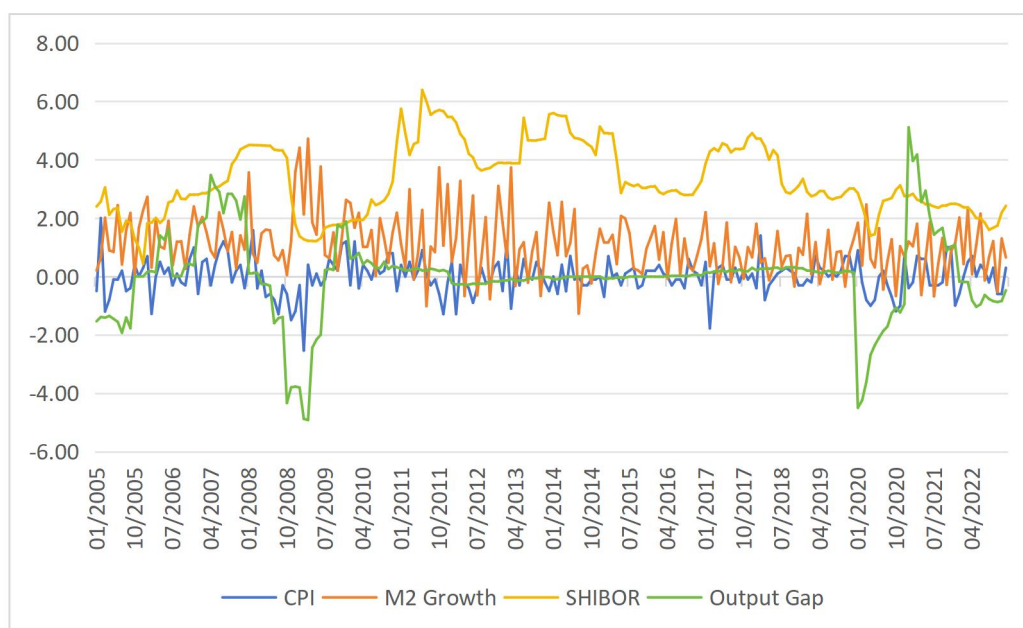


Figure 4.20: Parameter trends

The numerical trend of the indicators in the DSGE model as we preset it is displayed in Figure 4.20. The model simulates the remaining indications in a hypothetical manner.

## 2) Parameter calibration and setup

A large number of linear equations are constructed in the DSGE model to portray the economic behaviours of different sectors, so there are many parameters in the model to represent the behaviours of economic agents. We need to calibrate some of the parameters to provide effective support for Bayesian estimation of the parameters of interest.

It is worth noting that there is a commonality in the parameter calibration process. Specifically, based on the specific meaning of the model equations and referring to Milani and Treadwell (2011), we assume that the  $AR(1)$  coefficients in the shock equations obey the beta distribution and their standard deviation is 0.1. In addition, the S.D. of the shocks obey the Inv.Gamma distribution. In addition, we refer to Liu

(2010) and Herbst and Schorfheide (2015) for a priori assignments to the parameters to be estimated. Finally, the calibration of our parameters and the specifics of the a priori assignments to be estimated are shown in Tables 4.18 and 4.19, respectively.

Table 4.18: Parameter calibration

<b>Parameter</b>	<b>Definition</b>	<b>Priori mean</b>
$\beta$	Discount factor	0.9800
$h$	Consumption inertia factor	0.6000
$\sigma_l^{-1}$	Household labour supply elasticity	0.3300
$\sigma_c^{-1}$	Intertemporal elasticity of substitution of consumption	0.8500
$\sigma_m^{-1}$	Money demand elasticity	2.0000
$\delta$	Capital depreciation	0.0250
$\gamma_w$	Wage adjustment factor	0.3500
$\alpha$	Production function capital input ratio	0.6500
$\rho_G$	AR(1) coefficient on government purchase shocks	0.5000

Table 4.19: Priori assignment of parameters to be estimated

<b>Parameter</b>	<b>Definition</b>	<b>Prior distribution</b>	<b>Priori mean</b>	<b>Standard Error</b>
$\rho_B$	Discount factor shock AR(1) factor	beta	0.5000	0.1000
$\eta_B$	Discount factor shock standard deviation	Inv.Gamma	0.1000	Inf.
$\rho_m$	Money demand shock AR(1) coefficient	beta	0.5000	0.1000
$\eta_m$	Standard deviation of money demand shock	Inv.Gamma	2.0000	Inf.
$\rho_l$	Labour supply shock AR(1) coefficient	beta	0.5000	0.1000
$\eta_l$	Standard deviation of labour supply shock	Inv.Gamma	2.0000	Inf.
$\xi_w$	Wage price stickiness	beta	0.6000	0.1000
$\rho_I$	Investment shock AR(1) coefficient	beta	0.5000	0.1000
$\eta_I$	Standard deviation of investment shock	Inv.Gamma	2.0000	Inf.
$\rho_\alpha$	Technology shock AR(1) coefficient	beta	0.8000	0.1000
$\eta_\alpha$	Standard deviation of technology shocks	Inv.Gamma	5.0000	Inf.
$\xi_p$	Product price stickiness	beta	0.8000	0.1000
$\eta_G$	Government purchase shock standard deviation	Inv.Gamma	2.0000	Inf.
$\rho_v$	Quantity rule smoothing parameter	beta	0.8000	0.1000
$\xi_1$	Quantity rule expected inflation coefficient	Normal	1.0000	0.1000
$\xi_2$	Quantity rule output parameter	Normal	0.5000	0.1000
$\rho_M$	Quantity shock AR(1) coefficient	beta	0.7500	0.1000
$\eta_M$	Standard deviation of quantity shocks	Inv.Gamma	3.0000	Inf.
$\lambda_1$	Interest rate shock smoothing coefficient	beta	0.8000	0.1000
$\lambda_2$	Interest rate rule expected inflation coefficient	Normal	0.5200	0.1000
$\lambda_3$	Interest rate rule inflation coefficient	Normal	0.6000	0.1000
$\lambda_4$	Interest rate rule output coefficient	Normal	0.1200	0.1000
$\rho_R$	Interest rate shock AR(1) coefficient	beta	0.5100	0.1000

Parameter	Definition	Prior distribution	Prior mean	Standard Error
$\eta_R$	Standard deviation of interest rate shocks	Inv.Gamma	3.0000	Inf

### 3) Shock path recognition

In equations 36 and 39, we define the general form of policy shocks. Since the specific form of lags in the shock function affects the model structure and hence the Bayesian estimation of the parameters to be estimated, we should first effectively identify the shock paths based on different assumptions when performing the Bayesian estimation of the parameters. We refer to Milani and Treadwell (2011) and Gomes (2017) to set the maximum lag order of the expected factors in equations 36 and 39 to  $36(n \leq 36)$ , and select possible combinations of lagged factors (e.g.,  $n = 3$ ;  $n = 6$ ;  $n = 3,6$ ;  $n = 12,24$ ;  $n = 3,12,24$ , etc.). This allows us to compare the marginal densities of different policy equations with different orders of one lag and combinations of multiple lags, thus identifying the effective form of shocks that can be fitted to the data. The results are shown in Table 4.20.

Table 4.20: Marginal densities for different forms of policy equations

Quantity shocks				Interest rate shocks			
Single factor lag	Marginal density	Multi-factor combination n lag	Marginal density	Single factor lag	Marginal density	Multi-factor combination lag	Marginal density
n=0	88.3271	n=3,6	71.2348	n=0	124.6358	n=3,6	110.3231
n=3	85.7944	n=3,12	70.8123	n=3	129.3674	n=3,12	112.1749
n=6	97.7482	n=12,24	62.6389	n=6	130.7345	n=12,24	108.7864
n=9	84.1592	n=3,6,9	69.2174	n=9	128.3747	n=3,6,9	105.348
n=12	84.7639	n=3,12,24	65.3656	n=12	141.8673	n=3,12,24	104.6483

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n=15	85.3864	n=12,24,36	60.7862	n=15	134.2754	n=12,24,36	101.4752
n=18	83.749	n=3,6,9,12	62.6184	n=18	123.6493	n=3,6,9,12	102.4175
n=21	86.8471	n=3,12,24,36	61.3728	n=21	127.1385	n=3,12,24,36	100.9102
n=24	84.3411			n=24	122.3294		
n=27	85.8725			n=27	125.5349		
n=30	82.0336			n=30	118.1934		
n=33	81.6384			n=33	118.2745		
n=36	82.4385			n=36	117.0691		

---

From Table 4.13, we find that for different forms of policy equations, the marginal densities are larger after setting a single-element lag in the model than in the case of setting a multi-element lag combination. This suggests that the multivariate compound effect of policy expectations in our DSGE model is not significant after combining the data.

Further, for the one-factor lag model with quantity shocks, the marginal densities at  $n = 6$  are higher than the other values, suggesting that the behavioural equations under this setting ( $n = 6$ ) when considering only the quantity policy are a better fit with the modelling system we have set up and with the data.

Similarly, for the one-factor lag model with interest rate shocks, the case when the marginal density is higher at  $n = 12$  than the other values suggests that a better fit is obtained by considering only the behavioural equations of the setting ( $n = 12$ ) when interest rate policy is taken into account, together with the modelling system we have set up and the data.

To sum up, we set the shock equations considering policy expectations as follows: (1)

Quantitative shocks with a lagged factor of order  $n = 6$ ; (2) Interest rate shocks with a lagged factor of order  $n = 12$ .

In addition, our estimates include the case where only unanticipated policy shocks are considered (at  $n = 0$ ) and the marginal density is smaller than in the presence of policy expectations. This also illustrates the necessity of introducing policy expectations into the model in terms of the value of the marginal density.

#### 4) Bayesian estimation of parameters

Based on our identification of the shock equations, in order to further illustrate the impact of the introduction of expectations on the model estimation results, we estimate the model with quantity shocks and interest rate shocks separately, and then compare the Bayesian estimation results before and after the inclusion of policy expectations in the same shock framework. The comparison of the estimation results is shown in Tables 4.21 and 4.22.

Table 4.21: Model parameter estimation results including quantity-based shocks

Parameter	Definition	Without expected factors		With expected factors	
		Posterior mean	90% CI	Posterior mean	90% CI
$\xi_w$	Wage Price Stickiness	0.5371	[0.3998,0.6614]	0.5745	[0.4582,0.7024]
$\xi_p$	Product price stickiness	0.7845	[0.7527,0.8153]	0.7539	[0.7120,0.8015]
$\rho_\alpha$	Technology shock AR(1) coefficient	0.7026	[0.6063,0.8132]	0.5075	[0.3798,0.6197]
$\eta_\alpha$	Standard deviation of technology shocks	2.9832	[2.0249,3.9476]	2.8342	[2.1907,3.4364]
$\rho_v$	Quantity rule smoothing parameter	0.7219	[0.5452,0.9038]	0.6847	[0.5364,0.8312]

$\xi_1$	Quantity rule expected inflation coefficient	3.1374	[2.9943,3.2731]	3.1781	[3.0693,3.2931]
$\xi_2$	Quantity rule output parameter	0.5231	[0.4284,0.6112]	0.5317	[0.4074,0.6601]
$\rho_M$	Quantity shock AR(1) coefficient	0.6583	[0.5237,0.7365]	0.6294	[0.4879,0.7596]
$\eta_M$	Standard deviation of quantity shocks	0.8057	[0.6512,0.9384]	-	-
$\eta_M^0$	Standard deviation of unanticipated quantity shocks	-	-	0.7553	[0.6487,0.8605]
$\eta_M^2$	Standard deviation of expected quantity shocks	-	-	0.8367	[0.6836,0.9847]

Table 4.22: Model parameter estimation results including interest rate shocks

Parameter	Definition	Without expected factors		With expected factors	
		Posterior mean	90% CI	Posterior mean	90% CI
$\xi_w$	Wage Price Stickiness	0.5634	[0.4483,0.6912]	0.5412	[0.4234,0.6647]
$\xi_p$	Product price stickiness	0.8572	[0.8323,0.8790]	0.8631	[0.8129,0.9201]
$\rho_\alpha$	Technology shock AR(1) coefficient	0.6523	[0.5374,0.6728]	0.6256	[0.4922,0.7468]
$\eta_\alpha$	Standard deviation of technology shocks	2.2453	[1.6231,2.8363]	2.0637	[1.3953,2.8059]
$\rho_v$	Quantity rule smoothing parameter	0.5046	[0.3843,0.6281]	0.4595	[0.3468,0.5612]

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	Quantity rule				
$\xi_1$	expected inflation coefficient	1.5291	[1.4347,1.6296]	1.5539	[1.4305,1.6775]
$\xi_2$	Quantity rule output parameter	1.7262	[1.6182,1.8553]	1.7636	[1.6476,1.8837]
$\rho_M$	Quantity shock AR(1) coefficient	0.5646	[0.4595,0.6689]	0.5433	[0.4467,0.6506]
$\eta_M$	Standard deviation of quantity shocks	0.4268	[0.3015,0.5397]	0.3551	[0.2584,0.4516]
$\eta_M^0$	Standard deviation of unanticipated quantity shocks	0.8375	[0.7224,0.9446]	-	-
$\eta_M^2$	Standard deviation of expected quantity shocks	-	-	0.8122	[0.7263,0.9081]

---

As can be seen from Tables 4.21 and 4.22, in general, the estimates of the inflation and output coefficients are larger than the a priori levels when different forms of shock equations are included in the model. This implies that revealing the role of the monetary authority in the macroeconomic regulation process is relatively significant. In addition, the estimates of the smoothing coefficients of the policy instruments are smaller than the a priori setting, indicating that volatility of the quantitative policy instruments that deviates from the steady state can be recovered at a faster rate. To a certain extent, this suggests that the regulatory capacity of China's monetary policy has gradually improved in recent years compared with previous studies.

### 4.3.5 Effectiveness of unconventional monetary policy combination

#### 1) Impulse Response Analysis

We analysed and illustrated the shock response curves of the two main policy target variables, output and inflation, based on different model structures and sources of shocks, as described below. Where L represents left-hand side part of the figures and R represents right-hand side.

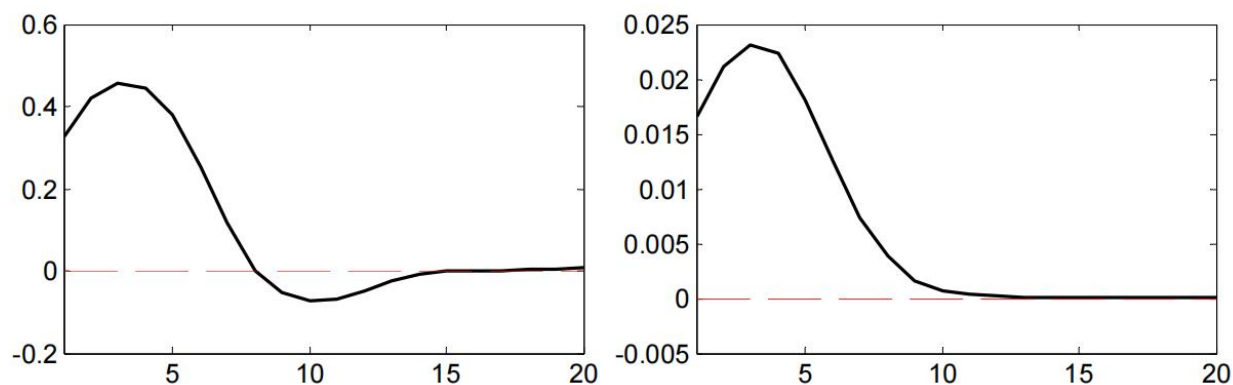


Figure 4.21: Output(L) and CPI(R) response to quantity shock<sup>35</sup>

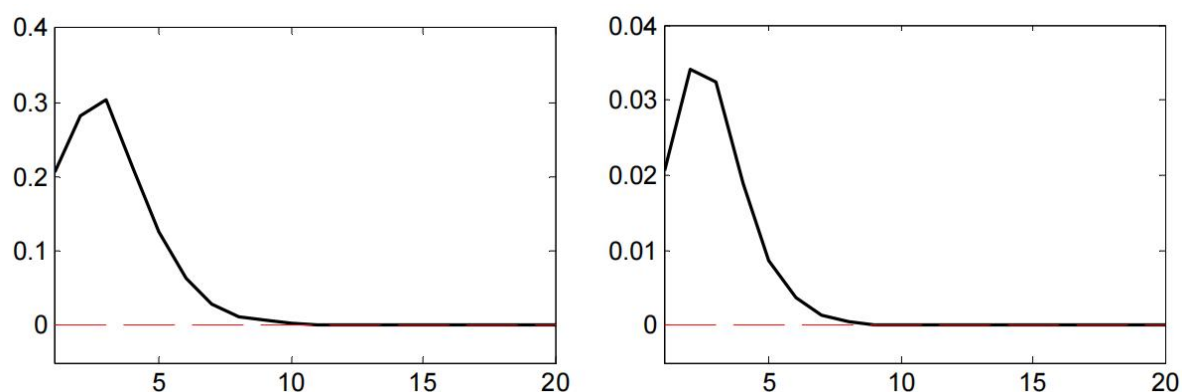


Figure 4.22: Output(L) and CPI(R) response to interest rate shock

<sup>35</sup> In the analysis of results in this section, the period in each figure and table is 3 months to simplify.

Figures 4.21 and 4.22 illustrate the response of output and inflation to monetary policy shocks when policy expectations are not taken into account. In Figure 4.21(L), a 1-unit quantity shock causes output to deviate<sup>36</sup> positively by about 0.326 (0.237,0.415) units after Period 1. The deviation peaks at 0.457 (0.362,0.552) units in Period 3 before falling to a negative value, and then output returns to its steady-state level around period 14. In Figure 4.21(R), inflation rises from an initial positive deviation of 0.017 (-0.010,0.024) units to a peak level of 0.023 (0.014,0.032) units in Period 3 following a 1-unit quantity shock, before converging to a steady state level around Period 11.

In Figure 4.22, on the one hand, output rises rapidly by 0.206 (0.132,0.280) units after a 1-unit interest rate shock and the deviation reaches a maximum of 0.303 (0.199,0.407) units in Period 3, and output returns to steady state in Period 10 under this model setting. On the other hand, inflation produces a maximum positive deviation of 0.034 (0.026,0.042) units in the peak period after a 1-unit interest rate shock and converges to steady state after 8 periods.

It is worth noting that when the quantity equations are introduced into the model, output fluctuates negatively in the process of convergence to the steady state after a policy shock, suggesting a certain degree of uncertainty about its effect in influencing output change. The numerical characteristics of the variable responses without considering policy expectations are shown in Table 4.23.

<sup>36</sup> Deviation refers to the deviation of a variable from its steady state level.

Table 4.23: Numerical characteristics of variable responses under different sources of shocks

Shock source	Output		Inflation	
	Quantity shock	Interest rate shock	Quantity shock	Interest rate shock
<b>Peak Response</b>	0.457 (0.303,0.611)	0.303 (0.193,0.413)	0.023 (0.015,0.031)	0.034 (0.025,0.043)
<b>Peak period</b>	3	3	3	2
<b>Response Period</b>	14	10	11	8

Figures 4.23 and 4.24 illustrate the response of the variables to different policy instrument shocks when policy expectations are taken into account in the modelling system. In Figure 4.22, the response paths of output and inflation to unanticipated quantity shocks are similar to those in Figure 4.21, and after accounting for policy anticipation factors, output and inflation show a reduced response, earlier peaks, and shorter response periods after unanticipated quantity shocks. As for the quantity policy expectation shock, on the one hand, output rises to a response peak of 0.421 (0.281,0.561) units after 4 periods after a 1-unit expectation shock, with an overall response period of 10 periods. On the other hand, the response of inflation after a 1-unit anticipation shock is essentially the same as the response to an unanticipated shock under this model structure. It is worth noting that output under the unanticipated shock also shows negative fluctuations during the convergence process, but the negative fluctuations are lower and short-lived compared to the model without the introduction of policy expectations. This suggests that the consideration of policy expectations in the model structure can reduce the uncertainty effect in the policy process to some extent.

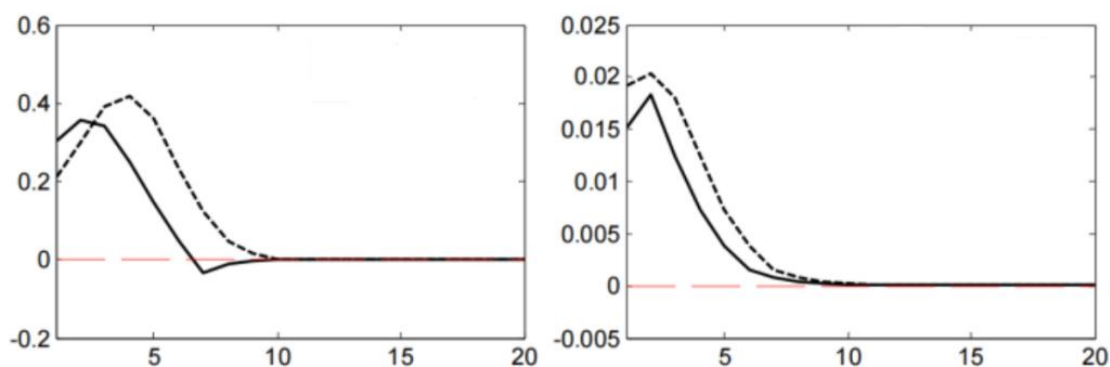


Figure 4.23: Output(L) and CPI(R) response to quantity shock

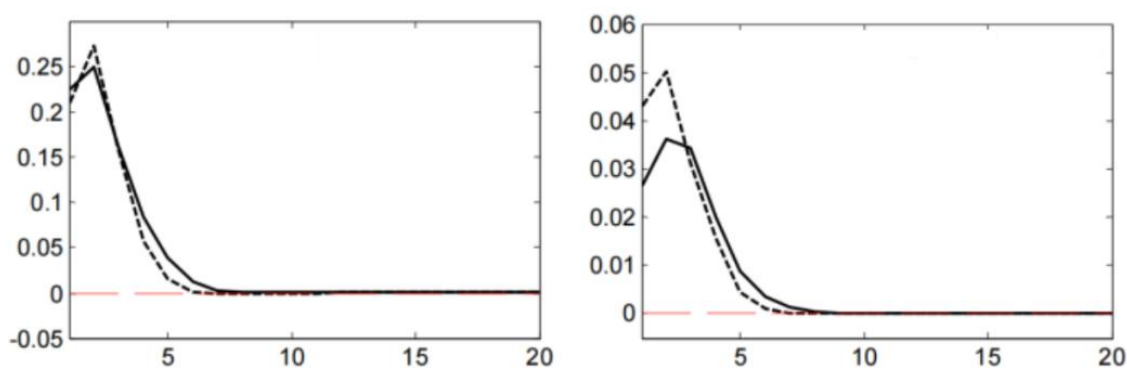


Figure 4.24: Output(L) and CPI(R) response to interest rate shock

When the interest rate regulation equation is introduced into the model, the response of the target variables to policy expectations and unanticipated shocks changes in a similar way, both showing a rapid response in the short run and returning to a steady state path in the medium run, and both reaching a peak in the response in Period 2. The difference is that, compared with the responses to unanticipated shocks in the models without and with policy expectations, the responses of output and inflation to expected interest rate shocks have larger peaks and converge more rapidly, which increases the ability of policy instruments to influence the target variables in the short run and reduces the risk of fluctuations in their effects in the medium and long run. The numerical characteristics of the heterogeneous shock responses after the introduction of the policy expectations factor in the model are shown in Table 4.24.

Table 4.24: Numerical characteristics of variable responses under different sources of shocks (considering expectations)

Response Indicator	Output (Unexpected Quantity Shock)	Output (Expected Quantity Shock)	Output (Unexpected Interest Rate Shock)	Output (Expected Interest Rate Shock)	Inflation (Unexpected Quantity Shock)	Inflation (Expected Quantity Shock)	Inflation (Unexpected Interest Rate Shock)	Inflation (Expected Interest Rate Shock)
Peak Response	0.356	0.421	0.251	0.273	0.018	0.020	0.036	0.510
	(0.257,0.455)	(0.271,0.571)	(0.194,0.308)	(0.168,0.378)	(0.011,0.025)	(0.014,0.026)	(0.022,0.050)	(0.314,0.706)
Peak Period	2	4	2	2	2	2	2	2
Response Period	9	10	8	7	9	9	8	7

Overall, output is more sensitive to regulation by quantitative instruments, while price instruments are better at regulating inflation. When expected shocks are included in the model, the source of the shocks and thus the effects of policy implementation and their paths can be more fully identified, and the aggregate form of shocks can have a more adequate moderating effect on the macroeconomic variables than if only the unanticipated policy scenario is considered. In addition, Table 4.24 shows that the effects of anticipatory policy shocks on the variables are more significant, again illustrating the need for monetary authorities to incorporate expectations management into the framework of the policy control system.

## 2) Variance decomposition analysis

Using variance decomposition analysis, the impact of including policy expectations in the model can be further illustrated in a comparative manner, as shown in Table 4.25. It is not difficult to find that when policy expectation factors are not considered in the model, in terms of different types of policy shock sources, quantitative instrument shocks have a higher explanatory capacity of about 57.58 percent for output deviations, while interest rate instrument shocks have a higher contribution of 25.61 percent to

changes in inflation. Further, when policy expectation shocks are included in the modelling process, the sources of shocks that have a superior ability to influence changes in the target variable do not change, in other words, the policy instruments that can effectively cause deviations in output and inflation are quantitative instruments and interest rate instruments, respectively.

Table 4.25: Variance decomposition in different model

Model structure	Modes of regulation	Type of shock	Target indicator	
			Output	Inflation
Without considering policy expectations	Quantitative regulation	Aggregate supply	41.08	82.76
		Aggregate demand	1.34	1.03
		Quantitative policy	57.58	16.21
		Aggregate Supply	48.91	67.57
	Interest rate regulation	Aggregate demand	21.05	6.82
		Interest rate policy	30.04	25.61
		Aggregate Supply	24.73	72.74
		Aggregate demand	0.88	0.69
Considering policy expectations	Quantitative regulation	Unanticipated quantity policy	31.65	10.31
		Anticipated quantity policy	42.74	16.26
		Aggregate policy shocks	74.39	26.57
	Interest rate regulation	Aggregate supply	58.43	35.94
		Aggregate demand	8.64	16.38
		Unanticipated interest rate policy	15.90	20.32
		Expected interest rate policy	17.03	27.36
		Aggregate policy shocks	32.93	47.68

In addition, the ability of policy shocks in general to explain fluctuations in the target variable is enhanced by the modelling achieved for the anticipation shocks. Table 4.25 demonstrates the contribution of different type of shocks to different model. The contribution of quantity shocks to changes in output increased from 57.58 percent to

74.39 percent, and their ability to explain fluctuations in inflation increased from 16.21 percent to 26.57 percent. In the case of interest rate regulation, its ability to influence output and inflation increased by 2.89 percent and 22.07 percent, respectively. It is worth noting that when anticipatory shocks are identified in the model structure, the anticipatable component of the shocks affects changes in the variables to a greater extent than the unanticipated component. This confirms one of the points summarised by the literature review that there is a need for PBOC to make full use of expectation management in order to enhance its ability to regulate the impact on the target variables. At the same time, combining the impulse response analysis and numerical characteristics in the previous section, we believe that China is in the process of transforming its monetary policy instrument system. At this stage, when conducting monetary control, we should fully consider and make use of the influence of the expectation factor on the effect of policy implementation, and select heterogeneous policy instruments for different policy targets to achieve the reasonable cooperation of quantitative and pricing instruments, and complete the precise control of the target variables.

#### **4.3.6 DSGE section conclusion**

This section constructs a DSGE model with heterogeneous shocks based on different types of policy instrument equations, and introduces the policy expectation factor in the model to compare its impact on the effectiveness of the target variable, and analyses the results through the identification of shock paths, impulse response curves and variance decomposition. The conclusions of this part are as follows. Firstly, when the policy expectation factor is introduced, the model can achieve a better fit with the data. Also the effective identification of the form of expected shocks makes the degree of response of instrumental variables to the fluctuation of the target variables all show

different degrees of change, which shows the necessity of introducing expected shocks in the model. Then, the impulse response analysis results show that inflation is more sensitive to the interest rate instrument regulation, the quantitative instrument regulation has a relatively large impact on output. However, the output is prone to reverse fluctuations under the quantitative shocks to reduce the effectiveness of regulation. When the expected and unanticipated shocks are identified, the expected shocks of the instrument variables have increased the impact on the fluctuations of the target variables, and the convergence period of the target variables has been shortened, which indicates that the consideration of the policy expectations in the model can enhance the regulatory ability of the policy instruments to a certain extent. Finally, according to the variance decomposition, it is pointed out again that the preferred sources of shocks affecting the fluctuation of output and inflation are the quantitative policy and interest rate policy, respectively, and the effective decomposition of the structure of the source of shocks can improve the degree of explanation of the changes of the target variable by the policy shocks, in other words, it can improve the effectiveness of the monetary policy.

# Chapter 5

## Measuring public inflation expectation

Expectations serve as the foundation for forward guidance monetary policy, encapsulating the assessments made by individuals and businesses regarding future economic trends. The assessment of micro-entities significantly influences their consumption and investment expenditures, ultimately impacting domestic output and economic performance. The examination of inflation expectations is crucial for the central bank in adapting price-based monetary policy and determining the appropriate level of policy interest rates. Expectation theory underpins various economic research frameworks, including the DSGE model, which necessitates the consideration of expectations regarding variable factors across multiple economic sectors. Additionally, the state-space model incorporates the Phillips curve alongside supplementary expectations. Expectations theory is significant as it posits that current spending and investment levels are influenced not only by present economic indicators but also by anticipated future economic conditions. The levels of economic indicators, both past and present, significantly affect expectations. Inflation expectations significantly influence financial product yields, market interest rates, and the development of the real economy and actual inflation levels. Inflation expectations significantly influence the effectiveness of monetary policy enacted by authorities.

Sims (2020) identified that financial innovation has resulted in a gradual reduction in the efficacy of traditional monetary policy instruments, highlighting the increasing significance of expectations management instruments. Cole (2018) identified that while expectations management plays a crucial role in the contemporary monetary policy

framework, significant uncertainty exists regarding the accurate estimation of inflation expectations among market participants, which in turn affects the effectiveness of monetary policy to some degree. Consequently, a more accurate assessment of the public's inflation expectations is essential in analyzing the PBOC's unconventional monetary policy response to Covid-19.

The interrelationship between monetary policy and inflation expectations is evident not only in the influence of monetary policy operations on fluctuations in inflation expectations but also in various other dimensions. Karia (2016) concluded that the stability of inflation expectations reflects not only the effectiveness of the monetary policy authority in managing inflation but also the commitment and credibility of the authority in ensuring price stability. Johan (2016) identified a significant correlation between a nation's actual inflation and the inflation expectations of experts and the market. However, the connection with residents' inflation expectations is less clear. This phenomenon is primarily attributed to the substantial professional background knowledge possessed by experts and markets, which significantly influences future price level trends in society. This perspective has faced growing scrutiny in recent years, particularly in studies concerning China, primarily due to the methodology employed by the PBOC in assessing public inflation expectations.

In particular, public inflation expectations can reflect, among other things, the influence of nearly all significant monetary policy choices on the public as well as the degree of credit of the central bank. However, despite the fact that policymakers recognise the significance of public inflation expectations, PBOC however, still uses a primitive questionnaire, to measure the public inflation expectation. A notable issue is that the design of the questionnaire by the PBOC is rather inadequate.

Simultaneously, the public is sometimes unable to provide a clear image of its own inflation expectations, but can perceive changes in the price level and so build a right but imperfect sense of what the price level will be in the next period. Numerous experiments have demonstrated that the inflation expectations of specialists are typically relatively accurate, however the statistics provided by the general public are highly biased, making it difficult for central banks to gauge inflation expectations. For example, Johan (2016) identified a significant correlation between a country's actual inflation and the inflation expectations of experts and markets; however, the connection with residents' inflation expectations is less clear. This phenomenon is attributed to the extensive background knowledge possessed by experts and markets.

As a result of the necessity to quantify inflationary expectations, economists from all over the world have employed a wide range of methods. The Federal Reserve, the Bank of Canada, and others, for instance, have chosen to issue Treasury Inflation-Protected Securities (TIPS), the Michigan survey method with a sample of households, the Livingston survey method with a sample of economists, the econometric model method represented by the Federal Reserve's MPS system, etc. Currently, according to an announcement by PBOC, the method used in China is a simple statistical survey method.



Figure 5.1: Public inflation expectation calculated using Net Balance Statistic

According to the PBOC's *Depositor survey Report*, the Chinese central bank calculates public inflation expectations using the net balance statistic approach. Due to the fact that the PBOC does not disclose the outcomes of the computed inflation expectations, we followed the published approach<sup>37</sup> and produced the findings shown in Figure 5.1, which illustrates the fit between the measured historical inflation expectations and the actual inflation rate, which is unsatisfactory.

However, are the calculated public inflation expectations accurate? In this context, two major questions have been raised by academics. First, do the net difference statistic's results truly reflect the inflation forecasts encoded in the survey? This questioning can be reflected in various ways. For instance, Su and Hu (2015) used the method to perform a simplified calculation of the survey results from the University of Michigan and concluded that the inflation expectations results obtained by the method do not match the TIPS-based calculations and the actual inflation rate at a high level. Second, whether the survey created by PBOC is overly simplistic, resulting in a substantial lack of information. Briefly, the PBOC-designed survey has only two items pertaining

<sup>37</sup> Depositor survey reports, quarterly, PBOC.

to inflation expectations. The first question is, "Do you believe that prices are currently high?" The second question is, "How do you anticipate pricing to change in the coming quarter relative to the current quarter?" In other words, the survey asked respondents to indicate their inflationary expectations using generic pricing levels. In contrast to the University of Michigan survey, the former does not require respondents to provide a digitalized inflation expectation (or rate of price change). Several Chinese researchers have already undertaken comparable research on this topic. For instance, the China Economic Report (CEP) published by Fudan University established a better fit between the measured results and the actual inflation rate by calculating the public's inflation expectations based on the results of its survey, alongside the China Economic Prosperity Index.

In addition, whether the information gathered via surveys is accurate is a major point of contention. According to Croushore (2010), questions frequently breach the fundamental idea of rationality. Mankiw (2004) finds bias between various survey behaviours and disparities in projected results. Researchers who have analysed errors based on University of Michigan surveys, such as Malmendier & Nagel (2016), Schulhofer-Wohl & Kaplan (2016), and others, have discovered that participant differences, such as age and gender, bring predictable errors. These surveys solely assessed target differences between respondents and did not account for any subjective differences that may exist. For instance, do participants choose dishonest responses for a number of reasons? Almost all contemporary research is predicated on the assumption that survey respondents are rational and truthful. In actuality, the likelihood of this assumption being accurate is low. On the basis of the survey, it is difficult to determine if people have participated honestly.

On the basis of the aforementioned studies, we believe it is worthwhile and feasible to

investigate more frequent and accurate methods of measuring public inflation expectations, taking into account the various "abnormal conditions" that may exist among the public, while increasing the number of participants. In the Internet age, the public's ability to communicate their sentiments has become more diverse and unrestricted. In lieu of a survey, we believe this can be accomplished by substituting a passive reaction to questions with a subjective and spontaneous expression of the public's feelings regarding inflation expectations. In other words, information freely posted by the public on social media can be collected and analysed in order to gauge public inflation expectations. A precise measure of public inflation expectations can enhance the assessment of unconventional monetary policy effectiveness and inform policy settings in various ways. Therefore, this chapter firstly compares the results of inflation expectation estimation based on original questionnaires by different statistical methods, and then proposes an estimation method based on social media information to improve the accuracy.

## 5.1 Probabilistic methods

First we estimated public inflation expectations using a probabilistic method matching to distinct distributions based on PBOC survey data. On the basis of the probability technique developed by Carlson and Pakin (1975), the following assumptions are made.

(1) Participants' inflation expectations are subject to a probability distribution that affects the survey results.

(2) If participants' expected inflation rate is within an interval  $(-a, a]$  centred on 0, participants will select "essentially constant" as a forecast for changes in the price level, this interval is defined as the sensitivity interval.

We assume that the expected inflation rate in period  $t$  for survey participants in period  $t-1$  is a random variable  $x_t^e$  with probability density  $f_t(x)$ , and that the resulting public inflation expectation  $\pi_t^e$  is the mean of this distribution  $\pi_t^e = E(x_t^e)$ . Under this assumption, the probability that  $x_t^e$  is greater than  $a_t$  is the proportion  $R_t$  of respondents who answered "prices will rise in period  $t$ ", the probability that  $x_t^e$  is less than or equal to  $-a_t$  is the proportion  $F_t$  of respondents who answered "prices will fall in period  $t$ ", and the probability that  $x_t^e$  is within the interval  $(-a, a]$  is the proportion  $N_t$  of respondents who answered "prices will remain relatively unchanged in period  $t$ ". That is:

$$P(x_t^e > a_t) = R_t \quad (5.1)$$

$$P(x_t^e \leq -a_t) = F_t \quad (5.2)$$

$$P(-a_t < x_t^e \leq a_t) = N_t \quad (5.3)$$

We calculated the survey results from the first quarter of 2010 through the last quarter of 2022 using three distinct distributions, namely the uniform, normal, and logistic distributions. The expectation calculation for the uniform distribution is relatively straightforward, and Figure 5.2 displays the results of our public inflation expectation calculation.

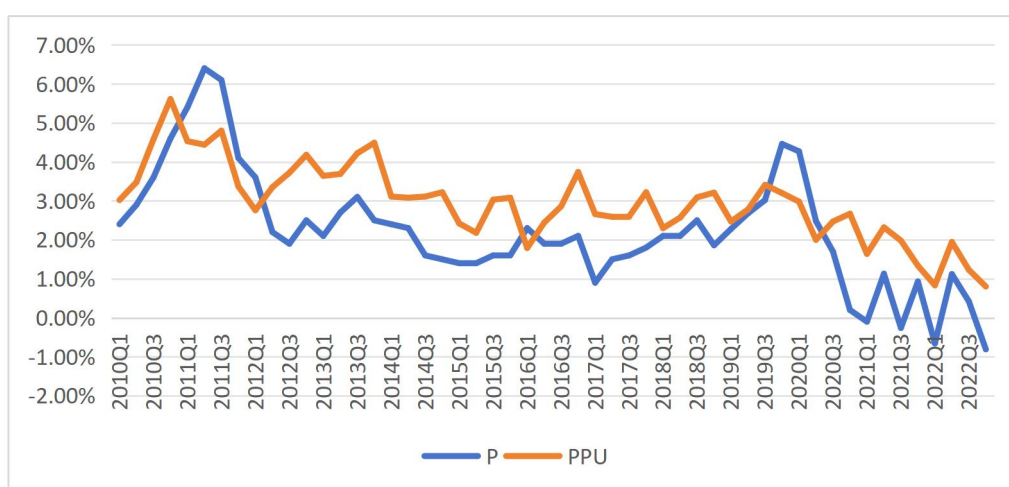


Figure 5.2: Public inflation expectation calculated by Uniform Distribution

Assuming that the public's inflation expectations follow a normal distribution with a mean of  $\pi_t^e$ , we can obtain:

$$P\left(\frac{x_t^e - \pi_t^e}{\sigma_t^e} > \frac{a_t - \pi_t^e}{\sigma_t^e}\right) = P(Z_t > \frac{a_t - \pi_t^e}{\sigma_t^e}) = R_t \quad (5.4)$$

$$P\left(\frac{x_t^e - \pi_t^e}{\sigma_t^e} \leq \frac{-a_t - \pi_t^e}{\sigma_t^e}\right) = P(Z_t \leq \frac{-a_t - \pi_t^e}{\sigma_t^e}) = F_t \quad (5.5)$$

where  $\sigma_t^e$  is the variance of  $x_t^e$  and  $Z_t = \frac{x_t^e - \pi_t^e}{\sigma_t^e}$  is a random variable with a normal distribution. Assuming  $\Phi(\cdot)$  to be the cumulative distribution function of the normal distribution, then set  $z_1(t) = \Phi^{-1}(F_t)$  and  $z_2(t) = \Phi^{-1}(1 - R_t)$ . Thus,  $z_1(t) = \frac{-a_t - \pi_t^e}{\sigma_t^e}$ ,  $z_2(t) = \frac{a_t - \pi_t^e}{\sigma_t^e}$ . From this, we can derive:

$$\pi_t^e = \frac{a_1[z_1(t) + z_2(t)]}{z_1(t) - z_2(t)} \quad (5.6)$$

In addition, we assume that the sensitivity interval is constant over all periods and that the mean of inflation expectations is equal to the mean of the inflation rate, i.e. that there is no systematic mistake in the public's estimation of inflation expectations, thereby satisfying:

$$\frac{1}{T} \sum_{t=1}^T \pi_t = \frac{1}{T} \sum_{t=1}^T \pi_t^e \quad (5.7)$$

Thus:

$$\sum_{t=1}^T [z_1(t) + z_2(t)]a = \sum_{t=1}^T \pi_t^e [z_1(t) - z_2(t)] \quad (5.8)$$

Solved For  $a$ :

$$a \equiv a_t = \frac{\sum_{t=1}^T \pi_t}{\sum_{t=1}^T \frac{z_1(t) + z_2(t)}{z_1(t) - z_2(t)}} \quad (5.9)$$

By substituting the resulting expression for  $a$  into the expression for  $\pi_t^e$ , the public's inflation expectations can be determined. The outcomes of our calculations are depicted in Figure 5.3.

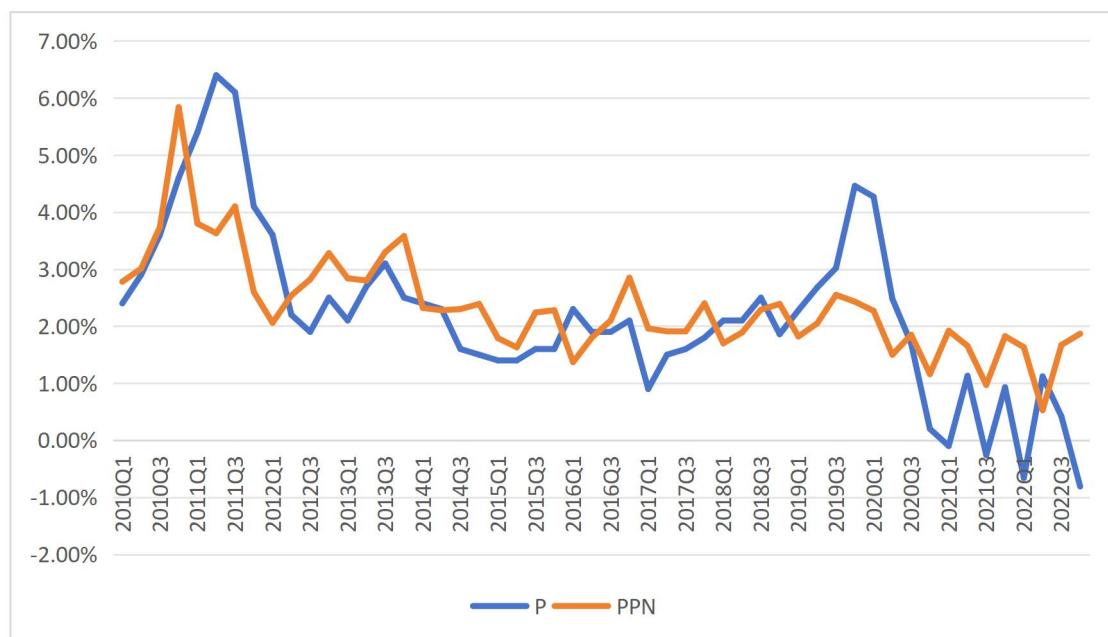


Figure 5.3: Public inflation expectation calculated by Normal Distribution

Similarly, we evaluated public inflation expectations based on the Logistic distribution and the results are displayed in Figure 5.4.

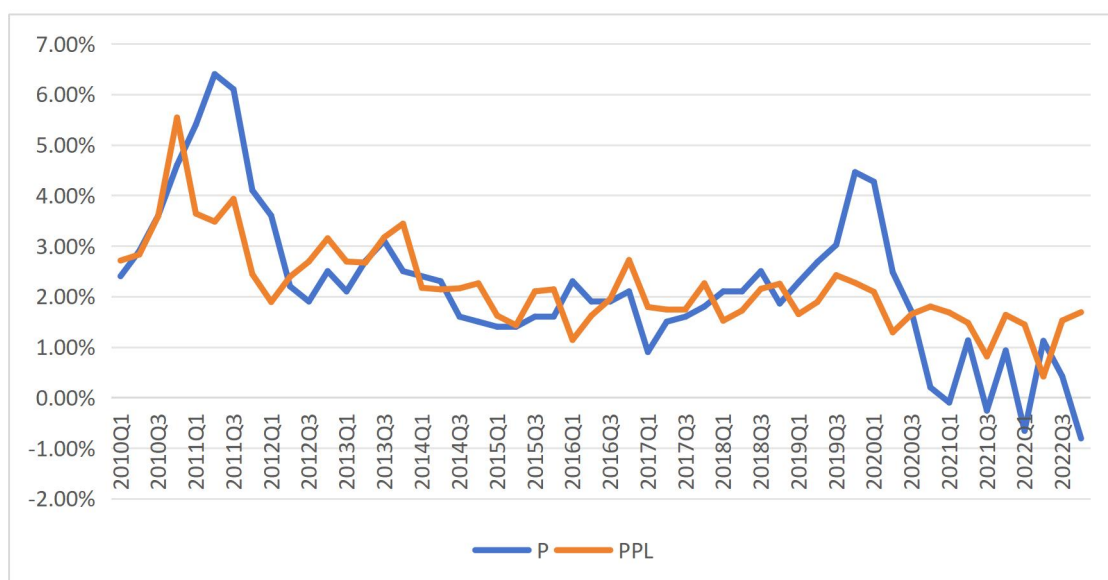


Figure 5.4: Public inflation expectation calculated by Logistic Distribution

Table 5.1 shows the comparison of the precision of the three distinct probability

distributions, while Table 5.2 shows the ADF residual tests.

Table 5.1: Precision comparison

	PB	PPN	PPL	PPU
MAE	0.1352	0.0105	0.0094	0.0121
RMSE	0.0213	0.0006	0.0002	0.0011
TUI	1.1146	0.0134	0.0011	0.0615

Table 5.2: ADF test for public expectation calculation

	PB	PPN	PPL	PPU
beta0	0.0008(0.1631)	0.0040(0.9448)	0.0022(0.4765)	-0.0065(-1.0229)
beta1	0.1683(5.3247)***	0.9995(5.3741)***	0.9982(5.3236)***	1.0001(5.1754)***
F	28.3523***	28.8813***	28.3412***	26.7953***
Residual ADF statistic	-2.8518***	-2.9663***	-2.9345***	-2.8342***

This suggests that the allegation in the PBOC report that the Net Balance Statistic approach was used to calculate public inflation expectations is relatively imprecise. If instead the probability technique based on a Logistic or Normal distribution is utilised, more accurate results can be achieved.

## 5.2 Using social media to assess public inflation expectation

The direction of inflation expectations inherent in media messages has been the subject of a substantial amount of research. These studies examine a variety of topics, such as the ability of the media to influence inflation expectations and the reasons why the

media are able to do so. However, the message of the media is not always neutral. Indeed, the media seeks commercial value in addition to its news value. And as a consequence of their pursuit of commercial gain, the media may forego objectivity and impartiality selectively and mislead the public. In the domains of political science and economics, corresponding research findings have been widely found. In previous research, the academics have endorsed the media panic theory. The proponents of this theory argue that, according to the danger attraction theory, the media should be held accountable for the consequences of reporting negative news in order to increase commercial profits, because when the media fails to adequately present the elements of an event, the public inaccurately interprets the news (Mutz & Reeves 2005; Newton 1999). However, not all research have demonstrated that media coverage negatively affects the population. According to carroll (2003), if the public is required to pay money or time for information, they will lower the cost of updating information by using more generic resources. In other words, the people will construct macroeconomic forecasts based on media coverage rather than pursuing statistics. Boomgaarden (2011) demonstrates that when the public lacks sufficient time and information access, they will rely more on the media to shape their economic perspectives. Carroll (2003) illustrates through empirical studies that the greater the media coverage of inflation, the more accurate the public's expectations are in terms of inflation and unemployment expectations.

The public is viewed as both a recipient and an influencer of media messages in almost all studies. The public does play this function, but in the era of highly developed social media, the public also plays another vital role: that of information publisher. In the case of perceptions of inflation expectations, for instance, the public may not be able to accurately determine specific inflation rates and expectations; however, they can easily perceive changes in the price levels of certain commodities in their daily lives and

share their perceptions via social media. A housewife with no education in economics may not be able to comprehend the significance of the central bank's announcement of a 0.5% reduction in the benchmark interest rate, but she can certainly perceive that the price of food items such as bread and vegetables in the supermarket has increased compared to the previous period and post on her social media accounts like: the price of cabbage has increased again! Or: perhaps milk prices will continue to rise next month? Otherwise: why do the chocolate becomes so expensive?

When thousands of customers detect changes in the price levels of different commodities, thousands of social media messages containing the public's perceptions and expectations of the price levels of different commodities are generated. By aggregating and analysing these signals, we may determine the public's expectations regarding price changes for specific commodities. In fact, the Consumer Price Index (CPI) is a widely-used indication of the actual rate of inflation, and the weightings of the various commodities in the CPI calculation are disclosed by the statistical offices of each economy. Theoretically, it is feasible to derive an index of public inflation expectations from social media messages.

### 1) Basic model

We believe that social media messages contain a great deal of information that can be considered, particularly attributes that are unavailable in traditional media and surveys, such as the geographical differences and the adjectives that express the individual's level of sentiment, specific product names, etc. Consequently, the following model was created:

$$\pi_{t,t+1}^e = \alpha\pi_t + \beta \sum_{i=1}^{32} [w_i * \sum f(\pi_{t,i,j}, g_{t,j})] + \varepsilon_t \quad (5.10)$$

Where:

$i$  denotes specified commodity within the 32 core commodities.

$j$  denotes the number of the information related to commodity  $i$ .

$\pi_{t,t+1}^e$  denotes the consumer's inflation expectations for the next period in period  $t$ .

$\pi_t$  denotes the actual inflation in period  $t$ .

$\pi_{t,i,j}$  denotes the consumer sentiment on price changes of commodity  $i$  in period  $t$ , obtained in information  $j$ .

$w_i$  denotes the weight of commodity  $i$ .

$g_{t,j}$  denotes the geographical area in which each relevant information  $j$  was published in period  $t$ .

$\varepsilon_t$  denotes the error.

We believe that the public's inflation expectations are primarily influenced by the actual inflation rate of the previous period. In addition to this, a valuable message posted by each resident on social media will contain the resident's sentiment about the price (and change in it) of a fixed commodity. For example, if a valuable message contains the name of a commodity "rice", the word "rise" to express the change in price and the word "too fast" to express the extent, we believe that the publisher's perception is that the price level of food is rising rapidly, which means that the resident's inflation expectations will be high. In addition, different commodities contribute to the CPI at varying rates, hence weights have been assigned to various commodities.

Currently, according to the National Bureau of Statistics' "Report on the Income and Consumption of Chinese People," the income and consumption disparity between urban and rural residents in China is continuously widening. Simultaneously, the disparity between the consumption and income levels of residents of first- and second-tier cities and those of third- and fourth-tier cities is rapidly widening. As a result, consumption preferences and feelings of consumption pressure vary substantially amongst different groups of individuals; nevertheless, it is impossible to discern precisely in social media

postings whose category the poster belongs to. A good way to push the process would be to use geographical distinction, dividing information publishers into first-tier cities, second-tier cities, and other cities, villages, and towns based on the city where the information is posted, and incorporating the various regions as new parameters in the model, hence we introduced the geographical index.

## **2) Measuring commodity weights**

Due to the fact that mainland China only publishes the weights for 8 broad commodity categories and not the weights for specific commodity categories, we have derived 32 core commodities and services that affect the CPI based on the methodology of Chun(2002) and calculated the corresponding weights. As we have selected a data interval from Q1 2010 to Q4 2022, we have confirmed the number and size of CPI calculation weight adjustments for China within this time frame. China's CPI weights will be altered slightly once a year and dramatically once every five years, according to an announcement by the National Bureau of Statistics of China. Nevertheless, for our chosen period of 2010 to 2022, the real effect of the "substantial" adjustment in 2016 was a "down in the year-over-year CPI growth rate from 2.0 percent to 1.9 percent over the period" according to the report provided by the Chinese National Bureau of Statistics of the implementation of monetary policy. Therefore, we choose to refer to the 2016 Chinese CPI weights published by Chun in 2017<sup>38</sup>, see Table 5.3.

<sup>38</sup> China CPI Composition Measurement Report, Chun Xia, Shanghai University of Finance and Economics, 2017

Table 5.3: Commodity weights

General category	General category	Proportion	General category	General category	Proportion
	Foodstuff	3.6%		Durable consumer goods	4.8%
	Meat, poultry and related products	8.2%	Household facilities and services	Household facilities	0.5%
	Eggs	0.6%		Family services and maintenance services	0.7%
Food	aquatic product	3.4%		Clothing consumption	8.5%
	Fresh vegetables	2.9%	Clothing	Clothing material consumption	0.6%
	Fresh fruit	1.7%		Entertainment durable goods and services	3.6%
	Dining out	12.6%	Entertainment, education and culture	Education	7.9%
	Medical care	4.5%		Cultural and entertainment supplies	1.1%
	Medical appliances and supplies	0.2%		Travel and going out	1.5%
Medical care and personal goods	Traditional Chinese medicine and proprietary Chinese Medicine	0.6%		Public transportation consumption	5.3%
	Western medicine	0.9%	Transportation	Vehicle	0.2%
	Health care appliances and supplies	0.1%		Vehicle fuel and spare parts	0.4%
	Health care	0.5%	Communication	Communication	4.9%

General category	General category	Proportion	General category	General category	Proportion
	services			consumption	
	Personal goods and services	3.1%		Consumption of building and decoration materials	5.7%
			Housing	Rental consumption	1.0%
Tobacco and alcohol	Tobacco	2.5%		Hydropower fuel consumption	6.5%
	Alcohol	1.4%			

### 3) Measuring geographical index

We have chosen to divide cities into tiers based on the *city business rankings* from the New Tier 1 Cities Institute, thereby assigning geographical indicators to the publishers to which they belong, the values of which are the city business index and disposable income per capita for each city in the rankings. As the Business Index ranges from 0 to 120, we have chosen to depict geographical characteristics by combining the business index and the disposable income per capita (in thousands of CNY), shown as equation 5.11.

$$g_{t,j} = f(\text{business index}_t, \text{disposable income per capita}_t) \quad (5.11)$$

### 4) Data measuring

#### a) Data collection

With the development of programming technologies and social media platforms, automated access and processing of information through computers has become a viable research method. Baker (2016), for instance, utilised a web crawler to access economic uncertainty-related texts in media repositories and conducted an in-depth analysis of them. Using web crawlers, we can retrieve information relating to inflation

expectations provided by the public via social media and derive more accurate inflation expectations as a result.

Currently, there is no public, unified chinese social media corpus that can be used for testing. To access the data, researchers must also rely on the official API interfaces given by each platform; however, the majority of platforms only offer partial API interfaces that restrict user access, necessitating a series of tedious processes. In this study, Python-based code is used to construct webcrawlers for the platform. We selected Sina Weibo, the largest social media platform in China, as the source of social media data.

Using the Sina Weibo platform's sophisticated search settings, the researcher can limit both the keywords and the time period. This is the foundation of the crawler software utilised in this study.

However, Sina Weibo has implemented display limits to avoid crawler misuse. Advanced searches display a maximum of 50 pages of Weibo data in reverse chronological order. Due to the vast number of Sina Weibo users and the matching volume of information provided, it is difficult for 50 pages to display all pertinent information for a given day. In order to overcome the 50-page limit, we programmed the crawler to automatically divide the time period into 1 hours.

After overcoming the limit on the number of displays, the crawler will crawl various data of the corresponding message, such as usernames, message texts, etc., based on keywords. Those information have been entered into a table to serve as the raw data for this study.

## **b) Data Processing**

After completing the gathering of raw data, we discovered that in addition to the severe sentiment data, the raw data contained a great deal of repetitious information. These messages were condensed into a short time frame and had an excessive amount of repetitious text. Consequently, the raw data were deduplicated. The de-duplication procedure comprised of the two types listed below.

### **i) De-duplication based on user name**

A time limit was established to exclude identical and similar people who had posted a high number of messages within the same time frame, and this was evaluated carefully. As a result, the majority of deviant and non-informative messages were eliminated (for example, individual users expressing deviant and extreme sentiments, and users who clearly belonged to the same organisation). After screening, we discovered, for instance, two accounts with the username of a corporation and a separate moniker. If these two accounts simultaneously post a substantial volume of content or content that is extremely similar, the information uploaded by these accounts will be deemed illegitimate and eliminated from the raw data set.

### **ii) De-duplication based on content**

Within a larger time constraint, we screened content for a high level of textual repetition. As a result, we removed information that may have been based on specific commercial practises (such as the marketing of financial commodities) and assured, to the greatest extent possible, that the information collected represented the personal expression of public sentiment.

After collecting the raw data, we must also analyse the collected information to meet

the sentiment extraction requirements. The processing of the text in this study includes the procedures listed below.

### **iii) Word division**

In contrast to the English language, where words are divided by fixed spaces, Chinese words are not separated from one another. Since words are the fundamental components of evaluating sentiments, word separation is an essential step for classifying sentiments. As the phenomenon of multi-syllabic and homophonic words is very widespread in Chinese, we can only rely on word separation to identify homophonic and multi-syllabic words; therefore, word separation is the initial stage.

In recent years, Chinese natural language research has grown in popularity, and academics have created a variety of Chinese word separation technologies. There are currently a multitude of practical and dependable word separation systems, the most prominent of which are:

#### **ia) Paoding System**

This system is largely based on lucene's Chinese word separation system and has rewritten the PaodingAnalyzer analyzer, whose primary responsibility is to build a TokenStream that can separate words.

#### **ib) Imdict-chinese-analyzerr**

It is written in Java, its technique is based on the Hidden Markov Model, and it may give direct support for Chinese word splitting for the lucene search engine.

#### **ic) Word Sorting System ICTCLAS**

This system is a highly regarded word separation system developed by Huaping Zhang

and Qun Liu of the Chinese Academy of Sciences' Institute of Computing. It is entirely written in C/C++, has been developed and enhanced over the past few years, and its word separation accuracy has been increasing.

Other renowned Chinese universities, such as Fudan University and Tsinghua University, have also launched word separation systems in rapid succession. In this study, the ICTCLAS word separation method is utilised.

### **5) Developing sentiment word weights**

There are numerous terms in Chinese that communicate sentiments very differently than in English, with degree adverbs being a particularly significant distinction. In English, degree adverbs may be extracted with relative ease, however in Chinese, degree adverbs can be found in multiple locations within a sentence and can even be inferred by other terms. Therefore, we cannot immediately use a sentiment lexicon based on English text to Chinese text analysis. To overcome this challenge, we created a new corpus based on an existing Chinese sentiment dictionary with manual sentiment annotation and used machine learning to determine the sentiment weight represented by each Chinese word with a sentiment meaning.

These are the stages involved in completing this task:

- a) From the information that has been screened, random samples are selected from each quarter in accordance to the number of the time of release. A total of 20,000 sentiment text set were obtained in the end.
- b) An evaluation panel was established by the us to manually annotate the 20,000 messages in the sentiment text set, evaluating the sentiment tendency (positive,

negative, or neutral) and the intensity (extreme, strong, no obvious, etc.) of each message as a foundation for machine learning. In order to ensure the most accurate representation of reality, the review panel included people of all ages as well as professional practitioners. To be precise, 20 minors under the age of 18, 30 university students under the age of 25, 40 men under the age of 60 and women under the age of 55 (the legal retirement age in China), and 10 men over the age of 60 and women over the age of 55 were invited to evaluate the message's sentiment content. As a result, a corpus of sentiment training texts for machine learning is produced.

Python implementation of SnowNLP-based sentiment word weighting. SnowNLP is a Python package for Chinese natural language processing that includes a corpus of sentiment training texts and Chinese word separation. However, SnowNLP's own training text collection is not appropriate for social platform data, and the word separation training library is not flawless. In this paper, the self-labeled sentiment training collection and the ICTCLAS Word Sorting System were replaced with SnowNLP's own database and separation system, and the sentiment word weights were acquired after training with SnowNLP's sentiment labelling function.

Following this, we performed the keyword setting. These keywords were separated into three categories, the first being product-related terms. The keywords were established for each of the 32 selected core commodities. For food, we list "rice" "flour" "pork" "beef" and "chicken", among others. These keywords have been blended with CPI construction weights to lend credibility to the message's attitude. The second category contains perceived keywords, such as "up" "down" "expensive" "cheap" etc., together with their synonyms and slang terms. The third category is for degree-related keywords, such as "rapid" "calm" "rapid" "bursting" etc.

Having obtained the keyword weights as well as the sentiment word weights, we can then calculate the final sentiment tendency. For each period, the texts are first classified by keyword and then evaluated for sentiment trend. The overall sentiment trend, the total positive sentiment, and the total negative sentiment for each period are determined by combining the keyword weights and sentiment word weights.

In addition, we filtered out the information that did not display a significant trend in sentiment and used it to determine the "sensitivity interval" in the probabilistic method discussed in section 2. This part is comparable to the "I don't know/I'm not sure" and "almost remain" parts of the survey findings. However, a substantial fraction of social media posts that are "shared daily" do not convey sentiment regarding price fluctuations. Accordingly, we employ the same proportion of "I don't know/I'm not sure" and "almost remain" responses as the PBOC survey results for the corresponding period. Notably, the "I don't know/I'm not sure" and "almost remain" options were not included in the surveys conducted between the first and third quarters of 2010. To compensate in the missing data, we chose to use the average of the proportion of residents who selected these options in the corresponding quarters from 2011 to 2013 instead.

To show the data processing procedure in detail, we provide an example of a valid piece of information after screening.

Original message:



Translation: Fengqiwu, the cuisine of the Sichuan river food in the GaoXin Distinct, is exquisite. The Universal Centre is crowded in the afternoons wherever children are playing. Parents must keep a constant eye on it, or else it will be overrun with children and they won't be able to locate their children, and the prices of the numerous amusement programmes are rising rapidly.

Username: 成都古倒吃

Location: 四川 (Sichuan province)

IP属地: 四川

Publish time: 01/06/2017

After validating this information and incorporating it into the original database, we first disassemble it. The deconstructed form of the sentence is as follows:

Fengqiwu,/ the cuisine of Sichuan (keyword)/ river food (keyword)/ in/ the GaoXin Distinct,/ is/ exquisite./ The Universal Centre/ is/ crowded/ in/ the afternoon/ wherever/ children/ are/ playing./ Parents/ must/ keep a constant eye/ on/ it,/ or else/ it/ will be/ overrun/ with/ children/ and/ they/ won't/ be able to/locate/ their children,/ and/ the price (keyword)/of the/ numerous/ amusement programmes (keyword)/ are/ rising(keyword)/ rapidly(keyword).

After decomposition, the decomposed words were matched to the established keyword database, and it was determined that the sentence contained the following keywords: 川菜 (cuisine of Sichuan), 河鲜 (river food), 价格 (price), 游玩项目 (amusement programmes), 涨 (rising) and 飞 (rapidly).

In this instance, the commodity-related keywords appear in two different categories: one for food and one for amusement services. The ICTCLAS system then identified several nouns and analysed the symbols or words in the sentence that conveyed segmentation and merging. No merged terms such as "at the same time" were detected in this sentence; nevertheless, the split word "afternoon" was found between the two keywords. Therefore, we believe that the sentiment indicated in this message pertains to the fluctuating price of entertainment services.

Consequently, this message provides the following information: the type of commodities as entertainment services, the price perception as rising, the perception level as high, the publication location as Sichuan, and the publication period as the third quarter of 2017. The process of translating these data into distinct indications is:

$$f(\pi_{2017Q3, entertainment, j}, g(\text{Sichuan})_{2017Q3}) \quad ()$$

Where  $\pi_{2017Q3, entertainment, j}$  in this message is the negative sentiment (the price has increased), the specific value of which is determined by the SnowNLP training, i.e. the value of the degree of the word "rapidly".  $w_{entertainment}$  is the weight of entertainment service for CPI, which is 3.6%.

$g(\text{Sichuan})_{2017Q3}$  is the aggregate of business index of all cities in Sichuan province for the third quarter of 2017.

All information pertaining to entertainment services that was published in Sichuan

during the third quarter of 2017 will be compiled to determine an overall trend in sentiment. The aggregate sentiment trend will then be weighted to reflect the public's perception of pricing in Sichuan during the third quarter of 2017, which will be used to compute inflation expectations.

$$W_{entertainment\ service} * \sum f(\pi_{2017Q3, entertainment, j}, g(Sichuan)_{2017Q3}) \quad (5.12)$$

After processing all the raw information, a collection of feature values was obtained. Included are the aggregate positive sentiment trend for each region, the aggregate negative sentiment trend for each region, and the geographical weights for each region. Ultimately, by combining the geographical weights with the corresponding sentiment tendencies, we have extracted from social media the public's perception of price level changes and the corresponding sensitivity interval, thereby satisfying the conditional requirement to calculate public inflation expectations, and allows us to determine the public's inflation expectations using the probabilistic method.

### 5.3 Calculation of the public expectation

In the previous discussion, we have demonstrated that it is possible to derive more precise public inflation expectations by employing the probabilistic method corresponding to the Normal and Logistic distributions, which exhibit great close precision. Therefore, we have applied the probabilistic method of the Normal distribution to assess public inflation predictions based on the sentiment tendencies acquired from social media information.

Figure 5.5 depicts the calculated public inflation expectations, and Appendix 2 has the detailed numerical outcomes:

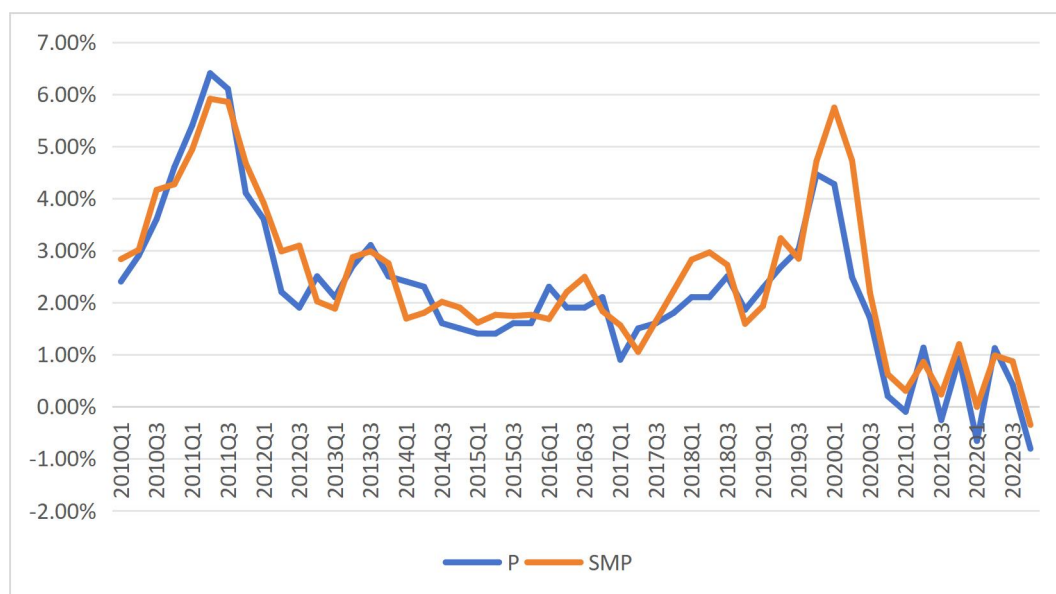


Figure 5.5: Social media based public inflation expectation

As evidenced, the public inflation expectations derived from social media information correspond more accurately to the actual inflation rate. We have analysed the results of 4 distinct calculations, and the correlation tests with the actual inflation rate are presented in Table 5.4:

Table 5.4: Correlation result

Variables	(p)	(ppn)	(ppl)	(ppu)	(wbppn)
p	1				
ppn	0.405***	1			
ppl	0.412***	0.999***	1		
ppu	0.421***	0.973***	0.981***	1	
smp	0.946***	0.394***	0.387***	0.371**	1

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Evidently, the information retrieved from social media has greatly increased the precision of the estimated public inflation expectations.

## 5.4 Ideas for improvement

In this sector, we employed a web crawler to collect the necessary social media information, manually annotated a training set of Chinese language corpus pertaining to price changes and inflation and a sentiment lexicon, and then used SnowNLP to weight the sentiment words and degree adverbs. These efforts have allowed us to extract subjective and "heartfelt" views of pricing and inflation from social media information. Our research has effectively proved that social media can give policymakers with a more effective, accurate, and informative instrument for estimating public inflation expectations than traditional media-based studies such as newspaper and television news.

However, our research has space for improvement. For instance, the web crawler that we developed does not cover all of the major social media platforms in mainland China. For instance, the Bilibili platform, which has a large number of youthful and active users as its primary competitive advantage, primarily distributes information through videos and short films, and our web crawler is unable to extract information from the videos and their accompanying comments. This fundamentally results in the imperfection of our raw information sources. In addition, in this study, we calculated quarterly inflation expectations based on social media information only, given that the questionnaire implemented by the PBOC is quarterly. In essence, the frequency of updates of social media information could well be calculated on a daily basis or even processed at a higher frequency. That is, social media information can provide a very high frequency of public inflation expectations when there is a demand for it. High-frequency measures of inflation expectations can also provide policymakers with more immediate references and sharper observations and feedback on possible economic shocks. Therefore, in subsequent studies, researchers may consider referring

to Tsinghua University's approach of measuring the daily internet consumer price level (ICPI) based on the online shopping platform to measure daily inflation expectations based on social media information, which can provide a more valuable reference for monetary policy research.

Social media continues to expand at a rapid rate, and policymakers as well as governments should be aware that social media has a frightening influence, but is more difficult to regulate than traditional media. To better create economic policy or maintain social stability, governments should examine social media platforms in more depth.

# Chapter 6

## Research conclusions and policy recommendations

This research presents an analysis of the PBOC's response to the unconventional monetary policy enacted during Covid-19. We examined the problem PBOC have to response, the response methods employed, and the effectiveness of these measures. Additionally, we proposed an improved estimation methodology for a key reference indicator in policy formulation: public inflation expectations. Based on the empirical study results, we draw some conclusions and present recommendations for monetary policymakers.

### 6.1 Research conclusions

1) The Covid-19 pandemic disrupted standard production across multiple industries on the supply side and affected consumption on the demand side, leading to significant direct and indirect adverse effects on the Chinese economy during the initial phase of the outbreak. Despite the economic system's interaction effects during the epidemic shock being mostly mitigated, they nonetheless produced significant repercussions in the medium and long run. The economic effects of Covid-19 from various transmission channels are markedly diverse. The cumulative effect of the demand-side shocks from the epidemic diminishes China's GDP by 4.65% relative to a no-epidemic scenario, exceeding the cumulative effect of the supply-side shocks by 2.26%. In the short term, China's supply side experiences a direct shock of 5.36%, surpassing that of the demand side. The interaction effect's beneficial impact on the supply side far exceeds that on the demand side, indicating that China's comparatively advanced industrial structure

is more resilient to abrupt disruptions. Nonetheless, the public's consuming mentality may inevitably undergo a lasting transformation. The magnitude of economic losses resulting from epidemic shocks differs significantly among industries. The influence of Covid-19 on the economic system, stemming from supply-side disruptions, is primarily evident in the tertiary sector. The wholesale and retail sector, together with the real estate business, experienced a more significant impact from the supply chain effects induced by the pandemic shock.

2) The four unconventional monetary policy instruments employed by the PBOC in response to Covid-19 demonstrated varying degrees of effectiveness for the three main targets. The conventional and generalised unconventional monetary instruments were more efficacious in enhancing output, less effective in restraining the exchange rate, and less effective in curbing prices. Conversely, targeted unconventional monetary interventions have demonstrated greater efficacy. Targeted Lending is the most beneficial for the seriously impacted tertiary SMEs. The policy instrument FEMI, aimed at exchange rate suppression, significantly influences the exchange rate but has a little effect on output and prices. The efficacy of the PBOC's unconventional monetary policy, designed to address China's vulnerability to Covid-19 shocks, is notably high. The interest rate channel is the most effective among the transmission channels of monetary policy, succeeded by the price channel. The credit channel, as the most rudimentary transmission medium, has subpar performance in the contemporary Chinese economy. The exchange rate channel demonstrates the greatest significance, exerting a robust and rapid influence on the price level. We believe that China's monetary policy transmission reform is progressing in alignment with the PBOC's strategy to progressively transition to the pricing channel.

3) Accurate monetary policy expectations substantially enhance the efficacy of

unconventional monetary policy in the Chinese economy. The DSGE model developed in this work achieves superior data fitting with the incorporation of the policy expectation feature. The responsiveness of the instrumental variables to the goal variables has also been enhanced. This indicates that it is essential and beneficial to customise the empirical model when the characteristics of the research subject markedly diverge from general assumptions. The current quantitative and price-based monetary policy combinations maintain considerable efficacy for the Chinese economy. In conjunction with research on the efficacy of distinct unconventional monetary policies, we assert that the quantitative monetary policy framework should prioritise standing lending facilities and targeted lending, whereas the price-based monetary policy framework should emphasise stock market valuations. Furthermore, our analysis of shocks to the two monetary policy portfolios indicates that quantity-based policy shocks have a greater impact on output, whereas price-based policy shocks predominantly affect price changes. Following the establishment of policy expectations, the alteration in the impact of the quantity-based policy shock is much greater than that of the price-based policy shock. This aligns with the PBOC's actual operations, which openly referenced the deployment of quantity-based policy in several briefings following the Covid-19 epidemic, while addressing price-based policy significantly less. The persistence of price-based policy's significant impact, despite the evident disparity in central bank communication<sup>39</sup>, confirms our belief that the public is more attuned to price-based policy than to quantity-based policy, highlighting the necessity of precisely gauging public expectations regarding the price level.

4) PBOC's current measurement of public inflation expectations is in dire need of optimisation, and social media is a quality source of data to consider. The correlation between public inflation expectations based on social media information and actual

<sup>39</sup> PBOC anti-Covid-19 epidemic conference. Holding on an irregular basis beginning 6 February 2020 and ending September 2021.

inflation is significantly higher than public inflation expectations measured by traditional methods. In addition, the ultra-high-frequency nature of social media information can help the PBOC understand the public's perception of inflation in a more timely manner and better determine subsequent policy actions, such as interest rate setting and forward guidance.

## **6.2 Policy recommendations**

In recent years, in the face of continued economic downward pressure and the ever-present risks to the financial system in the post-crisis era, China's monetary policy regulation model and instrument system have been further reformed and adjusted, but new changes are still needed, such as focusing more on micro-sectoral components such as SMEs and home-based individuals. In order to enable sound monetary policy to be fully transmitted to the real economy and to effectively regulate the quality of economic development, the Chinese government and monetary management authorities have repeatedly stressed that "flooding" no longer meets the purposes and requirements of policy regulation and resource allocation in China at this stage, and that the process of transitioning from a quantitative model to a pricing model is being gradually promoted. Especially in the past four years, the global epidemic continued to repeatedly outbreaks, the world economic development presents the state of super-expected recession, which is more demanding of China's monetary authorities based on different regulatory targets reasonable and flexible use of the combination of quantitative and pricing instruments to effectively support the macroeconomy in the development of a reasonable range.

In the forthcoming economic recovery plan, acknowledging that the service sector's

revenue shock significantly adversely affects China's economic framework, the Chinese government should adopt moderate demand-side stimulation policies in conjunction with supply-side assistance (e.g., Targeted Lending type policy instruments). In addition, efforts need to be made to promote the recovery of the services sector through various viable channels other than those of the monetary policymaking authorities. The tourism surge in 2023 from Harbin, Heilongjiang Province, and Zibo, Shandong Province, was mostly propelled by the Culture and Tourism Bureau of both cities. Furthermore, integrating China's current new infrastructure initiative with the advancement of productive services like the Internet, big data, and artificial intelligence, alongside the proactive enhancement of public service demand via government procurement, may significantly drive the transformation of the services sector within the framework of supply-side reform.

The PBOC should enhance expectation management to augment the effectiveness of monetary policy. China's monetary policy instruments are transitioning from a quantity-based framework to a price-based approach. Yet, the effectiveness of quantity-based monetary policy has been diminished by financial innovations and other influencing variables. The inefficiencies in the financial sector and the underdeveloped money market hinder the effective implementation of price-based monetary policy. The outcomes of quantitative monetary policy and price-based monetary policy are insufficient to anticipate the desired effects. Expectation management, as demonstrated by numerous Western economies, is crucial for assessing the efficacy of measures aimed at enhancing the effectiveness of monetary policy, focussing on three primary aspects. First, enhancing policy openness via explicit monetary policy signals aids the public in anticipating future monetary policy directions, mitigates market uncertainty, stabilises the macroeconomy, and fosters output growth. Secondly, the central bank's communication regarding monetary policy

enhances the public's capacity to anticipate future monetary policy, so facilitating the transmission of the central bank's intentions to the public and augmenting the efficacy of monetary policy. Ultimately, enhancing the openness of monetary policy fosters a more dependable relationship between the public and the central bank, establishing a virtuous period and facilitating the central bank's control over monetary policy. From the standpoint of expectation management, enhancing the efficacy of China's monetary policy appears to be a more viable approach. The central bank must bolster its communication with the public, augment the public's foresight regarding its policies, and ensure a credible commitment to the execution of monetary policy regulations, thereby maximising the effectiveness of the central bank's monetary policy instruments.

Further, reasonable shaping and guiding the expectations of the market micro subjects in the economic system can help to improve the ability of monetary policy to regulate the target variables and avoid policy overshooting and market blindness. Therefore, strengthening expectation management by the monetary authorities can provide a reasonable practical environment for the full play of the policy role, and it is also the inevitable requirement for the central bank to enhance the policy foresight and realise the precise regulation target in the new era. In view of this, China's central bank should pay full attention to and understand expectation management in the future, expand and improve the implementation methods and channels of expectation guidance in order to further enhance the effectiveness of policies and provide strong support for China's economic development and risk prevention.

In summary, while the PBOC's unconventional monetary policy in response to Covid-19 has demonstrated relative effectiveness, a disparity persists between China's monetary policy instrumentkit and that of developed Western nations. The target gaps are

attributable to historical deficiencies in the evolution and enhancement of economics and financial markets. The People's Bank of China should analyze advanced monetary policy and financial market practices from Western countries while developing suitable monetary policies tailored to the distinctive features of the Chinese economy. This approach is essential for addressing the dynamic international landscape and the increasing public demand for financial market services.

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