Non-Symmetry of China's and US Monetary Policy Spillovers: Theoretical Modelling and Empirical Analysis

Mei Dongzhou*, and Zhang Mi
School of International Economics and Trade, Central University of Finance and Economics (CUFE), Beijing, China

Abstract: *This study develops a structural vector autoregression (SVAR) framework to empirically examine the reciprocal transmission channels of monetary policies between China and the United States. The primary objective is to discern potential disparities in the spillover effects of monetary policies and ascertain any contrasting mechanisms underlying these effects across the two countries. Based on our research, it appears that there exists a certain level of non-symmetry in the spillover effects of monetary policy between the two countries. Moreover, this paper provides adequate analysis of disparities in the trade framework, capital control, and financial market operations of both countries in constructing a dynamic stochastic general equilibrium (DSGE) model that incorporates financial frictions for the examination of the theoretical rationale. The empirical findings indicate that China's monetary policy creates a spillover effect primarily through trade. In China, following an increase in its interest rates, the domestic economic activity will experience a contraction, leading to a decline in both investment and output. Consequently, this will result in a decrease in China's imports of investment goods from the United States, impacting the output of the US economy. In contrast, the US monetary policy exerts a spillover effect primarily through finance. An increase in interest rates by the United States is associated with a notable outflow of capital from China. This leads to a rise in the financing costs for Chinese firms, consequently diminishing their overall net worth. In light of the financial accelerator effect, corporate external financing risk premium will continue to increase, exacerbating the downward trajectory of China's output.*

Keywords: *Monetary policy spillovers, non-symmetry, trade channel, financial channel, international policy coordination*

JEL Classification Code: E44, E52, F42
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1. Introduction

The extensive implementation of monetary policy easing in advanced economies, along with the outbreak of the Russia-Ukraine conflict, has resulted in a notable increase in inflation rates within the United States, the eurozone, the United Kingdom, and certain emerging market economies. Consequently, this has necessitated a significant adjustment in the monetary policies of major global economies. In December 2021, the Federal Reserve reduced bond purchases by 20 billion US dollars in Treasuries and 10 billion US dollars in mortgage-backed securities (MBS) each month. These reductions preceded an increase in interest rates by 75 basis points on June 15, 2022. In the interim,

* CONTACT: Mei Dongzhou, e-mail: meidongzhoupku@126.com.

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China implemented a prudent monetary policy in order to sustain a steady pace of economic growth and provide an adequate level of liquidity. In January 2002, the People's Bank of China (PBoC) implemented a 10 basis point reduction in the interest rate for its one-year medium-term lending facility (MLF) loans and open market reverse repo rate (OMRR), respectively. Subsequently, in April, the PBoC further reduced the bank reserve requirement ratio by 0.25 percentage points. In response to economic cycles and domestic macroeconomic challenges, countries have been actively adapting their monetary policies. The increasing significance of spillover effects resulting from changes in monetary policies by major global economies has emerged as a subject of considerable public interest.

Global economic and trade interactions, interconnection in financial markets, and the formation of global financial cycles have given rise to new situations in which monetary policy spillovers occur (Miranda-Agrippino et al., 2020). The phenomenon of monetary policy spillovers originating from industrialized nations, particularly spearheaded by the United States, has garnered significant public interest. Miranda-Agrippin and Rey (2020) assert that the monetary policy of the United States has emerged as a prominent catalyst for global financial cycles, resulting in notable financial spillovers for the global economy. This phenomenon is attributed to the interconnectedness of the global financial market and the influential role played by the US dollar on the international stage. The increasing global impact of developing economies necessitates that developed nations take into account the potential disruptions caused by the emerging economies on their economic and monetary policy formulation. As the world's second largest economy, China is establishing stronger ties with the global economy with an increasing international influence. China's macroeconomic policies is producing spillover effects of growing importance. The reciprocal transmission of monetary policy effects between China and the United States has emerged as a topic of significant academic interest within this particular context.

Despite the considerable body of research conducted on the spillover effects arising from the monetary policies of China and the United States, numerous imperfections persist within the current academic literature. (i) The academic investigations carried out by Chinese scholars about the spillover effects of US monetary policy on China's economy have predominantly focused on China's role as a recipient of US monetary policy, thereby neglecting to adequately consider the reciprocal spillover impacts of China on the United States. In their study utilizing a structural vector autoregression (SVAR) model, Wu and Liu (2009) found evidence suggesting that the implementation of US monetary policy might potentially enhance its trade balance. In addition, their findings indicated that such policy measures could induce substantial fluctuations in China's trade surplus, while without adversely affecting the economic growth of the United States. Furthermore, Xu et al. (2020) conducted a study examining the spillover effects of the US monetary policy on the exchange rate. Utilizing a structural vector error correction model (SVECM), the researchers discovered that the tightening of US monetary policy resulted in a decline in the prices of commodities imported by China. Consequently, this led to a reduction in China's domestic manufacturing costs and price levels, while simultaneously stimulating an increase in output. In a study conducted by Chen et al. (2016), a research approach similar to that study was employed to examine the impact of the United States' quantitative easing (QE) policy. The findings of their study indicated that the QE program had contributed to China's economic overheating, mostly through the influence of interest rates on corporate bonds. (ii) There is a lack of theoretical and empirical studies examining the spillover effects of China's monetary policy. Furthermore, only a limited amount of research literature has addressed the influence of China's monetary policy on nations participating in the Belt and Road Initiative (BRI). Huang and Bai (2017) utilized the high-frequency incident research methodology to assess and analyze the effects of China's monetary policy changes on various intermediate targets of monetary policy, such as the exchange rate, short-term interest rate, and long-term interest rate, across more than 50 countries participating in the Belt and Road Initiative (BRI). The researchers discovered that as the economic and trade connections between China and these nations became stronger, the spillover effects of China's monetary policy became more extensive and had a more

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substantial impact. Notably, several research have observed that China's monetary policy transmission mechanism exhibits similarities to those of advanced economies (He and Wang, 2012; Fernald et al., 2014; Chen et al., 2017). Nevertheless, the current body of research literature has rarely examined the possibility of China's monetary policy implementation having comparable or even stronger spillover effects on advanced economies led by the United States. (iii) China plays a significant role in global trade, whereas the United States has traditionally held sway over global financial markets. In this context, it is probable that heterogeneity or non-symmetry may be present in the transmission channels and impacts of monetary policy spillovers between the two countries. The process of unraveling this question contributes to our understanding of the international transmission effects of monetary policy and promotes worldwide policy coordination with the aim of establishing a more stable and harmonious international economic environment.

This study aims to examine the spillover effects of monetary policy in China and the United States, respectively, based on the previous analysis. (i) Initially, an SVAR model is constructed by conducting a comprehensive search and compilation of macroeconomic data from both countries. This model aims to examine and validate the transmission mechanisms of monetary policies undertaken by both nations, specifically focusing on the spillover effects. The findings of this study suggest that there are noteworthy spillover effects in the monetary policies of China and the United States, and that these impacts exhibit a high degree of non-symmetry. The impact of US monetary policy on China's investment and output is manifested through its influence on the external financing risk premium of Chinese companies. Similarly, China's monetary policy exerts an influence on US output by affecting the imports and exports between the two countries. (ii) In order to explore the underlying theoretical justification for the observed non-symmetry in the transmission of monetary policy effects, we developed a dynamic stochastic general equilibrium (DSGE) model encompassing two countries. This model incorporates financial frictions and is based on the stylized facts of the trade and financial environments. By estimating the model parameters and conducting impulse response analysis and channel tests, we aim to identify the specific transmission mechanisms through which monetary policy spillovers from China and the United States occur. The implementation of an interest rate hike in China results in a recessionary phase for its economy, accompanied by notable reductions in output levels and investment activities. Consequently, China will experience a reduction in its importation of investment goods from the United States, leading to a decline in the output of the United States. When the United States increases its interest rate, there is a potential for capital outflow from China, resulting in higher financing costs for Chinese enterprises and a subsequent drop in corporate net value. The impact of the financial accelerator is observed in the persistent rise of the risk premium associated with corporate external financing, which exacerbates the decline in China's output.

In comparison to previous research, this paper presents three marginal contributions: The first step in the empirical analysis involves creating an instrumental variable using high-frequency data. This instrumental variable is used to identify policy shocks and accurately measure the spillover effects of China's monetary policy. In this paper, the impact of China's monetary policy adjustment during the narrow window period is measured by the high-frequency change in asset prices on financial markets. This guarantees the exogeneity of policy shocks to effectively overcome the identification problem of the endogenous variable in the macroeconomic structural model. Second, in this paper, we construct a two-country model with reciprocal effects and interactions for theoretical analysis. This model introduces the trade and financial exchanges and estimates key model parameters based on realistic data of trade and finance between the two countries, allowing for a more thorough analysis and discussion of the channels and determinants of their respective monetary policy spillover effects. This model specification provides a research framework for the discussion of comparable issues. Third, this paper reveals the theoretical rationale behind the asymmetric monetary policy spillovers of both countries and finds that the disparate monetary policy spillovers of both countries are determined by their respective trade structures, levels

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of capital control, and financial market frictions. This helps policymakers understand the framework and considerations for monetary policy decision-making and enhance their ability to predict and manage policy spillovers.

The subsequent sections of this paper are organized in the following manner: Section 2 establishes an SVAR model in order to empirically examine the spillover effects of monetary policy in both countries. Section 3 presents a two-country DSGE model in order to elucidate the non-symmetry of monetary policy spillovers. Section 4 is dedicated to the calibration and estimation of model parameters. Section 5 employs a numerical simulation and counterfactual analysis to validate the findings of the empirical analysis and ascertain the transmission mechanism of monetary policy spillovers from both countries. Section 6 provides a comprehensive analysis of the findings and presents the resulting conclusions and policy implications.

2. Empirical Facts and Empirical Analysis

In this section, we develop an SVAR model that includes macroeconomic variables of China and the United States for the purpose of analyzing China's and the United States' monetary policy spillover effects on each other. For a more straightforward comparison of the monetary policy spillovers of both countries, policy interest rate variations are used to measure monetary policy changes. Given that the interest rate cannot be less than zero, this paper uses Wu and Xia's (2016) shadow interest rate as a proxy for the US policy interest rate (Iacoviello and Navarro, 2019). We incorporate macroeconomic variables such as output, import, and export into the SVAR model, citing Miranda-Agrippino et al. (2020). In consideration of the stationarity requirement for variables, the output of China and the United States is measured by the year-on-year growth rate of industrial value-added, as are China's imports and exports with the United States[1]. To represent financial market responses to monetary policy disruptions, we incorporate an external financing risk premium into the model, citing Gertler and Karadi (2015) and Rey (2016), to account for changes in corporate financing costs. The empirical model contains eight variables[2], including policy interest rates, output levels, and bilateral trade, as well as the respective external financing risk premiums for the two countries. Due to the availability of data and the need to exclude special periods such as the financial crisis, the sample range for this paper is January 2009 to February 2019. All variable data are collected monthly, and the CEIC and Wind databases serve as data sources.

Figure 1 illustrates the impact of US monetary policy on China. Results indicate that for each standard deviation of increase in the US policy interest rate (15 basis points), the US output will decrease by 0.10 percentage points, while China's output will significantly decrease by 0.20 percentage points in the current phase. According to the trade variable, current US imports from China will increase by 0.10 percentage points year over year, while China's imports from the US will decrease by 0.15 percentage points. According to the financial variable, an increase in the US interest rate will not only cause the financing risk premium of US domestic enterprises to increase by four basis points, but it will also induce an increase in the financing risk premium for Chinese firms (which may cause the financing risk premium for Chinese enterprises to rise for approximately 1.5 years before reaching its peak of approximately 2 basis points)[3].

[1] Please refer to the appendix for the detailed test results of the stationarity of each variable.

[2] Here, the Cholesky decomposition identification method is employed. In this model, policy interest rate is ranked before macroeconomic variable, and financial variable comes last. Given that the empirical results are sensitive to the ranking of variables, this paper provides the impulse response results by other rankings. For details, please refer to the appendix.

[3] The empirical results are consistent with Miranda-Agrippino and Rey's (2020) and Miranda-Agrippino et al.'s (2020) findings, with the exception that they discussed the global spillover effects of US monetary policy on global trade and financial variables, whereas this paper focuses on the individual spillover effect of US monetary policy on China.

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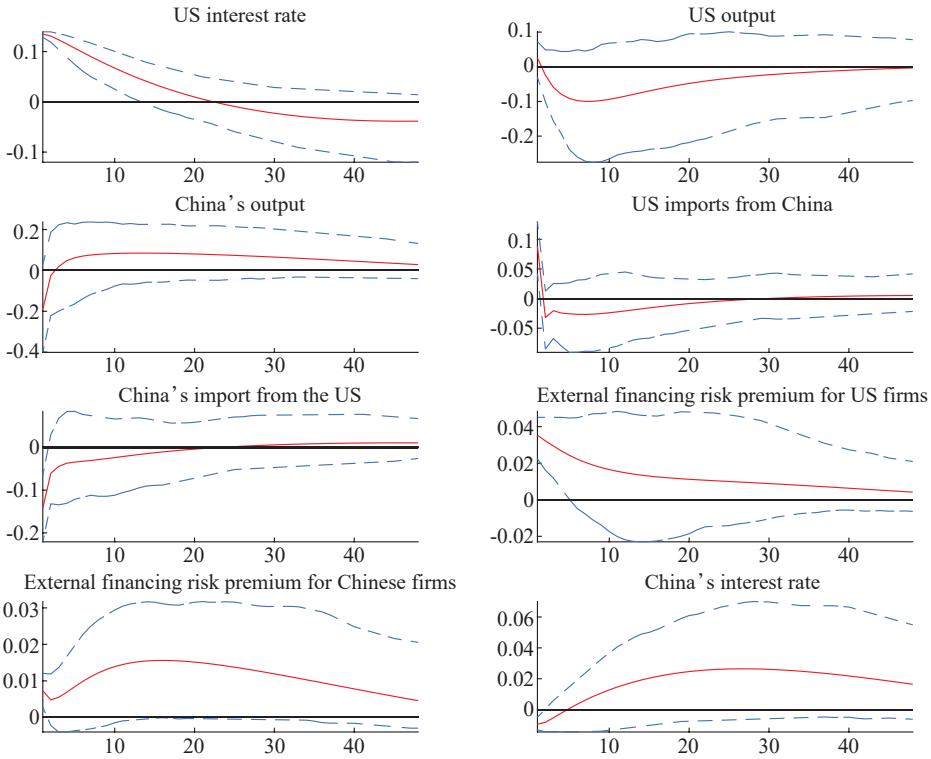

Figure 1: Spillover Effects of US Monetary Policy on China

Note: The dotted blue lines denotes a 95% confidence interval, same below.

Figure 2 depicts the effects of monetary policy shocks in China on the United States. Based on the findings from the impulse response analysis, it is observed that a one-unit increase in the standard deviation (equivalent to four basis points) of China's policy interest rate is linked to a statistically significant reduction of 0.50 percentage points in China's output. Furthermore, this increase in policy interest rate is also associated with a significant decline in the current output of the United States, which diminishes to 0.30 percentage points after a period of six months. Based on the trade variable, it can be observed that China's import from the United States and export to the United States have both experienced a year-on-year decline of 0.10 percentage point in the current phase. However, it is noteworthy that there has been no major alteration in the financing risk premium for US firms.

Some academics believe China is in the stage of economic restructuring with a modest level of market-based financial operations, barriers exist in its interest rate transmission mechanism, and the central bank has emphasized quantitative monetary policy regulation over the years (Wang et al., 2012; Zhuang et al., 2018). The accuracy of research into the spillover effects of China's price-based monetary policy shocks alone is therefore debatable. For this reason, we use the vector autoregression (proxy SVAR) model for the identification of external instrumental variable and construct an instrumental variable using high-frequency data to identify changes in monetary policy (Mertens and Ravn, 2014; Gertler and Karadi, 2015). Referencing Kamber and Mohanty (2018), we construct an instrumental variable for China's monetary policy shocks using the interbank overnight lending rate on the day of the policy change announcement[4]. Figure 3 is a chart of impulse response analysis. Results indicate that China's tightening monetary policy shocks will cause its policy interest rate to rise by three basis points,

[4] For details of the instrumental variable, available on request from the author.

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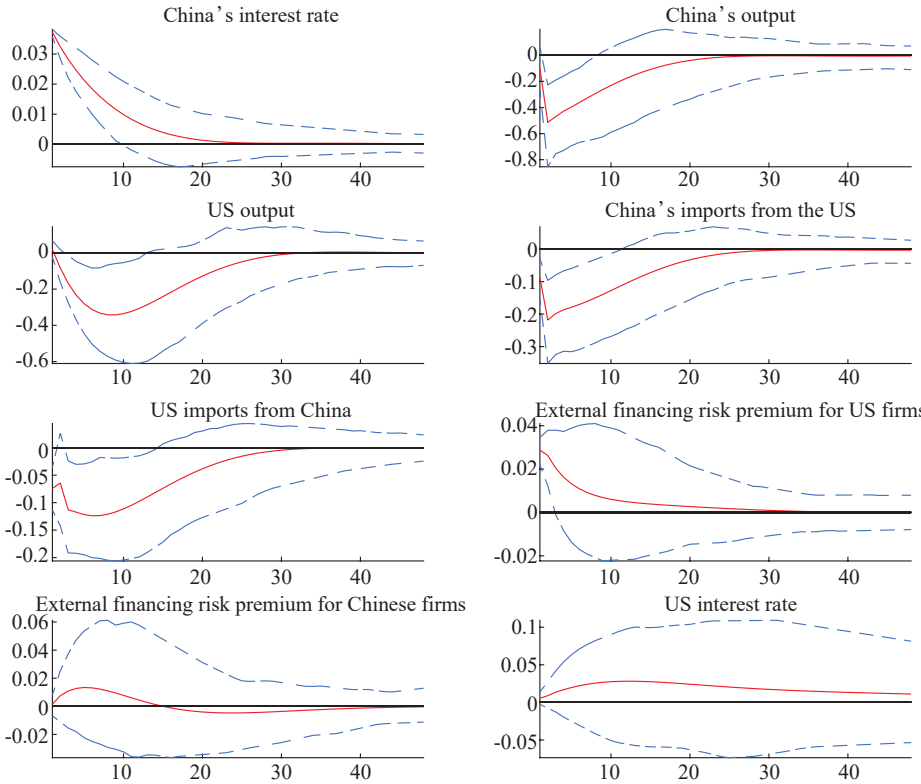

Figure 2: Spillover Effects of China's Monetary Policy on the US

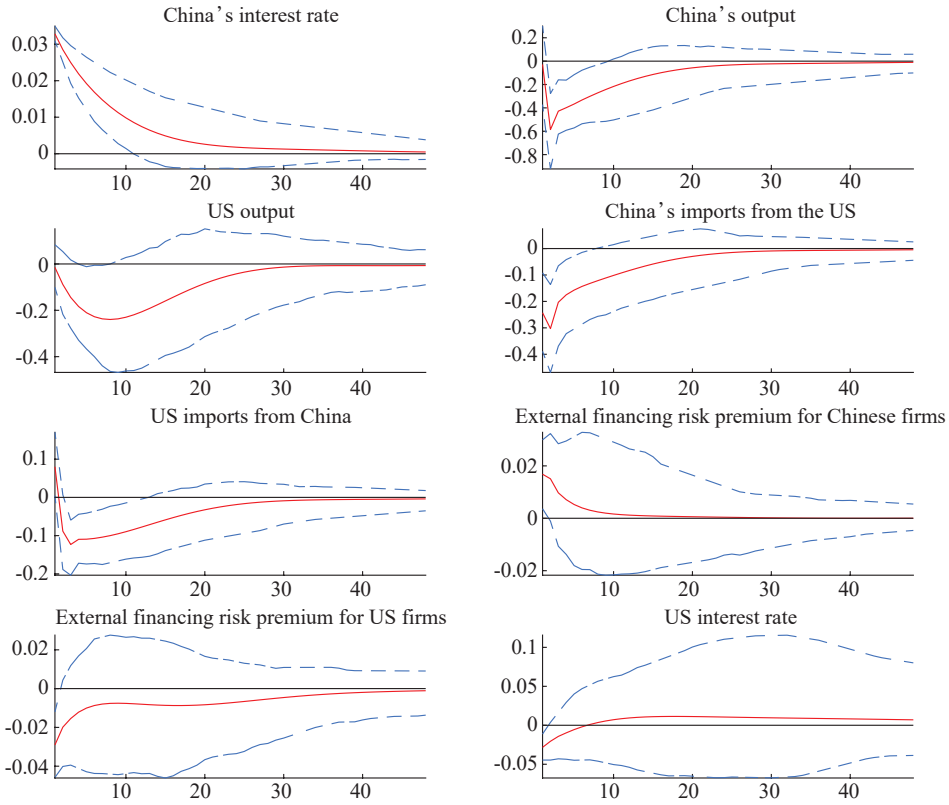

Figure 3: Spillover Effects of China's Monetary Policy on the United States (Proxy SVAR model)

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resulting in a 0.30 percentage point decrease in imports from the United States and a 0.20 percentage point decrease in US output. In the meantime, US firms will experience a slight but statistically insignificant decline in their financing risk premium. After replacing the method for identifying shifts in monetary policy, our empirical findings are consistent with Figure 2.

According to the preceding discussions, the spillover effects of China's and the US monetary policies are asymmetrical. Specifically, China's monetary policy mainly affects the US trade variable, whereas US monetary policy has a significant spillover effect on the financial variable while also affecting China's trade variable. Based on the above empirical results, we attempt to create a theoretical model to investigate the intrinsic rationale of asymmetric spillovers of China's and US monetary policies.

3. Theoretical Model

According to the results of the above empirical analysis, not only will US monetary policy adjustments have a spillover effect on China's economy, but China, as the second-largest economy in the world, also has a substantial spillover effect on US macroeconomic policy. Keeping this crucial fact in mind, we must illustrate the reciprocal effects and interactions between the two nations. Consequently, we develop a two-country DSGE model with financial frictions based on stylized facts of the trade and financial environments in China and the United States, taking into account the disparities between the two nations in terms of trade structure, capital control, and financial market frictions.

In this model, there are six categories of economic entities in both countries, including households, financial intermediaries, enterprises, producers and retailers of capital goods, and the central bank. Domestic households purchase imported foreign consumer goods and also domestic consumer goods, and manufacturers of capital goods purchase domestic investment goods while importing foreign investment goods, reflecting trade relations between the two nations. The financial connections between the two nations are evidenced by the fact that domestic households hold foreign bonds and therefore interact with foreign financial markets[5]. Since the economic entities in both countries in this model are relatively symmetrical, we will elaborate the home country's specifications, focusing on the differences between the home and foreign countries, while briefly introducing the foreign country's specifications[6].

3.1 Households

According to the standard assumption under the open-economy model, a representative household needs to not only select the optimal consumption portfolio of domestic and foreign goods in the current phase, but make cross-temporal decisions on consumption.

(i) Choice for the current phase. In our model, a country's purchase of consumer goods includes those manufactured at home and those imported from abroad. Referencing Gali and Monacelli's (2005) specifications, we assume that household consumer goods in the current phase are a combination of domestic and international goods in the form of the constant elasticity of substitution (CES) function. Thus, the home country's current-phase consumption can be expressed as:

$$c_t = \left[\gamma_1^{\frac{1}{\sigma_1}} c_{1t}^{\frac{\sigma_1-1}{\sigma_1}} + (1-\gamma_1)^{\frac{1}{\sigma_1}} c_{2t}^{\frac{\sigma_1-1}{\sigma_1}} \right]^{\frac{\sigma_1}{\sigma_1-1}} \tag{1}$$

where, c_t is the home country's current consumption, c_{1t} is the home country's consumption

[5] Referencing Lin et al.'s (2018) model specification, households may participate in domestic and international bond markets so as to smoothen consumption and hold domestic or foreign liabilities or assets.

[6] For the convenience of comparison with the home country's economic variables, we add an asterisk superscript to the foreign country's variables.

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of domestic goods, and c_{2t} is the home country's consumption of imported goods. γ_1 is the share of domestically manufactured consumer goods in the home country's composite consumer goods under steady state and may depict the preference of home-country households for domestic goods when purchasing consumer goods. σ_1 is the elasticity of substitution between the consumer goods of the home country and the foreign country. With the minimal one unit of spending on consumer goods by a domestic household, we may obtain one unit of price index for composite consumer goods and the relative demand equation for domestic and foreign goods.

$$p_t = \left[\gamma_1 p_{1t}^{1-\sigma_1} + (1-\gamma_1) p_{2t}^{1-\sigma_1}\right]^{\frac{1}{1-\sigma_1}} \tag{2}$$

$$\frac{c_{1t}}{c_{2t}} = \frac{\gamma_1}{1-\gamma_1}\left(\frac{p_{1t}}{p_{2t}}\right)^{-\sigma_1} \tag{3}$$

In equation (3), p_t is the price index of one unit of composite consumer goods for the home country, p_{1t} is the price of the home country's domestic goods, and p_{2t} is the price of foreign goods imported by the home country. In addition, we assume that the one-price law in the economy holds true, which means:

$$p_{1t}=Sp_{1t}^*,\ p_{2t}=Sp_{2t}^* \tag{4}$$

In equation (4), p_{1t}^* is the price of the home country's goods in a foreign country, and p_{2t}^* is the price of the foreign country's domestic goods. S is the nominal exchange rate under the direct pricing method. Trade conditions z_t for the two countries defined in this paper are:

$$z_t = p_{1t}/p_{2t} \tag{5}$$

(ii) Cross-temporal choice. It is assumed that household survival is infinite, and that utility in each phase is subject to consumption level, working hours, and possession of money. In order to maximize utility, a household needs to make cross-temporal decisions. For households in the home country, the objective function is:

$$\max \mathrm{E}_t \sum_{t=0}^{\infty} \beta^t \left(\ln c_t + \ln \frac{M_{t-1}}{p_t} - \frac{h_t^{1+\eta}}{1+\eta}\right) \tag{6}$$

In equation (6), β is the cross-temporal discount factor of households ($\beta \in (0,1)$), M_{t-1}/p_t is the actual balance of money held by households, h_t is labor provided by household, and η is the reciprocal of labor supply elasticity. Meanwhile, the budgetary constraint equation for households is:

$$c_t + \frac{D_t}{p_t} + \frac{R_{t-1}^F B_{t-1}^* S_t}{p_t} + \frac{\kappa_D}{2p_t}(S_t B_t^* - S_t \bar{B}^*)^2 + \frac{M_t}{p_t} = \frac{R_{t-1} D_{t-1}}{p_t} + \frac{M_{t-1}}{p_t} + w_t h_t + \frac{S_t B_t^*}{p_t} \tag{7}$$

On the left side of equation (7), D_t is household savings at domestic financial intermediaries, B_{t-1}^* is debt borrowed by households in foreign financial markets from $t-1$ to t period, R_{t-1}^F is the borrowing interest rate for domestic households, and M_t is the amount of nominal money held by households. $\frac{k_D}{2p_t}(S_t B_t^* - S_t \bar{B}^*)$ is the cost of adjustment that needs to be paid by domestic households for the possession of foreign debt, where k_D is the coefficient of adjustment cost and depicts the degree of a country's capital account regulation[7]. If the capital account is fully open, the value of k_D can be specified as zero; if

[7] Referencing the specifications of Devereux et al. (2006) and Schmitt-Grohe and Uribe (2003), it is necessary for households in a country to pay a secondary adjustment cost when adjusting their financial assets in an incomplete international financial market. This assumption ensures that a stationary solution exists under the deterministic steady state.

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capital account is regulated, the value of k_D is greater than zero. On the right side of equation (7), $R_{t-1}D_{t-1}$ is the income of principal and interest of deposits in the previous phase, M_{t-1} is the nominal balance of money held by households in the previous phase, and $w_t h_t$ is the labor wage income. In solving the problem of household maximization, we obtain the uncovered interest rate parity equation based on the first-order condition for calculating partial derivatives of deposits D_t and external debt B_t^*:

$$R_t\left[1-k_D\left(S_tB_t^*-S_t\overline{B^*}\right)\right]=R_t^F\frac{S_{t+1}}{S_t} \tag{8}$$

Notably, when the households in a country borrow money from foreign financial markets, there is a sovereign risk premium between their loan interest rates and the global benchmark interest rate due to country-level risk. Hence, a household's loan interest rate R_t^F in the foreign financial market is expressed as:

$$R_t^F=R_t^{glaobal}(1/y_t)^{\varphi_D} \tag{9}$$

In equation (9), $R_t^{glaobal}$ is the global benchmark interest rate, y_t is a country's output level, and φ_D is the elasticity of sovereign risk premium relative to national macroeconomic situation and may reflect the pro-cyclical attributes of capital flow[8]. When the domestic economy is in recession, national-level risk will intensify, and overseas funds will require a higher return, causing domestic benchmark interest rate to further increase, accelerating domestic economic deterioration and capital outflow.

Foreign households also make current and cross-temporal choices, and their relevant specifications are generally consistent with home-country households[9]. Notably, both the home country and foreign country's borrowing interest rates are subject to the sovereign risk premium with the global interest rate. However, there are differences in the elasticity of sovereign risk premium relative to a country's macroeconomic situation (φ_D and φ^*_D). For instance, the US Treasury interest rate is regarded as a global risk-free interest rate, for which international investors face a relatively small default risk when purchasing US dollar bonds (Caballero et al., 2017; He et al., 2016) with a small elasticity of sovereign risk premium. However, China is faced with a relatively significant sovereign credit risk with strong pro-cyclicality of capital flow (Yan, 2018; Li et al., 2012), hence the significant elasticity of sovereign risk premium.

3.2 Financial Intermediaries

Financial intermediaries acquire deposits from domestic households and lend received funds to enterprises. Considering the information asymmetry of financial markets, we introduce a financial accelerator mechanism to depict financial frictions. Referencing Bernanke et al. (1999) and Christensen and Dib's (2008) derivation results, the simplified form of the financial accelerator mechanism is expressed as follows:

$$E_tf_{t+1}=E_t\left[s(q_tk_{t+1}/n_{t+1})R_t/\pi_{t+1}\right] \tag{10}$$

In equation (10), E_tf_{t+1} is the expected marginal financing cost of firms, s is the premium of external financing risk, and q_tk_{t+1}/n_{t+1} is corporate leverage ratio. Specifically, the external financing risk premium is an increasing function of corporate leverage ratio. In addition, the elasticity of external financing risk premium is defined as ϕ, which denotes the magnitude of an increase in external financing risk premium as a result of corporate leverage ratio by each percentage point[10].

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[8] According to most research results, international capital flows are characterized by pro-cyclical attributes, and such pro-cyclicality is more evident for international capital inflows (Broner et al., 2013; Kaminsky et al., 2005). Referencing Akıncı (2013) and Uribe and Yue (2006), we assume that a country's borrowing interest rate in the international financial market is the sum between global risk-free interest rate and sovereign risk premium, and the amount of sovereign risk premium is dependent on domestic macroeconomic situation.

[9] Please refer to the appendix for the specifications of foreign households.

[10] Log-linearization of equation (10) gives us $\mathrm{E}_t\hat{f}_{t+1}=\phi\left(\hat{q}_t+\hat{k}_{t+1}-\hat{n}_{t+1}\right)+\hat{R}_t-\hat{\pi}_{t+1}$, where ϕ is the elasticity of external financing risk premium.

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In this model, the domestic and foreign financial accelerator mechanisms have the same specifications. However, the effects of financial accelerator vary across countries with different levels of financial market development.

3.3 Firms

Firms are in perfect competition. In each phase, firms finance from financial intermediaries and purchase capital goods using their own funds. At the end of each phase, they manufacture non-differentiated intermediate products using the purchased capital goods and labor force employed from the household sector. Relevant specifications are consistent between domestic and foreign enterprises. Take the home country for instance, the production function of representative firms satisfies the Cobb-Douglas function:

$$y_t=\alpha_t k_t^{\alpha} h_t^{1-\alpha} \tag{11}$$

In equation (11), k_t is capital input, and h_t is labor input. α is the share of capital in output, and α_t is the level of corporate technology. Firms are faced with the following problem of profit maximization:

$$\max p_{1t}^{w} y_t/p_t-w_t h_t-r_t^k k_t \tag{12}$$

In equation (12), p_{1t}^{w} is the wholesale price of intermediate products, and the difference between this price and the price at which firms sell intermediate products to retailers p_{1t} is defined as the price markup μ_t, expressed as $\mu_t p_{1t}^{w}=p_{1t}$. In solving the problem of profit maximization, we obtain the following demand equation of capital and labor:

$$r_t^k=\alpha p_{1t} y_t/\mu_t p_t k_t,\ w_t=(1-\alpha)p_{1t} y_t/\mu_t p_t h_t \tag{13}$$

After the end of each phase, firms sell the depreciated surplus capital goods and purchase new capital goods for the next phase. Hence, firms' profit from the purchase of capital goods in the previous phase includes profit from the input of capital goods into production $r_t^k k_t$ and the value from sales of depreciated capital goods $(1-\delta)q_t k_t$. Hence, firms' expected return $\mathrm{E}_{t-1}R_t^k$ from the purchase of capital goods with each unit of funds can be expressed as:

$$\mathrm{E}_{t-1}R_t^k=\mathrm{E}_{t-1}\left[\frac{(1-\delta)q_t+r_t^k}{q_{t-1}}\right] \tag{14}$$

Since expected marginal financing cost equals marginal income, we have: $\mathrm{E}_{t-1}R_t^k=\mathrm{E}_{t-1}f_t$.

Lastly, we assume that firms have a probability of $1-\upsilon$ to exit in each phase, where υ is the survival rate of firms. At this moment, the equation of corporate net value accumulation is:

$$n_{t+1}=\upsilon\left(R_t^k q_{t-1}k_t-\mathrm{E}_{t-1}f_t\left(q_t k_{t+1}-n_t\right)\right)+(1-\upsilon)g_t \tag{15}$$

In equation (15), g_t is the corporate retention value. The right side of equation (15) suggests that corporate net value includes the difference between surviving firms' actual income from capital goods and outstanding liabilities, as well as the retention value of exited firms.

3.4 Manufacturers of Capital Goods

In this model, specifications are the same between domestic and foreign manufacturers of capital goods. Take the home country for instance, the manufacturers of capital goods purchase depreciated capital goods $(1-\delta)k_t$ and new investment goods i_t at the end of each phase for the manufacturing of new capital goods k_{t+1}. Hence, the dynamic accumulation equation of domestic capital goods is as follows:

$$k_{t+1}=(1-\delta)k_t+i_t-0.5k_t\Phi\left(i_t/k_t-\delta\right)^2 \tag{16}$$

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In equation (16), $0.5k_t\Phi\left(i_t/k_t-\delta\right)^2$ is the adjustment cost of investment. It is assumed that the new investment goods i_t purchased by the manufacturers of domestic capital goods are a combination of domestic and foreign investment goods in the form of CES function, expressed as:

$$i_t=\left[\gamma_2^{\frac{1}{\sigma_2}}i_{1t}^{\frac{\sigma_2-1}{\sigma_2}}+(1-\gamma_2)^{\frac{1}{\sigma_2}}i_{2t}^{\frac{\sigma_2-1}{\sigma_2}}\right]^{\frac{\sigma_2}{\sigma_2-1}} \tag{17}$$

In equation (17), i_{1t} is the purchase of domestically made investment goods, and i_{2t} is the purchase of imported investment goods. γ_2 refers to the share of domestically made investment goods in the home country's composite investment goods under steady state, and the magnitude of this parameter may depict the level of preferences of capital goods manufacturers for domestic goods in their purchase of investment goods. σ_2 is the elasticity of substitution between investment goods made by the home country and the foreign country. For manufacturers' each minimal unit of spending on investment goods, we may obtain the price index for each unit of composite investment goods and the equation of relative demand for domestic and foreign investment goods:

$$p_t^I=\left[\gamma_2 p_{1t}^{1-\sigma_2}+\left(1-\gamma_2\right)p_{2t}^{1-\sigma_2}\right]^{\frac{1}{1-\sigma_2}} \tag{18}$$

$$\frac{i_{1t}}{i_{2t}}=\frac{\gamma_2}{1-\gamma_2}\left(\frac{p_{1t}}{p_{2t}}\right)^{-\sigma_2} \tag{19}$$

In equation (19), p_t^I is the price index for each unit of composite investment goods for the home country, p_{1t} is the price of domestic investment goods for the country, and p_{2t} is the price of foreign investment goods inputted by the home country.

Under the constraint of equation (16), we select the optimal investment level of capital goods i_t to maximize its profit function. According to the first-order condition, we may arrive at the following equation for determining the actual asset price of capital goods q_t:

$$q_t=\frac{p_t^I/p_t}{1-\Phi\left(\frac{i_t}{k_t}-\delta\right)} \tag{20}$$

3.5 Retailer

To introduce sticky price, it is assumed that retailers in monopolistic competition exist in the market. After retailers purchase commodities from domestic firms at the wholesale price p_{1t}^w and categorize the products into differentiated goods, they sell them to households and manufacturers of capital goods for consumption and investment at price p_{1t}. Specifications are consistent between domestic and foreign retailers. Take the home country for instance, it is assumed that the elasticity of substitution between differentiated intermediate inputs is ψ, and the composite CES function form for the final product is:

$$y_t=\left[\int_0^1 y_t\left(j\right)^{\frac{\psi-1}{\psi}}\mathrm{d}j\right]^{\frac{\psi}{\psi-1}} \tag{21}$$

Referencing the standard new Keynesian model specifications, such factors as incomplete information and menu cost that exist in the market preclude swift price adjustment. Referencing Calvo's (1983) pricing method, it is assumed that there is a probability of θ in each phase for retailers to maintain consistency with pricing in the previous phase. The problem of profit maximization for retailers is as follows:

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$$\max \mathrm{E}_t \sum_{i=0}^{\infty} \frac{\lambda_t}{\lambda_{t+1}} (\beta\theta)^i \left[p_{1t}(j) y_{t+i}(j) - p_{1t+i}^{w} y_{t+i}(j) \right] \tag{22}$$

In equation (22), λ_t is the Lagrange multiplier of the budget constraint and denotes the shadow price of consumption. By solving the first-order condition of the problem of maximization for retailers and log-linearizing the first-order condition, we may obtain the Phillips curve expression:

$$\hat{\pi}_{1t} = \beta \mathrm{E}_t \hat{\pi}_{1t+1} - (1-\beta\theta)(1-\theta)\hat{\mu}_t / \theta \tag{23}$$

In equation (23), $\pi_{1t}=p_{1t}/p_{1t-1}$. According to the relationship between the home country's composite consumer price indices p_t and p_{1t} and p_{2t}, we have:

$$\hat{\pi}_t = \hat{\pi}_{1t} - (1-\gamma_1)(\hat{z}_t - \hat{z}_{t-1}) \tag{24}$$

3.6 Central Banks

Central banks respond to changes in economic output, price level and nominal exchange rate by adjusting the nominal interest rate. Referencing Gertler et al. (2007), a country's monetary policy rules in an open economy can be expressed as:

$$R_t / \overline{R} = \left(R_{t-1} / \overline{R} \right)^{\rho_r} \left(y_t / \overline{y} \right)^{\rho_y} \left(\pi_t / \overline{\pi} \right)^{\rho_\pi} \left(S_t / \overline{S} \right)^{\rho_S} e^{m_t} \tag{25}$$

In equation (25), ρ_r is the interest rate smoothening factor, whose value is generally between 0.6 and 0.9. ρ_y, ρ_π and ρ_s are the reaction coefficients of interest rate to output, inflation and nominal exchange rate, respectively, while $\overline{R}$, $\overline{y}$, $\overline{\pi}$ and $\overline{S}$ are the steady-state values of interest rate, output, inflation and nominal exchange rate. Interest rate shocks m_t conform to normal distribution and are the focus of attention in this paper. Specifications of foreign monetary policy rules are consistent with those of the home country.

3.7 Market Clearing

Under the general equilibrium state, all products made by a country meet not only the needs of domestic consumption and investment, but also the needs of foreign consumption and investment. Hence, the resource constraint equations for the home country and the foreign country are respectively as follows:

$$y_t = c_{1t} + c_{1t}^{*} + i_{1t} + i_{1t}^{*} \tag{26}$$

$$y_t^{*} = c_{2t} + c_{2t}^{*} + i_{2t} + i_{2t}^{*} \tag{27}$$

The above equations comprise the backbone of the two-country model. In the following section, we will calibrate model parameters based on the stylized facts of trade and finance in China and the United States and provide a preliminary analysis of the model's mechanisms.

4. Parametric Calibration, Bayesian Estimation Model Mechanism

In this paper, we calibrate two types of parameters, including standard parameters and structural parameters. Standard parameters may be calibrated according to the parametric specifications of relevant representative literature while structural parameters may be calibrated based on the actual trade and financial data of China and the United States. Other relevant parameters are estimated using the Bayesian method.

4.1 Standard Parameters

Standard parameters include the household cross-temporal discount factor, labor supply elasticity, capital depreciation rate, price stickiness coefficient, and the elasticities of substitution for consumption

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and investment goods. According to Bernanke (1999) and Christensen and Dib (2008) and based on the calculation of the steady-state cross-temporal discount factors ($\beta=1/\overline{R}$ and $\beta^{*}=1/\overline{R}^{*}$), the household cross-temporal discount factors of both countries β and β^{*} are calibrated to be 0.990 and 0.993, respectively. According to the standard specification in the research literature, the values of labor supply elasticities η and η^{*} are both 1.500. Generally speaking, the annual depreciation rate of capital is 0.100, and the quarterly depreciation rates of capital employed in our model, i.e. δ and δ^{*} both have the value of 0.025. Referencing Gali et al.'s (2005) specification, firms have a probability of 0.250 to make a price adjustment in each phase. Therefore, the values of the price stickiness coefficient θ and θ^{*} are 0.750. Referencing Gertler et al.'s (2007) research on commodity price elasticity and Mei et al.'s (2013) specification of the price elasticities of consumer and investment goods, we assign the value of 1 to the elasticities of substitution between consumer goods from China and the United States σ_1 and σ_1^{*}, as well as the value of 0.100 to the elasticities of substitution between investment goods σ_2 and σ_2^{*}. Moreover, since China's capital account is not fully open, we specify the adjustment cost coefficient for the indebtedness of Chinese households κ_D to be 0.010 while the adjustment cost coefficient for the United States κ_D^{*} to be zero[11].

4.2 Structural Parameters

In this paper, we calibrate the structural parameters in our model based on the macroeconomic data of China and the United States. Those structural parameters are mainly intended to depict the economic structure and trade characteristics of both countries. Based on the annual GDP, consumption, investment, and import and export data of 2009-2019 from the International Monetary Fund (IMF), this paper offers a simple depiction of the economic structures of China and the United States. Results suggest that China's consumption as a share of GDP fluctuated within the range of 50% to 55%; fixed asset investments as a share of GDP fluctuated within the range of 43% to 47%; exports as a share of GDP fluctuated within the range of 20% to 27%, and imports as a share of GDP fluctuated within the range of 17% to 24%. Accordingly, US consumption as a share of GDP fluctuated within the range of 80% to 85%; fixed asset investment as a share of GDP fluctuated within the range of 18% to 21%; exports as a share of GDP fluctuated within the range of 11% to 14%; imports as a share of GDP fluctuated within the range of 14% to 17%. As for trade characteristics, Chang et al. (2016) estimated China's domestic consumer goods to account for approximately 0.973 of aggregate consumer goods and China's domestic investment goods to account for 0.492 of aggregate investment goods. In this paper, we calibrate the monthly data of relevant parameters of the United States based on the monthly data of imported consumer goods, imported investment goods, and aggregate investment goods from the Federal Reserve Economic Data (FRED). Results indicate that US domestic consumer goods as a share of aggregate consumer goods fluctuated within the range of 75% to 85%, and domestic investment goods as a share of aggregate investment goods fluctuated within the range of 55% to 75%.

The above data generally characterize the economic structures and trade characteristics of China and the United States. Based on such data, we calibrate the parameters of our model. The share of capital income has an impact on the proportion of consumption and investment to GDP for both China and the United States. Based on actual data and referencing Bai and Qian's (2010) estimation of China's capital and labor income shares, as well as Lawrence's (2015) research, we specify China's capital income share α to be 0.550 and US capital income share α^{*} to be 0.350. In addition, some important parameters include China's domestically made consumer goods as a share of China's composite consumer goods γ_1, China's domestically made consumer goods as a share of US composite consumer goods γ_1^{*}, China's domestically made investment goods as a share of China's composite investment goods γ_2, and China's

[11] Devereux et al. (2006) specifies the average degree of capital control for emerging economies to be 0.001, while this paper specifies the degree of capital control in China κ_D to be 0.010. In comparison, this paper follows a more stringent specification of capital control.

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domestically made investment goods as a share of US composite investment goods γ_2^*. Although these parameters cannot influence the share of aggregate investment, aggregate consumption, and imports and exports as a share of GDP, they will influence trade structure and the import and export proportions of consumption and investment goods for both countries. In light of their actual value range, we specify the value of γ_1 to be 0.973, the value of γ_1^* to be 0.862, the value of γ_2 to be 0.492, and the value of γ_2^* to be 0.795.

Other parameters of the model are estimated with the Bayesian methodology based on our search and compilation of relevant macroeconomic data. Specifically, this paper employs the quarterly GDP, investment and two-way import data of China and the United States between 2009 and 2019 to estimate the elasticity of external financing risk premium, the elasticity of sovereign risk spillovers, and the coefficient of the Taylor rule[12]. As can be learned from the Bayesian parametric estimation results, the elasticity of external financing risk premium for US firms ϕ^* is 0.020 while the elasticity of external financing risk premium for Chinese firms ϕ is 0.115, which is almost six times higher than the US level. That is to say, there is a much greater level of frictions in China's financial market in comparison with the United States, which is a key reason for the differences in the monetary policy spillovers via the financial channel. In addition, the estimated values of the coefficient of the Taylor rule are all within a reasonable value range.

5. Impulse Response Analysis and Channel Test

5.1 Impulse Response Analysis

In accordance with the sequence of empirical analysis, we will first examine the effects of US interest rate shocks on China. The red lines in Figure 4 depicts the impulse response results of the primary macroeconomic variable following a US interest rate increase, as simulated by the DSGE model. A rise in US interest rates causes domestic economic contraction and a decline in US output. According to the Euler equation of consumption, a rise in interest rates will increase the opportunity cost of current household consumption, resulting in a decline in current consumption. The combination of a decline in output and an increase in consumption costs results in a reduction in household consumption in the United States. Notable is the fact that US interest rate increases not only impact its domestic economic variable, but also have a spillover effect on China's economic variable.

On the one hand, a decline in US consumption will lead to a decrease in Chinese imports, as Chinese consumer goods account for a significant portion of US imports. Under the condition of non-arbitrage, US interest rate raises will result in a capital outflow from China, and China's interest rate will increase accordingly, as depicted by the interest-rate parity equation. The Chinese interest rate increase will result in a domestic economic contraction. In the meantime, the interest rate increase will make it more expensive for businesses to service their debt and will reduce their net worth. Under the financial accelerator effect, a decline in corporate net worth will increase the corporate leverage ratio and financing risk premium, thereby exacerbating the economic recession and amplifying the adverse effects of a US interest rate rise on China. Consequently, China's output will experience a substantial decline for an extended period of time. As demonstrated by the preceding analysis, a rise in U.S. interest rates has an effect on China's trade and financial interactions, as evidenced by an increase in US imports of Chinese final products and a shift in the risk premium of external financing for Chinese firms. In keeping with the empirical analysis depicted in Figure 1, a comparison of their respective changes reveals that the external financing risk premium is increasing more rapidly, whereas the US imports of Chinese final products are decreasing more slowly and persistently.

[12] Data source is the IFS database of the International Monetary Fund (IMF). In order to perform a Bayesian parametric estimation, this paper introduced relevant shocks, available on request from the author.

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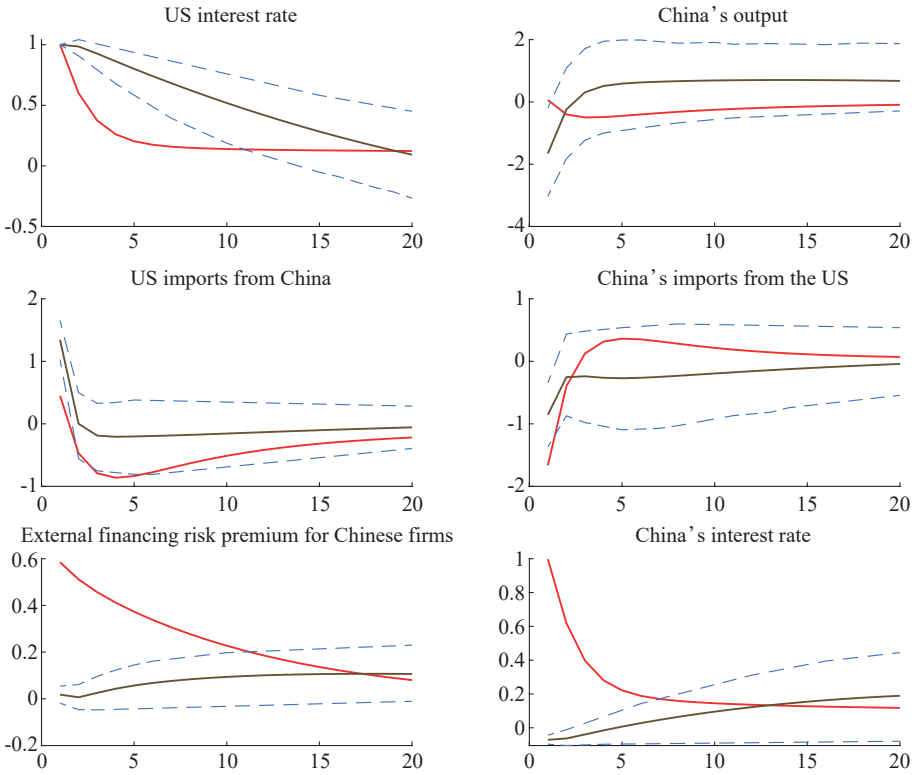

Figure 4: DSGE Fitting of US Monetary Policy Spillovers and VAR Estimation Comparison

Note: The estimated results of the VAR model are shown in the black lines, and the dotted blue lines denotes a 95% confidence interval; the simulated results of the DSGE model are shown in the red lines.

The red lines in Figure 5 represent the results of numerical simulations analyzing the effects of China's interest rate increase on the United States. The interest rate increase implemented by China is afterwards accompanied by a downturn in the domestic economy, as well as cutbacks in both domestic investment and output. Under the financial accelerator effect, China's interest rate rise will also increase the cost of debt service for businesses, decrease the net worth of firms, and increase the external financing risk premium, thereby exacerbating the declines in output and investment. In a similar manner, China's interest rate increase not only affects its domestic economic variables, but also has an effect on US economic variables. On the one hand, a decline in China's investment will reduce imports of investment goods from the United States. On the other hand, China's interest rate increase will also prompt a US interest rate increase, but China's rising sovereign risk premium as a result of declining domestic output will moderate the US interest rate increase. In addition, a rise in the US interest rates will activate its domestic financial accelerator mechanism, as evidenced by a rise in business debt service costs, a decline in corporate net worth, and an increase in the external financing risk premium. Due to the sophistication of the US financial markets, which feature relatively small financial frictions and a negligible financial accelerator effect, this rise in the external financing risk premium is, however, modest. Consequently, US production recovers gradually following a decrease in the current phase, in contrast to China's continuous output declines. In other words, the US trade variable is more sensitive to China's interest rate increase, i.e. there is a significant decline in China's imports of investment goods from the United States; the change in the US financial variable is relatively modest, i.e. there is a slight increase in corporate external financing risk premium, indicating that the financial accelerator has a

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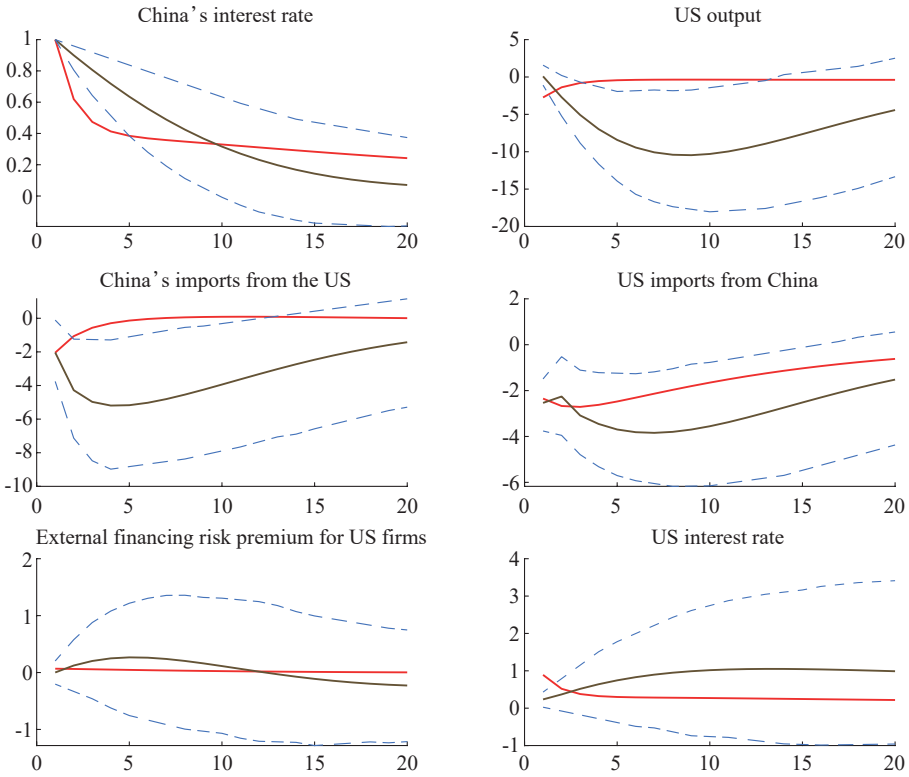

Figure 5: DSGE Fitting of China's Monetary Policy Spillovers and Comparison of VAR Estimations

Note: The estimated results of the VAR model are shown in the black lines, and the dotted blue lines denotes a 95% confidence interval; the simulated results of the DSGE model are shown in the red lines.

negligible effect on output. These conclusions align with the empirical findings presented in Figure 2.

Comparing the variables in Figures 4 and 5, the change in US imports of Chinese consumer goods is relatively slow in response to a one-unit positive shock to the US monetary policy interest rate, whereas the increase in the external financing risk premium for Chinese firms is rapid and more significant. With one unit of positive shock to China's monetary policy interest rate, China's imports of investment goods from the United States decrease more rapidly and significantly, while the increase in external financing risk premium for US firms is relatively small. Significant spillover effects exist in the monetary policies of both China and the United States, but the effects are considerably asymmetrical, as demonstrated by the results of the simulations and empirical analysis.

In this section, we compare the numerical simulation results of the model with the estimated results of the VAR empirical model in order to investigate the extent to which our model explains reality in order to provide an intuitive presentation of the model's goodness of fit. Figures 4 and 5 compare the impulse response analysis results of the VAR and DSGE models with one unit of US interest rate shock and one unit of China's interest rate shock, respectively. As seen in Figure 4, the direction of change in China's macroeconomic variables simulated with the DSGE model is generally consistent with the estimated results of the VAR model, and the model-fitted change in China's output falls within the confidence interval estimated with the VAR model, indicating that the DSGE model has a relatively high explanatory power for the change in output. According to the trade variable, the change in US imports from China fitted with the DSGE model almost overlaps with the lower bound of the confidence interval estimated with the VAR model, and the change in China's imports from the United States fitted with the model almost overlaps with the upper bound of the confidence interval estimated with the VAR model,

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indicating that the model has a relatively good fit. There is a difference between the fitted results of the DSGE model and the estimated results of the VAR model, as measured by the financial variable. In contrast to the former, which depicts a swift change in China's interest rate and corporate external financing risk premium, the latter illustrates a gradual change. Nonetheless, the estimated results of both the DSGE model and the VAR model indicate that an increase in US interest rates is associated with an increase in China's interest rates and the external financing risk premium of firms.

As depicted in Figure 5, changes in US output and China's imports from the US with one unit of China's interest rate shock fitted with the DSGE model nearly overlap with the upper bound of the confidence interval estimated with the VAR model, whereas changes in US imports from China, external financing risk premium for US firms, and changes in US interest rate fall within the confidence interval of the VAR model. This demonstrates that the DSGE model provides a good fit of the impact of China's interest rate shocks on US macroeconomic variables and has a high explanatory power for the observed phenomenon.

5.2 Test of Transmission Mechanism

The results of the impulse response analysis indicate an non-symmetry in the monetary policy spillovers between China and the United States. In this section, we will conduct a verification based on a few key parameters in order to determine the source of the non-symmetry.

(i) Test of transmission mechanism for the US monetary policy spillover effects. In this section, we focus on the discussion of the spillovers of US monetary policy through the financial channel. Considering that China's financial markets are underdeveloped with significant frictions, we specify the elasticity of China's external financing premium to be greater than that of the United States and the baseline model. One question is whether there would be any change in the spillover effects of US monetary policy on China? Based on the above discussions, we design the following counterfactual analysis: In Scenario 1, the value of ϕ is 0.115, which is consistent with the baseline model specification; in Scenario 2, the value of ϕ is 0.020, which is consistent with the elasticity of US external financing risk premium, i.e. the elasticity of external financing risk premium is as small as the elasticity of US financing premium. In testing the financial channel, we have closed the path of US monetary policy's effect on China through trade channel[13]. Figure 6 shows the test results of US monetary policy's effect through the financial channel. In comparison of Scenario 1 and Scenario 2, it can be found that when the elasticity of China's external financing risk premium is the same with the elasticity of US external risk premium, i.e. China's financial market frictions become negligible, US monetary policy spillover effects through financial channel will become weak. The implication is that China's significant financial market frictions are the key for US monetary policy spillover effects through the financial channel. Considering China's capital account control, it is also necessary to incorporate the degree of capital control in the analysis of US monetary policy spillover effects through financial channel. In addition to financial channel, we have also tested US monetary policy spillovers through the trade channel and found them to be weak[14].

(ii) Test of transmission mechanism for China's monetary policy spillover effects. As can be learned from the empirical results, China's monetary policy shocks primarily affect US trade variable with little impact on the financial variable. Hence, we have focused on testing China's monetary policy spillovers via the trade variable. Considering that investment goods account for a major share of China's imports

[13] Closing the trade channel of US monetary policy transmission means specifying the value of US imports of consumer goods from China as a share of its total imports $1-\gamma_1^*$ to be zero or close to zero.

[14] In addition to the counterfactual analysis shown in the main text, we have also tested US monetary policy spillovers via the financial channel based on the level of capital control, as well as US monetary policy spillovers via the trade channel based on the proportion of the inputs of consumer goods, available on request from the author.

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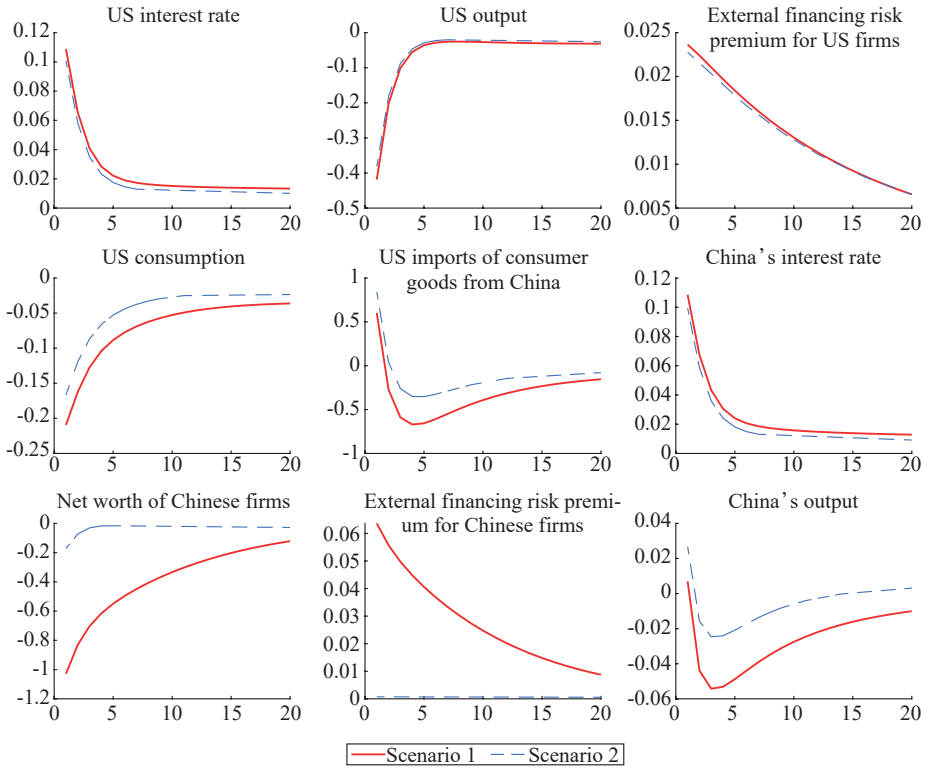

Figure 6: Test of the Financial Transmission Channel of US Monetary Policy Spillovers (based on China's external financing risk premium elasticity)

Note: Scenario 1 (baseline scenario) and Scenario 2 (relatively small elasticity of external financing risk premium).

of finished goods from the United States, we may conduct a counterfactual analysis on the proportion of China's imports of investment goods from the United States ($1-\gamma_2$). If the trade channel is an important conduit for China's monetary policy spillovers, a reduction in the proportion of China's imports of investment goods will weaken the impact of China's monetary policy on US output via imports from the United States. To test the trade channel for China's monetary policy spillovers, we design the following two scenarios, respectively: Under Scenario 1, the value of γ_2 is consistent with the baseline model's specification, and in Scenario 2, the value of γ_2 is 0.680, i.e. the proportion of China's imports of investment goods is very low. While testing the trade channel, we have closed the financial channel for China's monetary policy effects on the United States to avoid interference[15]. Figure 7 presents the test results of the trade channel for China's monetary policy spillovers. In comparison between Scenario 1 and Scenario 2, it can be found that after reducing the proportion of China's imports of investment goods from the United States, the decrease of China's import of investment goods from the United States becomes much smaller, and the decline of US output also becomes significantly subdued. That is to say, China's monetary policy creates strong spillover effects via the trade channel. Moreover, we have also tested China's monetary policy spillovers via the financial channel[16]. Results indicate that the trade transmission mechanism serves as a more important conduit of China's monetary policy spillovers while the financial channel is less important.

[15] Closing the financial channel of China's monetary policy spillovers means specifying the elasticity of China's external financing risk premium to be zero or maximizing the elasticity of sovereign risk premium.

[16] For details, available on request from the author.

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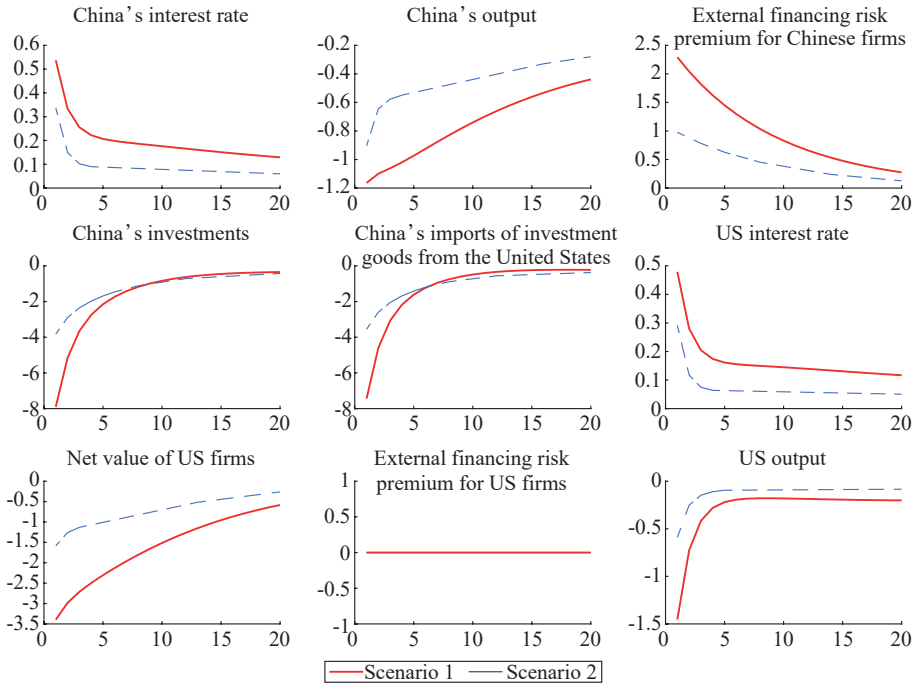

Figure 7: Test of the Trade Channel of China's Monetary Policy Spillovers

Note: Note: Scenario 1 (baseline scenario) and Scenario 2 (relatively small proportion of China's imports of investment goods).

In a nutshell, due to their dissimilar trade structures, China's and the United States' monetary policies have divergent spillover trajectories. In this paper, we outline the primary spillover trajectories of China's and the United States' monetary policies. This causes China to import fewer investment goods from the United States, which leads to a decrease in US output. Based on the interest-rate parity condition, an increase in the US interest rates is associated with an increase in China's interest rates, resulting in domestic economic contraction and output decline in China. Meanwhile, China's interest rate rise will increase firms' debt service costs and decrease their net worth. Under the financial accelerator effect, the external financing risk premium will increase, exacerbating the output decline.

6. Conclusions and Policy Implications

Since the onset of the global financial crisis in 2008, both academics and policymakers have acknowledged the necessity of international coordination in macroeconomic policymaking in order to address the structural contradictions confronting global economic development. Given the disparities in their economic cycles and macroeconomic policy objectives, however, it is unlikely that China and the United States will coordinate their monetary policies comprehensively. To avoid the impact of monetary policy differences, it is crucial to accurately measure the monetary policy spillover effects of both countries and to clarify the transmission mechanisms of monetary policy spillovers.

In order to empirically assess the spillover effects of China's and the United States' monetary policies, we developed an SVAR model and discovered an non-symmetry between the two countries' monetary policy spillovers. In particular, the US trade variable is more sensitive to changes in China's monetary policy, whereas China's financial variable is more sensitive to changes in US monetary policy. We have created a two-country DSGE model with financial frictions to identify the primary transmission mechanisms of the monetary policy spillovers from the two countries through numerical simulation and

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counterfactual analysis in order to investigate the intrinsic rationale of such non-symmetry. In particular, China's monetary policy influences China's imports of investment goods from the United States by affecting domestic output and investment, thereby influencing China's imports of investment goods from the United States and depressing US output. In contrast, the US monetary policy influences the cost of debt service and net value of Chinese companies. In accordance with the financial accelerator effect, this will have an effect on the external financing risk premium for Chinese firms, thereby amplifying the spillover effect on China's output.

Based on the preceding research findings, the following policy recommendations are put forward: First, China's monetary policy spillover effects are becoming increasingly significant as its economic prowess and global influence increase. Given their various economic and financial positions and levels of development, it is natural for China and the United States to have distinct monetary policy spillovers. We have identified an non-symmetry in the monetary policy spillovers of both countries through empirical research. Policymakers should be well-versed in the theoretical rationale underlying this non-symmetry, have a clear understanding of the monetary policy decision-making framework and considerations of both countries, and identify the impact of trade structure, capital control, and financial market frictions on monetary policy spillover effects. In light of this, policymakers should enhance their ability to foresee policy spillover effects and take appropriate precautions. On the other hand, they should develop the capacity to create targeted solutions to address external spillover effects. Second, the negative spillover effects of monetary policies should be mitigated based on the characteristics of both countries' monetary policy spillover. According to the results of our test of the monetary policy transmission mechanism, China's financial market frictions - including its underdeveloped financial markets and a high degree of information asymmetry - are a significant reason for US monetary policy spillovers on China via the financial channel. Short-term, China should be more concerned with the volatility of financial markets, take proactive measures to address financial market risks originating from external shocks, and prevent the transmission of financial risks to the real economy. Long-term, China must continue to improve its financial market system, reduce financial market frictions and information asymmetry, and develop the capacity to avoid and mitigate financial risks. Third, policymakers must closely monitor the interactions between monetary policy and other macroeconomic policies. For example, they should closely monitor and proactively address the effect of financial sector openness in amplifying foreign monetary policy spillovers. Our findings indicate that China's capital control will mitigate the adverse effects of US monetary policy on China's output. With China's increasing financial sector openness and capital control easing, US monetary policy spillovers are likely to become even more pronounced. During the process of financial sector opening up, the Chinese government should place a premium on the spillover effects of US monetary policy via the financial channel, maintain the independence and controllability of its domestic monetary policy, and coordinate financial sector opening up with the progress of domestic institutional development in order to protect domestic macroeconomic stability. Fourthly, both nations should improve policy communication at the level of the central bank, increase information exchange, and collaborate to advance international monetary policy coordination. As the two largest economies in the world, China and the United States have reciprocal monetary policy spillovers that have significant effects on their respective economies and the global economy. Therefore, both nations must actively participate in international monetary policy coordination. Due to their disparities in inflationary and economic cycles, China and the United States have increasingly divergent monetary policies, making it difficult for the two countries to cooperate on monetary policy. However, both nations may endeavor to begin with coordination in certain sectors, avoiding other sectors in which they have significant differences, in order to coordinate policy objectives and instruments in areas where consensus is easier to achieve. By pursuing common ground and fostering mutual trust, the two nations should take measures to strengthen and expand monetary policy coordination.

Notably, our research has only revealed the existence of non-symmetry in the monetary policy

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spillovers of China and the United States and offered a theoretical model-based explanation. However, we have not discussed in this paper the factors underlying the divergent monetary policy orientations of both nations. Therefore, the reasons for the divergence in monetary policy between the two nations represent an essential area for future research. What policy initiatives should countries implement to counteract the asymmetrical spillover effect? How should governments improve international coordination of monetary policy? These questions merit additional investigation and discussion.

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