Financial Crises and Climate Shocks during the Great Depression: A DSGE Perspective

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12 February 2025

Abstract: *This study explores the compound crisis that struck China in the 1930s, fueled by the overlapping impacts of the Great Depression and frequent rare and severe natural disasters. By utilizing a newly constructed annual climate index based on the self-calibrated Palmer Drought Severity Index (scPDSI) and financial crises data from Reinhart and Rogoff (2008, 2009), we identify key periods of compounded disruptions during the Great Depression. Employing a Dynamic Stochastic General Equilibrium (DSGE) model specifically designed for China's multi-sector economy under the silver standard, we assess the contributions of external financial shocks and internal climate shocks to macroeconomic fluctuations. Our findings demonstrate that climate shocks had a dominant and lasting impact on agricultural output and GDP, far outweighing the effects of the Great Depression, which primarily affected trade through declining exports and imports. The analysis further uncovers how disruptions in agriculture propagated through other sectors, intensifying economic instability. Counterfactual simulations reveal that modern monetary policies, such as flexible interest rate adjustments, could have mitigated short-term fluctuations but would have required effective fiscal coordination to avoid resource misallocation and maintain agricultural investment. The study highlights the critical role of agriculture as a transmission channel for compound shocks and provides policy insights for modern economies, emphasizing the need for coordinated monetary and fiscal responses to manage overlapping crises.*

Keywords: Great Depression; Climate Instability; Natural Disasters; Compound Crises; Agriculture; Financial Crises; Bayesian Estimation; DSGE Model; Transmission Mechanism

Acknowledgements: I am deeply grateful to my dissertation committee: Professor Gabriel Mathy (chair), Professor Xuguang Simon Sheng, and Professor Evan Kraft, for their invaluable guidance and support. I also sincerely thank Professor Deng Guichuan from Sun Yat-sen University and Professor Xu Wenli from Anhui University for their advice in modeling and coding.

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1 Introduction

The Great Depression of 1929, originating within the U.S. financial system, quickly spread globally, affecting economies such as China. While typically viewed as a singular financial and economic catastrophe, the Great Depression in certain regions was compounded by large-scale natural disasters—a phenomenon herein referred to as "compound crises."

China in the 1930s represents a quintessential case of such a compound crisis. During this tumultuous decade, the Chinese economy suffered both from external shocks triggered by the global economic downturn—such as collapsing export demand and sharp fluctuations in exchange rate—and from an array of rare and severe natural disasters, notably the 1931 floods in the Yangtze River basin followed by severe droughts. The interaction of these domestic and international shocks was further exacerbated by China's distinctive silver standard system, which uniquely positioned the country to experience monetary contractions and expansions shaped by the international price of silver (Chen and Xie, 2022; Ma, 2016). Despite the persistent outflow of silver during the early 1930s, China's banking system, highly competitive and increasingly reliant on bank deposits and paper currency, managed to augment the overall money supply—thereby moderating some of the downturn's adverse impacts on domestic industrial production.

Existing scholarship on China's economic history in this period has tended to focus on either a single shock (e.g., foreign demand contractions or monetary regime shifts) or descriptive analyses of natural disasters. Relatively few studies have examined how these multiple shocks dynamically interacted to shape a broader "compound crisis." Moreover, most current research on the impact of climate disasters in historical contexts employs simplified models that primarily emphasize agricultural output (Dell, Jones, & Olken, 2012). Such an approach risks understating the broader economy-wide effects of shocks that originate in the agricultural sector but propagate to non-agricultural sectors through intricate supply chains and intermediate-input linkages, amplifying overall economic volatility.

Against this backdrop, the present study aims to fill a notable gap in both economic history and macroeconomic modeling by quantifying the dual impacts of the Great Depression and major climate shocks in 1930s China. Specifically, it addresses three core questions:

1. **Identifying and Quantifying Compound Crises under Data Constraints**: How can we establish the existence of a **compound crisis** when historical data are limited? What methodologies can effectively quantify the simultaneous impact of financial and climate shocks in early 20th-century China?
2. **Relative Significance of Shocks**: To what extent did climatic disruptions versus external shocks—such as plummeting foreign demand and exchange rate volatility—drive economic fluctuations in China during the Great Depression?
3. **Transmission Pathways**: Through what channels did natural disasters propagate from agriculture into non-agricultural sectors, the financial system, and the broader economy? How did such channels intersect with the external shocks unleashed by the global crisis, and what was the resulting impact on macroeconomic stability?
4. **Role of Monetary Policy**: As the only major economy under a silver standard at the time, could China moderate these compounded shocks through any form of domestic

monetary policy? Moreover, would the adoption of a more modern monetary rule (e.g., a Taylor-type rule) have significantly mitigated the severity of the compound crisis?

To systematically examine these questions, this study first establishes a quantitative framework for identifying compound crises. Using a newly constructed climate index based on the self-calibrated Palmer Drought Severity Index (scPDSI) alongside financial crisis data from Reinhart and Rogoff (2008, 2009), we identify 1929–1932 as the key period of compounded financial and climate shocks in China. During these years, severe climatic events, such as the 1931 flood, overlapped with financial distress, deepening the economic downturn.

To disentangle the contributions of natural disasters, external shocks, and policy responses, we develop a DSGE model tailored to China's multi-sector economy under the silver standard. By simulating scenarios involving isolated and combined shocks. Our findings reveal that climate shocks were the primary drivers of China's economic fluctuations, with severe disruptions to agricultural output reducing rural consumption and triggering spillover effects on non-agricultural sectors. In contrast, external financial shocks, while significant in the trade sector, had a relatively modest impact on overall GDP. Counterfactual simulations show that even under modern monetary policy frameworks, climate shocks would still pose significant challenges without coordinated fiscal responses, highlighting the need for targeted agricultural investments to mitigate long-term impacts.

These results provide new insights into the ongoing debate about the Great Depression's impact on China by refining existing perspectives. Contrary to the low-impact view proposed by Brandt (1989) and Myers (2014), which argues that China's agrarian economy insulated it from global financial turmoil, our findings reveal that climate shocks played a far more disruptive role than previously acknowledged. While China's limited integration into global markets may have tempered the direct effects of external financial shocks, its vulnerability to extreme climate events led to prolonged economic distress.

Similarly, while the financial shock hypothesis (Friedman, 1992; Zhao and Sui, 2011) emphasizes silver outflows and currency instability, our findings suggest that external financial shocks, though significant in the trade sector, had only a modest impact on overall GDP. Crucially, we find that imports were more affected than exports, a nuance often overlooked in prior studies that focused primarily on declining foreign demand.

Our results also extend the climate shock hypothesis (Xu and Wu, 2003; Lai Cheng, 2009), which underscores the role of natural disasters in economic downturns. Unlike previous studies that primarily document agricultural disruptions, our DSGE model provides quantitative evidence that climate shocks had broader and more persistent effects on macroeconomic stability than financial disruptions, particularly in the absence of countercyclical policies.

Building on Shiroyama's (2021) compound crisis narrative framework, we further demonstrate the asymmetric effects of financial and climate shocks, showing how their interaction exacerbated economic instability. While financial shocks primarily affected trade, climate shocks triggered sustained declines in agricultural output, rural consumption, and overall economic growth.

By integrating multiple shocks within a unified framework, this study offers insights into the mechanisms of China's compound crisis during the Great Depression and provides lessons for contemporary economies facing similar risks.

The paper is structured as follows: Section 2 reviews the literature on compound crises and the global impact of the Great Depression. Section 3 discusses the compound risk identification method, identifying China's compound crises during the Great Depression and presenting evidence of its exposure to multiple shocks. Section 4 introduces a DSGE model integrating climate, financial, and policy shocks. Section 5 details the estimation strategy, including data, calibration, and model diagnostics. Section 6 discusses the results and their macroeconomic implications. Section 7 conducts a historical decomposition of shock contributions. Section 8 presents counterfactual analyses, exploring climate shocks, the Great Depression, and their combined effects. This section also examines modern monetary policy responses under hypothetical scenarios and offers policy recommendations. Section 9 concludes with key findings and implications for modern economies facing similar compound crises.

2 Literature Review[1]

The impact of the Great Depression on China's economy and financial system in the 1930s has been widely debated in the literature (Shiroyama, 2009; Fagan, 2012; Young, 1971; Burdekin, 2008; Rawski, 1989, 1993; Zhao and Sui, 2011; Guan, 2007; Li, 1997; Du, 2009; Dai, 2009; Ma, 2019; Ma and Zhao, 2020; Fabio Braggion et al., 2019). While early studies often underestimated the Depression's effects on China, recent research suggests that its impact was more complex than previously assumed. The debate primarily centers around four competing perspectives: (1) the low-impact view, which argues that China's economy remained relatively insulated; (2) the global financial shock hypothesis, which emphasizes silver flows and external trade disruptions; (3) the climate shock hypothesis, which highlights the role of natural disasters; and (4) the compound crisis perspective, which integrates financial, climatic, and institutional shocks.

2.1 Competing Perspectives in Literature

The low-impact perspective, supported by scholars such as Brandt (1989), Myers (2014), and Rawski (1989, 1993), contends that the Great Depression had only a limited effect on China's economy. Proponents of this view argue that China's large agrarian sector reduced its dependence on global markets, while its adherence to the silver standard shielded it from the financial turmoil affecting gold-standard economies. Brandt (1989), for example, challenges Friedman's claim that the U.S. Silver Purchase Policy triggered deflation and economic collapse in China, pointing out that while general price levels declined, evidence of severe economic contraction remains scarce. Similarly, Myers (2014) asserts that China continued to experience slow but steady growth throughout the 1930s, while Fei and Fei (2006) describe China as largely insulated from the global downturn due to its peripheral role in international trade.

[1] For the definition, characteristics, and transmission mechanisms of compound crises, please refer to Chapter 1 of the literature review.

In contrast, the global financial shock hypothesis, advanced by scholars such as Friedman (1992) and Zhao and Sui (2011), emphasizes the destabilizing effects of external financial disruptions, particularly silver outflows. Friedman (1992) argues that the simultaneous effects of the global financial crisis and silver outflows weakened China's monetary stability and contributed to economic contraction. Zhao and Sui (2011) provide empirical evidence using an Autoregressive Distributed Lag Model（ARDL) model, showing that silver outflows were a significant source of economic distress, exacerbating China's financial vulnerabilities.

The climate shock hypothesis, advocated by Xu and Wu (2003), Lai Cheng (2009), and Zhao and Sui (2011), shifts the focus toward internal climatic disasters as the primary cause of economic instability. This perspective contends that rare and severe natural disasters—such as floods and droughts—disrupted agricultural production, leading to declines in rural incomes and broader economic distress. Given China's predominantly agrarian economy, climate-induced crop failures had cascading effects on consumption, investment, and economic growth.

2.2 Toward a Compound Crisis Perspective

More recent research has moved toward a compound crisis perspective, recognizing that China's experience during the Great Depression involved overlapping financial, climatic, and institutional risks. As Shiroyama (2021) notes, both the Great Depression and climatic disasters significantly influenced China's economic trajectory, though her analysis remains largely descriptive and lacks quantitative validation.

Despite these advances, several gaps remain in the literature. First, most studies focus on either financial shocks or climate shocks in isolation, without quantitatively assessing their combined impact. Second, the transmission mechanisms of compound crises are not well understood, particularly the interplay between financial shocks, climatic disasters, and government policy responses. Additionally, other factors, such as the role of government spending and technological change during this period, have been largely neglected. One critical factor that exacerbated China's vulnerability was its reliance on debt-financed fiscal policies amid declining revenues. Natural disasters led to reduced agricultural output and lower tax collections, forcing the government to depend heavily on domestic borrowing. Deficit monetization proved ineffective, as revenues from key sources like customs duties and salt taxes fell short of covering fiscal deficits. By the early 1930s, both domestic and external debts had risen significantly, reflecting the mounting financial pressures faced by the government during this period (Feuerwerker, 1976). Moreover, although China's technological development lagged during the Depression, some policy measures, such as the 1932 Provisional Regulations on Incentives for Industrial Technology, sought to promote industrial innovation.

To address these gaps, this study develops a multi-sector DSGE model incorporating China's silver standard. By integrating climatic, financial, technological, and government spending shocks, the model provides a quantitative assessment of the Depression's impact on China and reveals the mechanisms driving its prolonged economic instability. In doing so, this research not only extends the compound crisis framework but also contributes empirical evidence to ongoing debates about the relative importance of financial and climatic shocks in shaping China's economic trajectory during the 1930s.

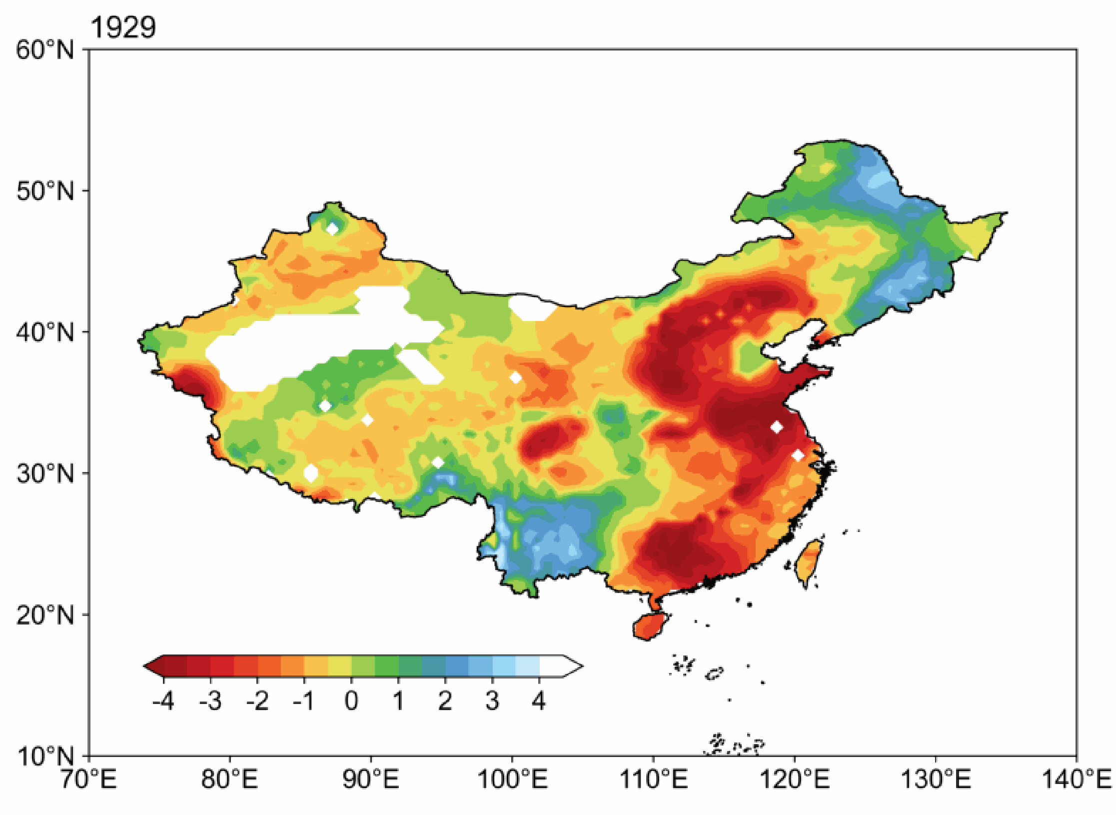
3 China's Compound Crisis During the Great Depression

This section examines how natural disasters, combined with global economic turbulence, contributed to the destabilization of China's economy during this period.

3.1 Identifying Climate Shocks: A New Climate Index

Quantifying the economic impact of natural disasters in 1930s China is challenging due to the lack of comprehensive historical data. Unlike modern economies with detailed records of disaster-related losses, China during this period lacked systematic documentation, making it difficult to apply conventional benchmarks, such as losses exceeding 1% of GDP (Fomby et al., 2013; Parker, 2018; Fratzscher et al., 2020; Baker et al., 2018). To address this, we construct a new Climate Index using the scPDSI data. Following van der Schrier et al. (2013), scPDSI values above 2, 3, and 4 indicate varying degrees of wetness, often linked to floods, while values below -2, -3, and -4 reflect increasing drought severity. These thresholds allow for the systematic identification of regional moisture stress, critical for understanding agricultural productivity in China's agrarian economy.

Figure 1 Climate Index During the Great Depression (1929-1936)



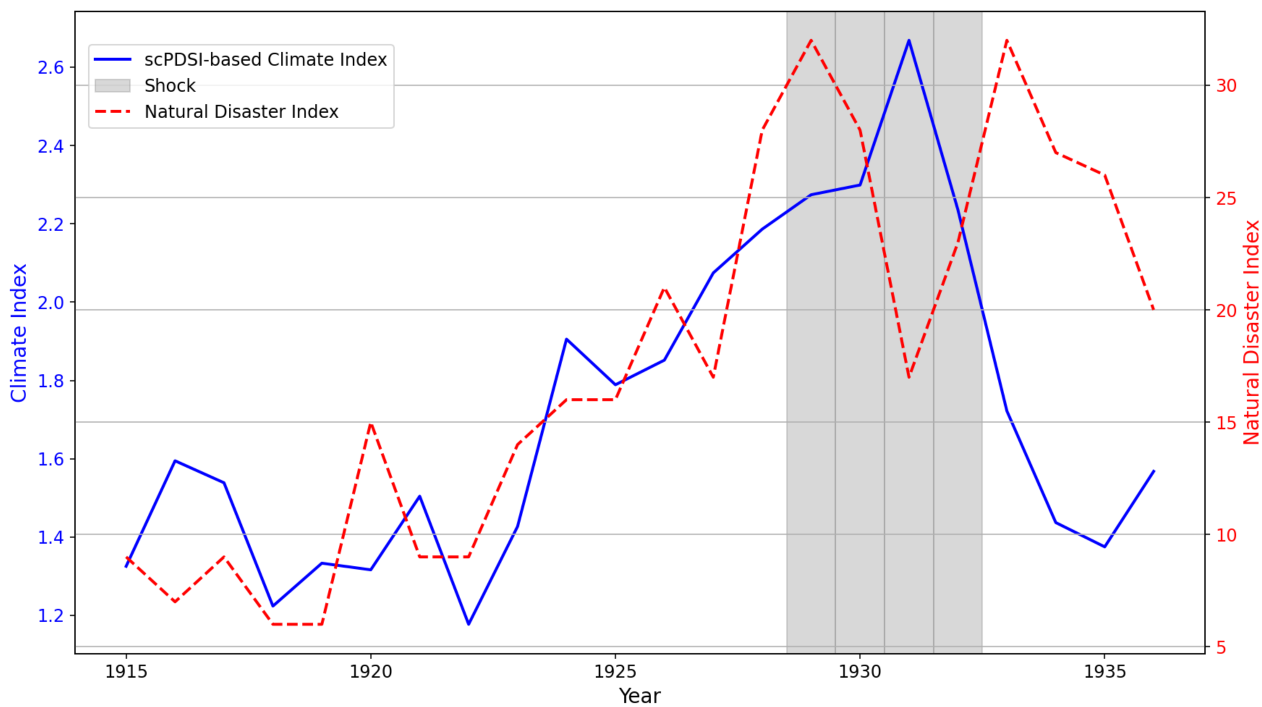
Data source: van der Schrier (2013). Figure created by the author.

Note: This figure presents annual self-calibrated Palmer Drought Severity Index (scPDSI) data for 1929-1936 in China's warm temperate semi-humid region (35°-40°N, 110°-120°E) and northern subtropical humid region (25°-35°N, 105°-120°E), covering areas such as the North China Plain, the middle and lower Yangtze River, and the Sichuan Basin. Dominated by wheat, corn, and rice, agriculture in these regions is highly climate-sensitive. Using *monthly scPDSI grid data from van der Schrier et al. (2013), we generated annual averages and visualized drought and wetness trends with archGs software. In the figure, scPDSI values below -2, -3, and -4 indicate moderate, severe, and extreme drought, while values above 2, 3, and 4 indicate varying degrees of wetness, often associated with extreme events like floods*

Given China's diverse climatic conditions, we focus on two critical agricultural regions: the warm temperate semi-humid region (35°–40°N, 110°–120°E) and the northern subtropical humid region (25°–35°N, 105°–120°E). These regions include economically vital areas such as the North China Plain, the middle and lower Yangtze River, and the Sichuan Basin, where climate-sensitive crops like wheat, corn, and rice are cultivated. Figure 1 reveals drought and flood patterns derived from scPDSI data cross the study regions that align with historical records, such as those in the Atlas of Drought and Flood Distribution in China Over the Past 500 Years (Modern Central Meteorological Bureau, 1981).

To measure the overall impact of climatic stress, we aggregate grid-level scPDSI data into a regional-level scPDSI-based Climate Index (blue line in Figure 2), generating regional averages compiled into an annual index. This provides a continuous, standardized measure of year-round climatic conditions, ensuring comparability across diverse climatic zones and enabling the evaluation of drought and flood impacts during the Great Depression.

Figure 2: Climate and Natural Disaster Indices with Shock Periods (1915–1936)



Data Source: Annual average for the aggregated climate index was generated using monthly scPDSI grid data from van der Schrier et al. (2013). Data for the Natural Disaster Index is sourced from Chen (2021).

Significant climatic shocks are identified when deviations exceed 1.5 standard deviations from the historical mean, marking 1929–1932 as key shock years. A stricter threshold of 2 standard deviations isolates 1931—the year of the catastrophic Yangtze River flood—as the most severe event[2]. In contrast, traditional indices like the Natural Disaster Index (dotted red line in Figure 2) record discrete events but fail to reflect sustained moisture stress, missing the full severity of 1931's rare disaster.

The regional-level findings based on the scPDSI Climate Index align with EM-DAT disaster records and historical evidence from Liu and Yang (2012), confirming the index's reliability in detecting major natural disasters and its usefulness in assessing their economic impacts (Appendix A Table 1).

3.2 Identifying Financial Crises and Defining Compound Crises

To capture the financial dimension of the compound crises, we apply Reinhart and Rogoff's (2008, 2009) framework, which classifies financial crises into categories such as banking, currency, and sovereign debt crises. Compound crises are defined as periods when financial crises coincide with significant climatic shocks, amplifying economic instability. For China, we identify 1929–1932 as years of overlapping financial and climatic crises, during which external financial shocks—such as silver outflows and declining foreign demand—combined with severe natural disasters to exacerbate the economic downturn. In the U.S., the Dust Bowl of 1933 coincided with ongoing financial crises under Reinhart and Rogoff's criteria, making 1933 a key year of compound crisis (Frank and Bernanke 2007; Hayes 2023). Table 1 highlights how the alignment of financial and climatic shocks intensified economic distress in both countries, underscoring the role of overlapping crises in prolonging the economic downturn.

Table 1 Compound Crises in China During the Great Depression

Country	Year	Natural Disaster	Currency Crisis	Banking Crisis	Systemic Crisis	Domestic Debt Default	Sovereign Debt
China	1929	1	1	0	0	0	1
	1930	1	0	0	0	0	1
	1931	1	1	1	1	0	1
	1932	1	1	0	0	1	1
	1933	0	0	0	0	0	1
	1934	0	0	1	1	0	1
	1935	0	1	1	1	0	1
	1936	0	0	1	1	0	1
United States	1933	1	1	1	1	1	1

[2] The flood affected over 61 million people and caused 3.7 million deaths (Agricultural Report, 1936).

Data Sources: scPDSI data from van der Schrier et al. (2013) and financial crises data from Rogoff (2008, 2009). The definitions and identification criteria for crises follow Reinhart and Rogoff (2008, 2009).

Note: (1) A crisis event is denoted by "1"; otherwise, by "0." Rare and severe natural disasters are marked as "1" when economic losses exceed 1% of GDP (see Fomby, Ikeda, and Loayza, 2013; Parker, 2018; Fratzscher et al., 2020; Cantelmo, 2020). Financial crises include banking, systemic, currency, sovereign debt, inflation, or domestic debt crises, following definitions by Reinhart and Rogoff (2009, 2014). A compound crisis is defined as the simultaneous occurrence of a natural disaster (marked "1") and at least one financial crisis in a given year. (2) China's sovereign debt crisis began in 1921, persisting until the establishment of the People's Republic in 1949. Meanwhile, its domestic debt crisis emerged during the Great Depression in 1931, intensifying the financial challenges of the era.

3.3 Compound Crises and Their Vicious Cycle of Disruption

3.3.1 Agricultural Crisis

The agricultural sector, which contributed over 60% of China's GDP and supported more than 80% of the population (Wu 2011), was particularly vulnerable to the combined shocks of natural disasters and external shocks from the Great Depression.

Frequent natural disasters between 1929 and 1936 (see Appendix A, Table 1) exacerbated China's agricultural crisis during the Great Depression. The resulting compound crises led to a sharp decline in agricultural output, which fell from USD 10.07 billion in 1931 to USD 5.41 billion in 1934, a 46.26% decrease. Similarly, the agricultural price index dropped significantly, falling from 100 in 1931 to 56 in 1934, reflecting a 44% decline (Table 2).

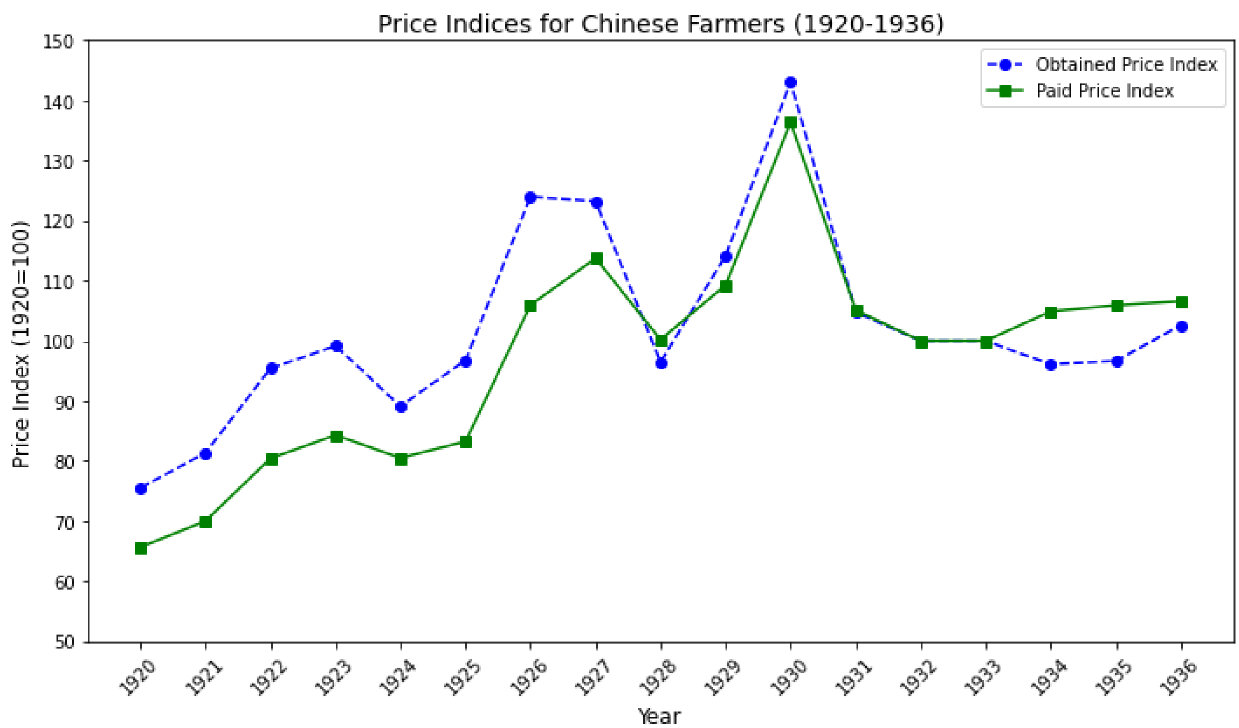
Table 2 China's Agricultural Price Index and Output (1931-1936)

Year	Agricultural Price Index	Reduction Rate of Agricultural Price (Relative to 1931) (%)	Agricultural Output (Billion USD)	Reduction Rate of Agricultural Output (Relative to 1931) (%)
1931	100	0	10.07	0
1932	72	28%	7.93	−21.27%
1933	61	28%	6.36	−36.81%
1934	56	44%	5.41	−46.26%
1935	57	43%	6.07	−39.68%
1936	60	40%	6.45	−35.92%

Sources: Yangge (1981). The agricultural output values in the table have been converted from Chinese silver yuan to U.S. dollars using an exchange rate of 1 yuan = 0.412903 USD. This conversion is based on historical exchange rates from the year 1929 (Liu, 2013).

This vicious cycle of agricultural crises and natural disasters caused a sharp decline in rural purchasing power, creating ripple effects on industrial production and reflecting China's dual economic structure. As silver flowed into urban centers like Shanghai, it rarely returned to rural areas, deepening the divide between the traditional, labor-intensive agricultural sector and the industrial sector. The combined effects of economic turmoil and natural disasters worsened farmers' incomes and production costs. Prior to 1931, farmers earned more from selling crops than they spent on production inputs. However, as the compound crises intensified, agricultural prices collapsed, significantly reducing farmer income (Figure 3).

Figure 3 Changes in Farmer Purchasing and Selling Price Indices in China (1920-1936)



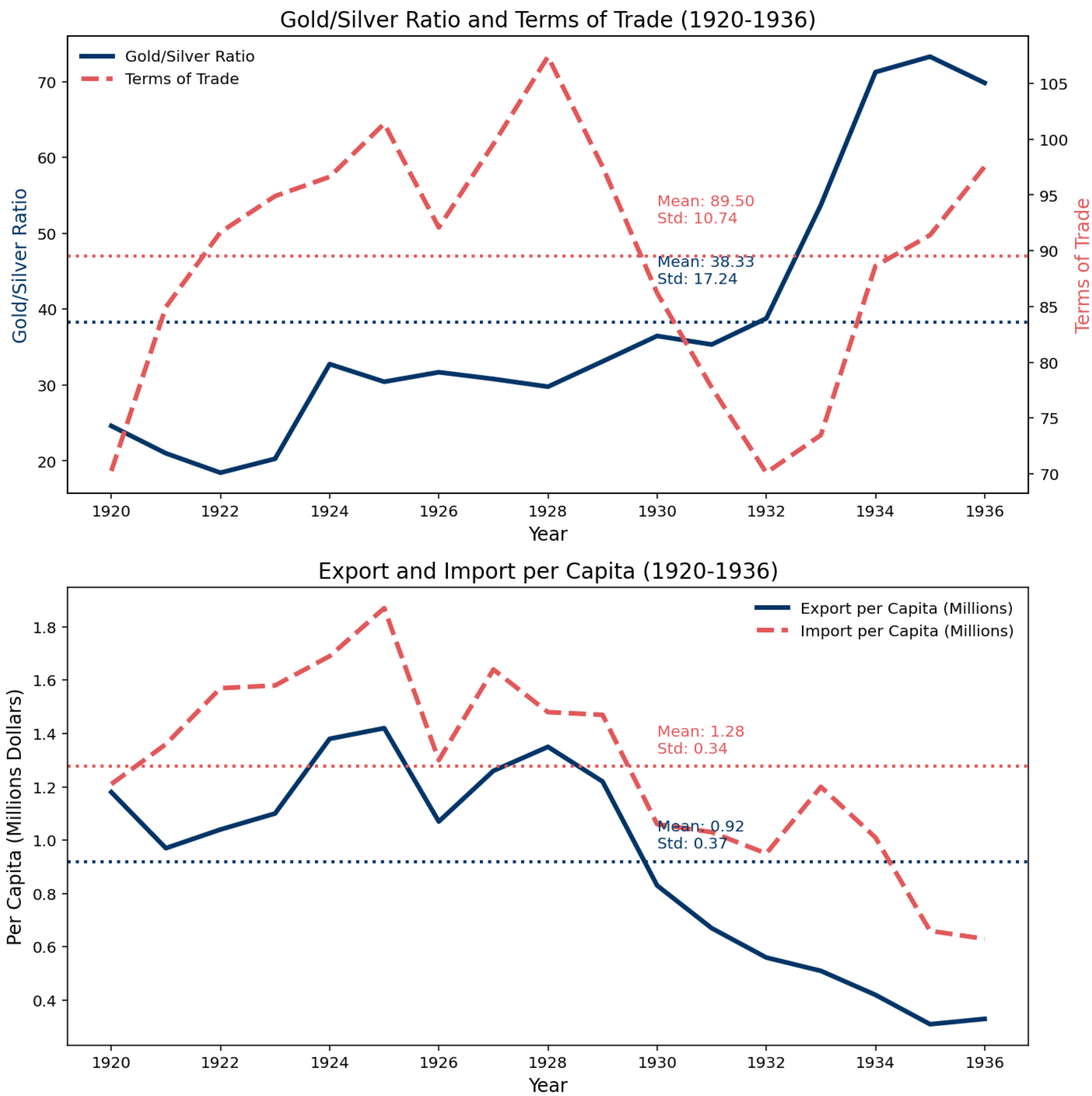
Data source: Wang (2008). Figure created by the author.

3.3.2 Twin Crises: Currency Crisis and Banking Crisis

Table 1 highlights China's dual financial crisis during the 1930s, characterized by currency instability and banking fragility, as identified through Reinhart and Rogoff's (2008, 2009) framework. The root of this instability lay in exchange rate fluctuations under the silver standard, where China's currency was tied to the global gold-to-silver ratio, making the economy vulnerable to sharp movements in silver prices. These fluctuations affected China's economy through two key channels: trade competitiveness and the monetary supply (Guan 2007).

Between 1929 and 1932, the global gold-to-silver ratio surged as silver prices plummeted - the price of silver in New York fell by 53% (Figure 4). Although currency depreciation theoretically should have improved China's export competitiveness, this advantage was offset by the collapse in global demand triggered by the Great Depression. By 1934, export revenues had shrunk to 300–400 million USD, weakening industrial production and depleting foreign exchange reserves. On the import side, depreciation drove up import costs, causing a significant decline in imports (Figure 4).

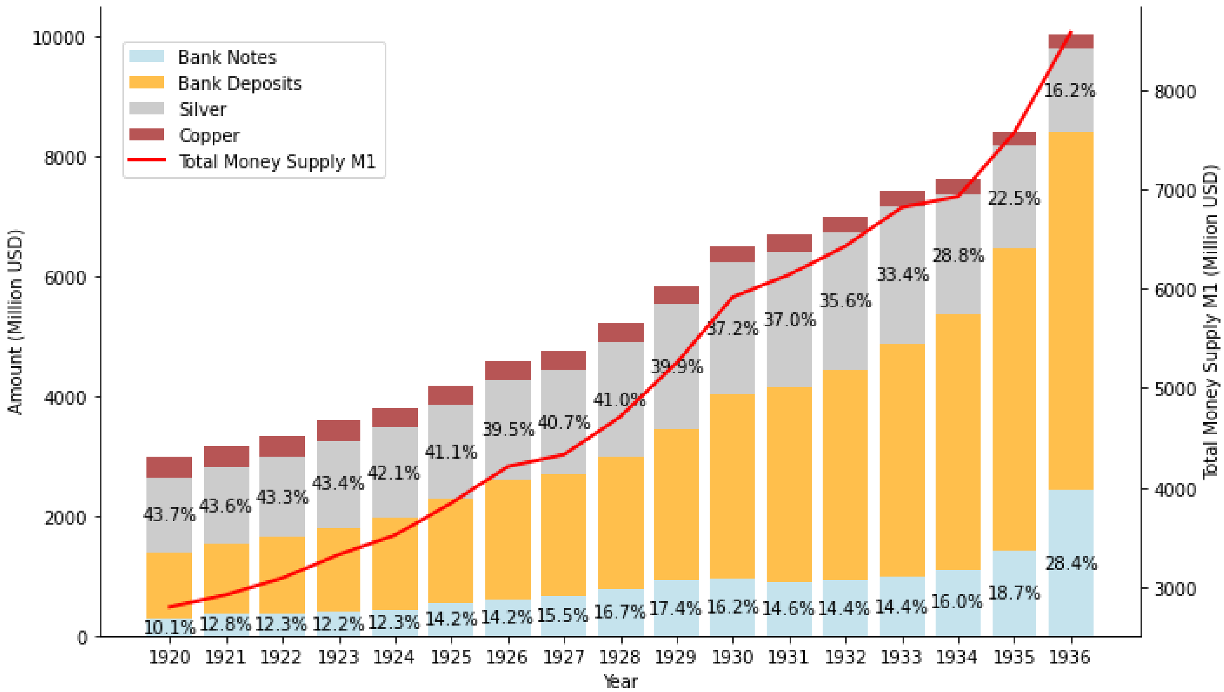
Figure 4 Silver/Gold Ratio and Terms of Trade (Top); Exports and Imports (Bottom)



Data source: Global Financial Database. Figure created by the author.

The exchange rate volatility also disrupted China's monetary system by reducing the circulation of silver and copper coins, leading to a greater reliance on bank deposits and paper currency (Figure 5). To alleviate liquidity pressures, the 1935 currency reform, driven by the U.S. Silver Purchase Act, introduced expansionary monetary measures. These policies eased credit shortages, stabilized the financial sector, and encouraged investment, ultimately supporting the country's economic recovery.

Figure 5 Money Supply Composition (1920-1936) with Silver and Bank Notes Ratios



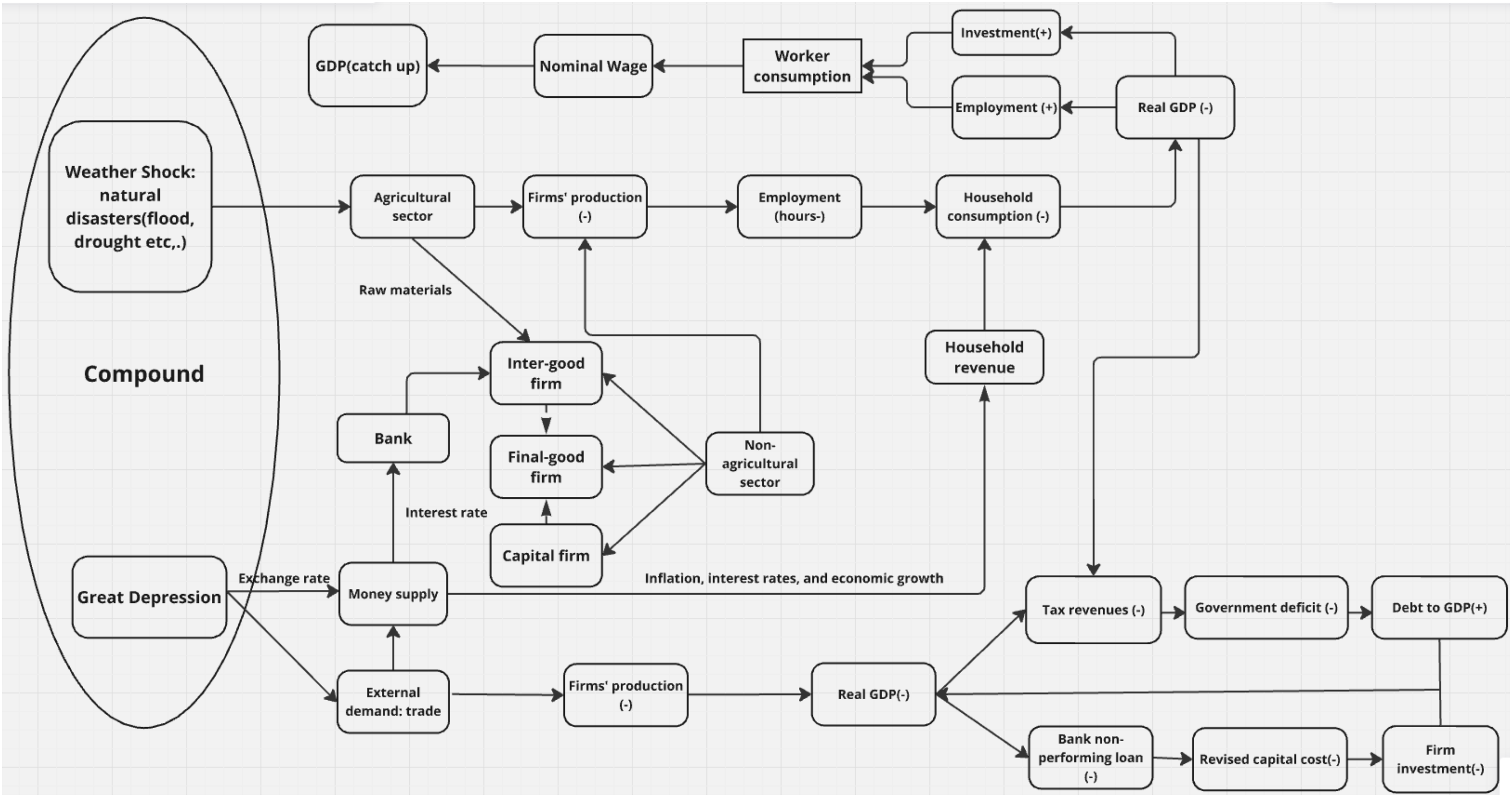
Data source: Rawski (1989)

3.3.3 Debt Defaults, Deficit Monetization, and Government Spending Shocks

During the Great Depression, in addition to natural disasters and external shocks, government spending and deficit monetization played a crucial but overlooked role in China's economic instability. Natural disasters and currency fluctuations strained fiscal resources, limiting foreign capital inflows and forcing the government to issue $693 million in domestic bonds between 1927 and 1936 (Wang and Ma, 2015). By 1935, the fiscal deficit had reached 26.57% of GDP (Zheng, 1984), with domestic debt accounting for 27.3% of revenue, compared to only 3.79% for foreign debt (Yan, 2015). Much of the spending was diverted to military purposes, crowding out private investment and worsening economic instability. The 1931 Yangtze River flood compounded these issues, while limited relief efforts and insufficient aid exacerbated rural and urban economic decline

4 Model

Figure 6 Compound risk transmission channels



The DSGE model illustrates how compound crises unfold by integrating climate-related shocks and the economic impacts of the Great Depression. It captures key interactions among the agricultural, non-agricultural, and banking sectors within an open economy vulnerable to external shocks.

The model includes an agricultural sector inspired by Gallic and Vermandel (2020), which relies on labor and land to produce raw materials. Climate shocks, such as floods and droughts, directly impact this sector, disrupting production capacity and reducing firms' output. These disruptions lead to decreased employment and wages, ultimately lowering household consumption and overall GDP. Households, in turn, invest in government-issued domestic bonds, supply labor to domestic firms, and consume a basket of domestic and foreign goods. The banking sector, modeled after Gertler and Karadi (2011), collects deposits from households and extends loans to domestic industrial firms. These firms use the borrowed capital to purchase production inputs from capital producers, contributing to domestic goods production. They also face price adjustment costs, allowing monetary policy to influence economic activities.

Simultaneously, the Great Depression introduces exchange rate fluctuations and reduces external demand, compounding the adverse effects on domestic production and trade. As illustrated in Figure 6, these combined shocks reduce tax revenues, increase government deficits, and raise the debt-to-GDP ratio. The model captures how interconnected sectors respond to and propagate the effects of financial and environmental shocks, highlighting the complex and reinforcing mechanisms underlying compound crises.

4.1 Agricultural Sector

A representative household is assumed, allowing for labor mobility across sectors [3]. To investigate the effects of climate change specifically, extreme climate events on overall economic stability-a climate variable, ϵ_t^C is introduced. This variable captures the impact of significant climate changes on agricultural production. Drawing from Gallic and Vermandel (2020), it is assumed that the total climate shock follows a first-order autoregressive (AR) process with one lag:

$$\ln(\epsilon_t^C) = (1-\rho_s)\ln \epsilon_t^C + \rho_s \log(\epsilon_{t-1}^C) + \sigma_s u_t^C,\ u_t^C \sim \mathcal{N}(0,1) \tag{1}$$

where $\rho_s \in [0,1]$ represents the persistence of climate shock, and $\sigma_s \geq 0$ is its standard deviation. The stochastic nature of the model reflects the historical unpredictability faced by farmers in responding to these climate events.

Farmers produced a variety of agricultural goods, relying on land and labor. Extreme climate events compromised soil fertility and arable land, with drought damaging soil quality and floods causing erosion-both diminishing land productivity. These conditions also disrupted labor, affecting farmers' health and reducing their efficiency. Thus, climate extremes posed a severe

[3] This assumption is reasonable for the Republican period due to several key factors. Natural disasters, wars, and a weakened government gradually eroded traditional restrictions on labor movement, while the rise of a capitalist economy and expansion of commodity markets accelerated the breakdown of rural economies. As rural poverty deepened, bankrupt farmers became a reserve labor force for urban industries. The combination of surplus labor in rural areas and the pull of urban economic opportunities made labor mobility a logical outcome. Despite the lack of a modern household registration system, labor market fluidity significantly increased, with farmers exhibiting a greater tendency toward free movement (Li and Zhou, 2005; Liu, 1997).

threat to agricultural productivity. Given the limited material capital in rural Republican China, agriculture mainly depended on labor-intensive traditional methods. Unlike Gallic and Vermandel (2020), this model does not explicitly include physical capital in the production function, instead emphasizing the roles of land and labor. Agricultural output is measured using a Cobb-Douglas function, taking into account the economic and climate conditions affecting land productivity:

$$y_t^A = [\Omega(\epsilon_t^C) l_{t-1}]^{\omega} [\epsilon_t^Z \kappa_A h_t^A]^{1-\omega} \tag{2}$$

where y_t^A represents the production function of intermediate agricultural products, combining land l_{t-1} and agricultural labor demand h_t^A. Farmers own land l_t, which is subject to changes in economic and climatic conditions. During the production period from $t-1$ and t, the land l_t is influenced by climate ϵ_t^C. The productivity shock is modeled as an autoregressive process of AR(1):

$$\ln(\varepsilon_t^Z) = (1-\rho_z) \ln \epsilon_t^C + \rho_z \ln(\epsilon_{t-1}^z) + \sigma_z u_{z_t},\ \epsilon_{z_t} \sim \mathcal{N}(0,1) \tag{3}$$

Land productivity is impacted by climate through the function $\Omega(\varepsilon_t^C)$. The production process also reflects a technological shock ε_t^Z affecting both sectors via an AR(1) process. The parameter ω represents the elasticity of output relative to land, while $\kappa_A > 0$ is a technology parameter determined endogenously in steady state. The loss function $\Omega(\epsilon_t^C)$ is defined as:

$$\Omega(\epsilon_t^C) = (\epsilon_t^C)^{\theta} \tag{4}$$

where θ determines the elasticity of land productivity with respect to climate. Setting $\theta = 0$ would effectively disable the climate-driven propagation of economic cycles.

Lagged climate effects, as described by Gallic and Vermandel (2020), have been empirically shown to affect agricultural production over time, not only in the immediate period but also in the long term. This dynamic is evident in both livestock and crop production, demonstrating that climate conditions can have enduring effects on agricultural yield (Rosen et al. 1994; Narasimhan and Srinivasan 2005; Gallic and Vermandel 2020). Such lagged effects steer agricultural economics away from the traditional static concept of land productivity. This model adapts Gallic and Vermandel's (2020) framework to suggest that land productivity may change over time.

According to this perspective, each farmer's land productivity follows an endogenous law of motion, expressed as:

$$l_t = [(1-\delta_l) + v(x_t)] l_{t-1} \Omega(\epsilon_t^C) \tag{5}$$

where $\delta_l \in (0,1)$ indicates the decay rate of land productivity, reflecting its lasting effect.

The land cost is defined as

$$\phi_{Lt} = v(x_{it}) \ell_{it-1} \Omega(\epsilon_t^C) = \frac{\tau}{\phi} x_t^{\phi} \ell_{it-1} \Omega(\epsilon_t^C) \tag{6}$$

The functional form of how non-capital investment x_t, such as such as seeds, fertilizers[4], translates into land productivity is proposed as $v(x_t) = \frac{\tau}{\phi} x_t^{\phi}$, where $\tau \geq 0$ and $\phi \geq 0$. For $\phi \to 0$, land productivity exhibits constant returns, whereas, for $\phi > 0$, land costs manifest increasing returns. Finally, the profit of a farmer is denoted by:

$$d_t^A = p_t^A y_t^A - w_t^A h_t^A - p_t^N x_t$$

where $p_t^A = \frac{P_t^A}{P_t}$ is the relative production price of agricultural goods. The model assumes that a representative farmer is a price taker. The profit maximization she faces can be cast as choosing the input levels under land efficiency and technology constraints:

$$\max_{h_t^A, l_t, x_t} = E_t \sum_{s=0}^{\infty} \Lambda_{t,t+s} d_{t|s}^A$$

First order conditions are given by:

$$w_t = (1-\omega) p_t^A \frac{y_t^A}{h_t^A} \tag{7}$$

$$\lambda_t^L = E_l \left\{ \Lambda_{t,t+1} \left[\left(\omega p_{t+1}^A \frac{y_{t+1}^A}{l_t} \right) + \lambda_{l+1}^L \Omega(\epsilon_{t+1}^C)(1-\delta_l) \right) + \frac{\phi_{Lt+1} \lambda_{l+1}^L}{l_t} \right] \tag{8}$$

$$\frac{p_t^N}{\tau x_t^{\phi-1} l_{t-1} \Omega(\epsilon_t^C)} = E_t(\lambda_t^L) \tag{9}$$

where $\Lambda_{t,t+1}$ is the household stochastic discount factor between t and $t+s$. Equations $E_t(\lambda_t^L)$ is the optimal demand for intermediate expenditures The left-hand side of the equation captures the current marginal cost of land maintenance, while the right-hand side corresponds to the sum of the marginal product of land productivity with the value of land in the next period. A climate shock deteriorates the expected marginal benefit of lands and rise the current cost of land maintenance. The relative price of the product increases in the aftermath of a climate shock. This necessitates that the function $v(x_{it})$ must be either linear or convex, i.e., $\phi \geq 0$. If $v(x_{it})$ were a concave function (signified by $v''(x_{it}) < 0$), a climate shock would lead to a reduction in expenditures on land maintenance. This, in turn, would cause a decrease in the relative price of agricultural goods.

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[4] Notably, since the Qing dynasty period, the implementation of advanced agronomic techniques, like crop rotation, irrigation, and fertilization, significantly enhanced the average yield per unit area of crops. The enlargement of cultivated areas, coupled with improved yields, markedly boosted the total output of grain, thereby ensuring the survival of the population on an unprecedented scale (Shi 2017).

4.2 Household

In this economic model, the total population is normalized to one. Households fully absorb any idiosyncratic risks, allowing us to use a representative household construct. This entity has to resolve both inter-temporal and intra-temporal problems. The former involves decisions on consumption, labor, and resource allocation over time. The latter problem involves determining the distribution of consumption expenditure among agricultural and non-agricultural, and domestic and foreign goods.

The representative household maximizes the following utility function:

$$\mathbb{E}_0\left[\sum_{t=0}^{\infty} \beta^t \left(\log c_t - \frac{h_t^{1+\varphi_H}}{1+\varphi_H} + \frac{\left(\frac{M_t}{P_t}\right)^{1-\varphi_L}}{1-\varphi_L} \right)\right]$$

Where c_t denotes consumption, h_t represents total hours worked, and $\frac{Mt}{P_t}$ captures the real money balances. The parameters φ_H and φ_L represent the curvature of disutility from labor and the utility from holding money, respectively.

The household is subject to an inter-temporal budget constraint, which governs the allocation of income between consumption, saving, and money holdings.

The budget constraint is given by:

$$c_t + b_t + \frac{M_t}{P_t} = \frac{r_{t-1} b_{t-1}}{\pi_t} + \frac{M_{t-1}}{P_t} + w_t h_t + \Gamma_t - t_t$$

where b_t is the quantity of risk-free domestic bonds purchased at time t, r_t is the gross nominal interest rate on bonds and deposits, and $\pi_t = \frac{P_t}{P_{t-1}}$ is the gross inflation rate. Additionally, w_t represents the real wage rate, Γ_t denotes profits from firms and banks, and t_t is the lump-sum tax paid by households. Households supply labor to both agricultural and non-agricultural sectors, and the total hours worked h_t are divided across these sectors. The household maximizes its utility subject to the inter-temporal budget constraint. This yields the following first-order conditions:

The derivative with respect to consumption yields:

$$\frac{1}{c_t} - \lambda_t = 0$$

which implies that the marginal utility of consumption equals the Lagrange multiplier:

$$\lambda_t = \frac{1}{c_t}$$

The Euler equation for bond is derived from the household's inter-temporal trade-off between current and future consumption. It is expressed as:

$$1 = \beta E_t\left(\frac{c_t}{c_{t+1}}\frac{r_t}{\pi_{t+1}}\right) \tag{10}$$

Where β is the household's discount factor, r_t is the nominal interest rate, π_{t+1} is the expected inflation rate.

The labor supply condition is derived from the intertemporal trade-off between labor and consumption. It equates the marginal disutility of labor with the marginal utility of consumption, multiplied by the real wage:

$$h_t^{\varphi_H} = \frac{w_t}{c_t} \tag{11}$$

The money demand equation describes the optimal holding of real money balances, given the opportunity cost of holding money, which is the foregone interest income:

$$\left(\frac{M_t}{P_t}\right)^{-\varphi_L} = (m_t)^{\varphi_L} = \frac{1}{c_t} - \beta E_t\left(\frac{1}{c_{t+1}\pi_{t+1}}\right)$$

So that

$$m_t = \left(\frac{1}{c_t} - \beta E_t\left(\frac{1}{c_{t+1}\pi_{t+1}}\right)\right)^{\frac{1}{\varphi_L}}$$

In the steady state, the money demand equation reflects the relationship between consumption, inflation, the discount factor, and the household's risk aversion toward holding money.

$$m = c^{\frac{1}{\varphi_L}}\left(1 - \frac{\beta}{\pi}\right)^{\frac{1}{\varphi_L}} \tag{12}$$

Together, these first-order conditions define the household's optimal decisions regarding consumption, labor supply, savings in bonds, and money holdings, and they form the foundation of the model's equilibrium dynamics.

4.3 Intra-temporal problem

In the following, we delve into the distribution of consumption across non-agricultural/agricultural and domestic/foreign goods. Initially, the representative household divides the total consumption, denoted as c_t, between two categories of goods produced by non-agricultural and agricultural sectors, represented as c_t^N and c_t^A .

The CES consumption bundle is defined as follows:

$$c_t = \left[(1-\varphi)^{\frac{1}{\mu}}(c_t^N)^{\frac{\mu-1}{\mu}} + \varphi^{\frac{1}{\mu}}(c_t^A)^{\frac{\mu-1}{\mu}}\right]^{\frac{\mu}{\mu-1}}$$

where the substitution elasticity between the two types of consumption goods is represented by $\mu \geq 0$, and $\varphi \in [0,1]$ signifies the proportion of agricultural goods within the total consumption basket of the household.

Second, each index c_t^N and c_t^A is also a composite consumption subindex composed of domestically and foreign-produced goods:

$$c_t^S = \left[\left((1-\alpha_s)^{\frac{1}{\mu_s}}\left(c_{H,t}^S\right)^{\frac{\mu_S-1}{\mu_s}}\right) + \left(\alpha_s^{\frac{1}{\mu_s}}\left(c_{F,t}^S\right)^{\frac{\mu_S-1}{\mu_s}}\right)\right]^{\frac{\mu_S}{\mu_S-1}}, \text{ for } S \in [A, N]$$

where A and N denote agriculture and industry, respectively. $c_{H,t}^S$ and $c_{F,t}^S$ denote consumption of domestic and foreign good. η_s is the elasticity of substitution between domestic and foreign goods within each sector, and α_s is the fraction of foreign goods in the consumption basket of each sector. To minimize expenditure for a given level of consumption, households determine their optimal demand for non-agricultural goods (c_t^N) and agricultural goods (c_t^A), which is defined by:

$$c_t^N = (1-\varphi)\left(\frac{P_{C,t}^N}{P_t}\right)^{-\mu} c_t$$

$$c_t^A = \varphi\left(\frac{P_{C,t}^A}{P_t}\right)^{-\mu} c_t$$

where φ is the share of agricultural goods in total consumption, μ is the substitution elasticity, $P_{C,t}^N$ and $P_{C,t}^A$ are the price indices for non-agricultural and agricultural goods respectively, and P_t is the domestic CPI.

The non-agricultural and agricultural consumption are composed of domestic and imported goods:

$$c_{H,t}^N = (1-\alpha_N)\left(\frac{P_t^N}{P_{C,t}^N}\right)^{\mu_N} c_t^N$$

$$c_{F,t}^N = \alpha_N\left(e_t^*\frac{P_t^{N*}}{P_{C,t}^N}\right)^{-\mu_N} c_t^N$$

$$c_{H,t}^A = (1-\alpha_A)\left(\frac{P_t^A}{P_{C,t}^A}\right)^{-\mu_A} c_t^A$$

$$c_{F,t}^A = \alpha_A\left(e_t^*\frac{P_t^{A*}}{P_{C,t}^A}\right)^{\mu_A} c_t^A$$

where α_N and α_A are the proportions of imported goods in the non-agricultural and agricultural sectors respectively. P_t^N, P_t^{N*}, P_t^A, and P_t^{A*} are the prices of domestic non-agricultural goods, imported non-agricultural goods, domestic agricultural goods, and imported agricultural goods, respectively. α_N and α_A are the substitution elasticity in these sectors.

The domestic CPI(P_t) is defined as:

$$P_t = \left[(1-\varphi)P_{C,t}^{N\ 1-\mu} + \varphi P_{C,t}^{A\ 1-\mu}\right]^{\frac{1}{1-\mu}}$$

$$1 = (1-\varphi)\left(p_{C,t}^N\right)^{1\mu} + \varphi\left(p_{C,t}^A\right)^{1-\mu} \quad (13)$$

with the price indices $P_{C,t}^{N}$ and $P_{C,t}^{A}$ given by:

$$P_{C,t}^{N} = [(1-\alpha_N)(P_t^N)^{1-\mu_N} + \alpha_N(e_t^* P_t^{N*})^{1-\mu_N}]^{\frac{1}{1-\mu_N}} \tag{14}$$

$$P_{C,t}^{A} = [(1-\alpha_A)(P_t^A)^{1-\mu_A} + \alpha_A(e_t^* P_t^{A*})^{1-\mu_A}]^{\frac{1}{1-\mu_A}} \tag{15}$$

4.4 Banking Sector

Through the examination of historical archival materials on fiscal finance and taxation of the Nationalist Government (1927-1937) and the balance sheets of major banks at that time, such as Jin Cheng Bank, this study found that the characteristics of banks at that time were very similar to modern banks in terms of their balance sheets. Therefore, the bank modeling in this paper is as follows:

There is a continuum of banks indexed by j. Each bank j features the following balance sheets:

$$f_t(j) = d_t(j) + n_t(j)$$

where $f_t(j)$ denotes loans of bank *j* to domestic firms, in CPI terms; $d_t(j)$ represents domestic deposits; Domestic firms borrow from banks to finance their capital expenditure $q_t k_t(j)$, where k_t denotes capital and q_t is its price. It holds: $f_t(j) = q_t k_t(j)$.

Conditional on surviving, the net worth of bank *j* is equal to profits, i.e. lending revenues minus borrowing costs:

$$n_{t+1}(j) = r_{Bt+1} q_t k_t(j) - \frac{r_t}{\pi_{t+1}} d_t(j)$$

where r_{Bt} is the real lending rate;

Using the balance sheets condition to substitute for $d_t(j)$, we obtain a law of motion for

$$n_{t+1}(j) = \left(r_{Bt+1} - \frac{r_t}{\pi_{t+1}}\right) q_t k_t(j) + \frac{r_t}{\pi_{t+1}} n_t(j)$$

The equation above delineates the net worth of bank j at time $t+1$ as comprising three parts. The first part, $\left(r_{Bt+1} - \frac{r_t}{\pi_{t+1}}\right) q_t k_t(j)$, reflects the differential between loan returns and deposit costs. The second component, $\frac{r_t}{\pi_{t+1}} n_t(j)$, represents the compounded effect of the previous period's net worth with the deposit interest rate.

Let $\beta^t \Lambda_{t,t+1}$ be the stochastic factor applying in *t* to earnings at $t+i$. This could represent various uncertainties such as market fluctuations, changes in economic conditions, and so on. Bank j will be willing to operate in period if and only if:

$$E_0\left[\beta^t \Lambda_{t,t+1}\left(r_{Bt+1+i} - \frac{r_{t+i}}{\pi_{t+1+i}}\right)\right] \geq 0$$

In models with perfect financial markets, the above equation. always holds with equality, otherwise, it pays to expand assets indefinitely. In this model, this is not necessarily true for China's case. During the period of the Republic of China, the financial market in China was not fully developed and various forms of financial frictions existed. Hence, bank j maximizes the expected terminal wealth, which means that Bank j is seeking the optimal strategy or decisions to maximize its wealth in expectation. This process involves making decisions based on current information and factors, while also considering and balancing the expected benefits of continuing operations versus exiting the market at each period:

$$V_t(j) = \max\left[(1-\chi)\beta\mathbb{E}_t\left(\frac{\lambda_{t+1}}{\lambda_t}n_{t+1}(j)\right) + \chi\beta\mathbb{E}_t\left(\frac{\lambda_{t+1}}{\lambda_t}V_{t+1}(j)\right)\right]$$

Given that with probability $1-\chi$ banker j exits the market getting $n_{t+1}(j)$ at the beginning of period $t+1$, while with probability χ banker j continues the activity, getting the continuation value. The constraints of the value function are the evolution of the net worth and the incentive constraint. The financial friction is the following: Bankers can divert a fraction θ of their assets. Therefore, lenders are willing to lend only if the following incentive constraint is satisfied:

$$V_t(j) \geq \theta f_t(j)$$

This implies that only when the value of Bank j at period t, $V_t(j)$, surpasses or equals a fraction of its assets, $\theta f_t(j)$, is the banker not incentivized to divert its assets, and creditors feel comfortable to lend.

The value function of bank j is expressed as:

$$V_t(j) = \max(1-\chi)\,\beta\mathbb{E}t\left(\frac{\lambda t+1}{\lambda_t}n_{t+1}(j)\right) + \chi\beta\mathbb{E}t\left(\frac{\lambda t+1}{\lambda_t}V_{t+1}(j)\right)$$

This equation is subject to the probability $(1-\chi)$ of banker j exiting the market and obtaining

$$V_t(j) = \max\left[(1-\chi)\beta\mathbb{E}_t\left(\frac{\lambda_{t+1}}{\lambda_t}n_{t|1}(j)\right) + \chi\beta\mathbb{E}_t\left(\frac{\lambda_{t+1}}{\lambda_t}V_{t+1}(j)\right)\right] \tag{16}$$

This equation is subject to the probability $(1-\chi)$ of banker j exiting the market and obtaining $n_{t+1}(j)$ at the outset of period $t+1$. Alternatively, with a probability of χ, banker j continues his activities, gaining the continuation value. The restrictions of the value function are the evolution of the net worth and the incentive constraint.

With $\phi_t(j) \equiv \frac{q_t k_t(j)}{n_t(j)}$ denoting the leverage of bank j, Gertler and Karadi (2011) show that the solution of the bank's problem yields an optimal leverage that is the same for each bank (thereby, we can omit the index j :

$$\phi_t = \frac{\nu_t}{\theta-\mu_t} \tag{17}$$

Where ν_t is the marginal value of owning an additional unit of net worth:

$$\nu_t = \beta \mathbb{E}_t \left(\frac{\lambda_{t+1}}{\lambda_t} \Omega_{t+1} \frac{r_t}{\pi_{t+1}} \right) \tag{18}$$

and

$$\mu_t = \beta \mathbb{E}_t \left(\frac{\lambda_{t+1}}{\lambda_t} \Omega_{t+1} \left(r_{Bt+1} - \frac{r_t}{\pi_{t+1}} \right) \right) \tag{19}$$

Ω_t augments the household's stochastic discount factor $\beta \mathbb{E} t \frac{\lambda t+1}{\lambda_t}$ to take into account that banks do not have an infinite lifespan like households do, and that they value resources more due to an incentive constraint:

$$\Omega_t = 1 - \chi + \chi(\mu_t \phi_t + \nu_t)$$

The equation above reveals that optimal leverage increases as the marginal value of loan investments increases. This is driven by the credit spread $r_{B_t+1} - \frac{r_t}{\pi_{t+1}}$, which is positively correlated. If loans are relatively high compared to net worth, depositors demand higher bank profitability (i.e., a higher lending spread) to deter deposit withdrawals. This equation essentially presents a credit supply mechanism where banks augment lending as the credit spread escalates. A credit spread materializes in equilibrium as banks are constrained, hence unable to freely arbitrage between deposits and loans.

4.5 Final-Good Non-Agricultural Firms

The representative final-good firm uses the following CES aggregator to produce the domestic final good y_{Ht} :

$$y_{Ht} = \left[\int_0^1 y_{Ht}(i)^{\frac{\varepsilon_H - 1}{c_H}} di \right]^{\frac{c_H}{\varepsilon_H - 1}}$$

Where $y_{Ht}(i)$ is an intermediate input produced by the intermediate firm i ,whose price is $P_{Ht}(i)$. The optimal demand function for the intermediate input I reads:

$$y_{Ht}(i) = y_{Ht} \left(\frac{P_{Ht}(i)}{P_{Ht}} \right)^{-\varepsilon_H}$$

where P_{Ht} is the producer price index(PPI) :

$$P_{Ht} = \left[\int_0^1 P_{Ht}(i)^{1-\varepsilon_H} di \right]^{\frac{1}{1-\varepsilon_H}}$$

The representative final-good firm uses a similar CES aggregator to produce the domestic final good y_{Xt}.

4.6 Intermediate-Good Non-Agricultural Firms

There is a continuum of firms indexed by i, each producing a differentiated domestic input. The production function now incorporates agricultural products as an input：

$$y_t^N = k_{t-1}^{\alpha_k}(h_t^N)^{\alpha_h} a_t^{1-\alpha_k-\alpha_h} \tag{20}$$

Where $a_t(i)$ denotes the quantity of agricultural goods used by firm i. α_k, α_h and $1-\alpha_k-\alpha_h$ represent the output elasticities with respect to capital, labor, and agricultural inputs, respectively.

These firms operate under monopolistic competition, setting prices subject to final good firms' demand and incur quadratic adjustment costs $AC_{Ht}(i)$ (Rotemberg 1982) when adjusting prices relative to the target inflation rate $\bar{\pi}$:

$$AC_{Ht}(i) = \frac{\kappa_{PN}}{2}\left(\frac{P_t^N(i)}{P_{t-1}^N(i)} - \bar{\pi}\right)^2 P_{Nt} y_{Ht}$$

and for exports:

$$AC_{Xt}(i) = \frac{\kappa_{PZ}}{2}\left(\frac{P_{Xt}(i)}{P_{Xt}(i)} - \pi^*\right)^2 P_{Xt} y_{Xt}$$

Domestic firms borrow from banks to finance capital expenditure:

$$f_t(i) = q_t k_t(i)$$

Assuming producer currency pricing and the law of one price, prices remain consistent in domestic and foreign markets. Intermediate firms borrow to purchase physical capital from capital producers, who buy non-depreciated capital from intermediate firms. Denoting δ as the depreciation rate and defining the rental rate of capital as:

$$r_t^k = r_{Bt} q_{t-1} - (1-\delta) q_t \tag{21}$$

The profit maximization problem of a generic firm i is:

$$\max \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left[p_t^N(i) y_{Ht}(i) + p_{Xt}(i) y_{Xt}(i) - w_t^N h_t^N(i) - r_t^k k_{t-1}(i) - p_t^A a_t(i) - \frac{AC_{Ht}(i)}{P_t} - \frac{e_t AC_{Xt}(i)}{P_t} \right] \right\}$$

subject to:

$$y_{Ht}(i) = y_{Ht}\left(\frac{P_t^N(i)}{P_t^N}\right)^{-\varepsilon_H}$$
$$y_{Xt}(i) = y_{Xt}\left(\frac{p_{Xt}(i)}{p_{Xt}}\right)^{-\varepsilon_X}$$
$$y_{Nt}(i) = \left(k_{t-1}(i)\right)^{\alpha_k}\left(h_t^N(i)\right)^{\alpha_h}\left(a_t(i)\right)^{1-\alpha_k-\alpha_h}$$
$$y_{Nt}(i) = y_{Ht}(i) + y_{Xt}(i)$$

The maximization is over the set

$$\{p_t^N(i), h_t^N(i), k_{t-1}(i), a_t(i), y_{Ht}(i), y_{Xt}(i), p_{Xt}(i)\},$$

where $p_{Xt} \equiv \frac{e_t P_{Xt}}{P_t}$ represents the price set in foreign markets, expressed in terms of the domestic CPI.

In equilibrium, firms choose the same price, inputs, and output, allowing us to suppress the index i. The optimality conditions yield the input demands. Taking the derivative of the profit function with respect to each input, we obtain:

First-Order Condition with respect to Capital k_{t-1} :

$$r_t^k = \alpha_k mc_t \frac{y_{Nt}}{k_{t-1}} \tag{22}$$

First-Order Condition with respect to Labor h_t^N :

$$w_t = \alpha_h mc_t \frac{y_{Nt}}{h_t^N} \tag{23}$$

First-Order Condition with respect to Agricultural Input a_t :

$$p_t^A = (1 - \alpha_k - \alpha_h) mc_t \frac{y_{Nt}}{a_t} \tag{24}$$

where mc_t denotes the real marginal cost of production. The optimal pricing conditions are derived similarly. For domestic sales, the price adjustment equation becomes:

$$\pi_{Ht}(\pi_{Ht} - \bar{\pi}) = \beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\pi_{Ht+1}(\pi_{Ht+1} - \bar{\pi})\frac{p_{t+1}^N y_{Ht+1}}{p_t^N y_{Ht}}\right] + \frac{\varepsilon}{\kappa_P}\left(\frac{mc_t}{p_t^N} - \frac{\varepsilon_H - 1}{\varepsilon_H}\right) \tag{25}$$

where $\pi_{Ht} = \frac{P_i^N}{P_{t-1}^N}$ is the producer price inflation. Equation above is a non-linear Phillips curve, linking current inflation to future inflation and real variables.

For exports, the optimal pricing equation is:

$$\pi_{Xt}(\pi_{Xt} - \pi^*) = \beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\pi_{Xt+1}(\pi_{Xt+1} - \pi^*)\frac{p_{Xt+1} y_{Xt+1}}{p_{Xt} y_{Xt}}\right] + \frac{\varepsilon}{\kappa_P}\left(\frac{mc_t}{p_{Xt}} - \frac{\varepsilon_X - 1}{\varepsilon_X}\right) \tag{26}$$

where mc_t is the real marginal cost and $\pi_{Ht} = \frac{P_t^N}{P_{Ht-1}}$ is PPI inflation, which can be written as:

$$\pi_{Ht} = \frac{p_t^N}{p_{t-1}^N}\pi_t \tag{27}$$

$\pi_{Xt} = \frac{P_{Xt}}{P_{X,t-1}}$ is export price inflation, which can be written as:

$$\pi_{Xt} = \frac{p_{Xt}}{p_{X,t-1}}\frac{s_{t-1}}{s_t}\pi^* \tag{28}$$

4.7 Capital producers

Domestic capital producers buy the investment good (i_t) from final-good firms and non-depreciated capital $(1-\delta)q_t k_{t-1}$ from intermediate firms in order to produce a capital good sold to intermediate firms $(q_t k_t)$. Capital producers solve the following problem:

$$\max_{i_t,k_t} E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} [q_t k_t - (1-\delta)q_t k_{t-1} - i_t] \right\}$$

subject to the law of motion of capital:

$$k_t = (1-\delta)k_{t-1} + \left[1 - \frac{\kappa_I}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2\right] i_t \tag{29}$$

The first order condition yields the evolution of the price of capital:

$$1 = q_t \left\{1 - \frac{\kappa_I}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2 - \kappa_I \frac{i_t}{i_{t-1}}\left(\frac{i_t}{i_{t-1}} - 1\right)\right\} + +\beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} q_{t+1} \left(\frac{i_{t+1}}{i_t}\right)^2 \kappa_I \left(\frac{i_{t+1}}{i_t} - 1\right)\right] \tag{30}$$

Log-linearizing the last equation, one can show that capital producers increase investment when the price of capital q_t is higher.

4.8 Government and Central Bank[5]

Silver Flow and Foreign Reserves

Under the silver standard, the flow of silver determined changes in foreign reserves, which in turn impacted the domestic money supply. Silver circulated in international markets through trade and capital flows, making China's money supply highly dependent on silver reserves. These reserves were influenced by global silver prices, the gold-silver ratio, and trade movements. By modeling the sensitivity of foreign reserves to silver prices, exchange rates, and trade-related capital flows, we capture silver flows' direct impact on China's money supply, with a focus on the trade sector

[5] In 1928, the Nationalist Government established the Central Bank, gradually centralizing currency issuance. The 1935 Legal Currency Reform allowed only designated banks—the Central Bank, Bank of China, Bank of Communications, and Farmers Bank—to issue currency, removing silver from circulation and creating a "legal currency" system. This reform made the Central Bank the primary issuer, with other banks subject to its regulation and reliant on its monetary policy.

during the Great Depression. Trade surpluses and deficits, the primary mechanisms for silver flows, drove significant monetary instability. While capital flows like remittances were relevant, trade data from the 1930s is more reliable, and global trade disruptions were more direct. Thus, prioritizing trade in this model is methodologically sound. Future research may incorporate capital flows, though data limitations and complexity make it beyond this paper's scope. The inflow and outflow of silver can be described as follows:

$$\Delta FR_t^{in} = \frac{e_t P_t^*}{P_t^{w,s}} xp_t = \frac{e_t}{p_t^{w,s}} xp_t \tag{31}$$

$$\Delta FR_t^{\text{out}} = \overbrace{\underbrace{\frac{\iota m P_t}{e_t P_t^{w,g}}}_{\text{outflow of gold}} (1-\omega)\frac{P_t^{w,g}}{P_t^{w,s}}}^{\text{outflow of silver}} = (1-\varrho)\frac{\imath m_t}{s_t p_t^{w,s}} \tag{32}$$

where $\Delta FR_t^{in} > 0$ represents the inflow of silver from exports, while ΔFR_t^{out} represents the outflow due to imports. In these equations, $p_t^{w,s} = \frac{P_t^{w,s}}{P_t^*}$ denotes the international silver price in foreign currency, while e_t and s_t represent the nominal and real exchange rates, respectively. The cumulative silver reserve is then represented as follows:

$$FR_t = FR_{ss} + \rho_{FR} \cdot (FR_{t-1} - FR_{ss}) + (1-\rho_{FR}) \cdot \left(\Delta FR_t^{in} - \Delta FR_t^{\text{out}}\right) \tag{33}$$

where FR_{ss} is the steady-state value of foreign reserves.

Money Issuance Mechanism

Under the silver standard, the issuance of money was directly influenced by silver reserves. During the Nanjing Nationalist Government period, 60% of the currency issued was backed by silver reserves, while the remaining 40% was backed by government bonds (Yan, 2015). The money supply can be represented as:

$$\frac{m_t}{m_{ss}} = \left(\frac{FR_t}{FR_{ss}}\right)^{\phi_{fr}} \cdot \left(\frac{b_G}{b_{Gss}}\right)^{\phi_{bG}} \tag{34}$$

where m_t denotes the money supply, FR_t the silver reserve, and b_G the government bonds. The issuance of currency thus depended not only on the silver reserves but also on the funds raised through government bonds. When silver reserves were insufficient, the government increased bond issuance to support the money supply.

Silver and Gold Price Dynamics

The price of silver, denoted $P_t^{d,s}$, and its real price, $p_t^{d,s}$, follows an autoregressive (AR) process[6]:

[6] We simplify the analysis by using a single silver price variable to represent the 1930s silver market. However, during major policy interventions, such as the 1934 U.S. Silver Purchase Act that raised international silver prices, domestic markets were notably affected. Distinguishing between domestic and international silver prices is helpful for analyzing such periods and policy impacts. For general analysis of silver price shocks over the entire period, the high correlation (95%) and rapid transmission between international and domestic prices justify using a single variable. This approach

$$\ln p_t^{d,s} = \left(1 - \rho_{d,s}\right) \ln p^{d,s} + \rho_{d,s} \ln p_{t-1}^{d,s} + \sigma_{pds} u_t^{d,s},\ u_t^{d,s} \sim \mathcal{N}(0,1) \tag{35}$$

Assuming that one unit of domestic currency equals one gram of silver, and one unit of foreign currency equals one gram of gold, the nominal exchange rate e_t between these two units is given by:

$$e_t \equiv \frac{P_t^{w,g}}{P_t^{d,s}} = \frac{p_t^{w,g}}{p_t^{d,s}} \tag{36}$$

where $p_t^{w,g}$ is the international prices of gold, following an AR (1) process:

$$\ln p_t^{w,g} = \left(1 - \rho_{w,g}\right) \ln p^{w,g} + \rho_{w,g} \ln p_{t-1}^{w,g} + \sigma_{pwg} u_t^{w,g},\ u_t^{w,g} \sim \mathcal{N}(0,1) \tag{37}$$

To account for the correlation between prices of gold and silver, we set $\rho_{\epsilon_{t\ t}{}^{pds},pwg} < 0$.

The real exchange rate s_t adjusts the nominal exchange rate e_t by relative price levels:

$$s_t = e_t \cdot \frac{P_t^*}{P_t}$$

where P_t is the domestic general price level, and P_t^* is the price level on the international market. We then have the relationship:

$$\frac{s_t}{s_{t-1}} = \frac{e_t}{e_{t+1}} \cdot \frac{\pi_t^*}{\pi_t} \tag{38}$$

Government Budget Constraint and Bond Issuance

The government's budget constraint directly impacts the money supply, as it can raise funds through bond issuance to support the currency. The government budget constraint is represented as follows:

$$P_t^N G_t + \frac{r_{t-1}}{\pi_t} b_{G,t-1} = t_t + b_{G,t} \tag{39}$$

where b_G denotes the total government debt. We further define $b_{G,t}$ as the sum of government debt held by households b_t and the central bank $b_{C,t}$:

$$b_G = b_t + b_{C,t}$$

These equations capture the interactions among silver reserves, foreign exchange, and bond issuance, as well as the impact of international price movements and government budget constraints on the domestic money supply. By focusing on these mechanisms, the model aligns with the economic environment of 1930s China, illustrating the dependency of the currency supply

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captures the overall impact effectively and avoids collinearity issues, as international silver price changes were quickly reflected in domestic silver markets.

on silver reserves and government financial policies. The steady-state government debt is given by:

$$b_{G,ss} = \bar{b} \cdot GDP_{ss}$$

where $b_{G,ss}$ is steady-state government debt, $\bar{b}$ is the debt-to-GDP ratio, and GDP_{ss} is steady-state GDP. G_t is the government spending, following an AR (1) process:

$$\ln G_t = \left(1 - \rho_g\right) \ln G_t + \rho_g \ln G_{t-1} + \sigma_g u_t^g,\ u_t^g \sim \mathcal{N}(0,1) \tag{40}$$

4.9 Foreign Economy

Following the literature on estimated small open economy models exemplified by Adolfson et al. (2007), Adolfson et al. (2008) Justiniano and Preston (2010) and Gallic and Vermandel (2020), our foreign economy boils down to a small set of key equations that determine China exports and real exchange rate dynamics. The foreign country is determined by an endowment economy characterized by an exogenous foreign consumption:

$$\ln\left(c_{jt}^*\right) = (1 - \rho_C) \ln\left(\bar{c}_j\right) + \rho_C \ln\left(c_{j,t-1}^*\right) + \sigma_C \eta_t^c,\ \eta_t^c \sim \mathcal{N}(0,1) \tag{41}$$

where the $0 \leq \rho_C < 1$ is the root of the process, $\bar{C}_j^* > 0$ is the steady state domestic consumption and $\sigma_C \geq 0$ is the standard deviation of the shock. The parameters σ_C and ρ_C are estimated in the fit exercise to capture variations of the foreign demand. Each period, foreign households solve the following optimization scheme:

$$\max_{\left\{c_j^*, b_j^*\right\}} E_t \quad \left\{\sum_{\tau=0}^{\infty} \beta^t \log\left(c_{jt+\tau}^*\right)\right\}$$
$$\text{s.t.} \quad r_{t-1}^* b_{jt-1}^* = c_{jt}^* + b_{jt}^*$$

The foreign sector's first-order conditions (FOC) are expressed in the following equations:

$$\lambda_t^* = \frac{1}{c_t^*}$$
$$1 = \beta^* \left(\frac{\lambda_{t+1}^*}{\lambda_t^*}\right) \frac{r_t^*}{\pi_{t+1}^*}$$

where λ_t^* represents the marginal utility of consumption for the foreign sector at time t. Substituting λ_t^*, we get:

$$1 = \beta^* \left(\frac{c_t^*}{c_{t+1}^*}\right) \frac{r_t^*}{\pi_{t+1}^*} \tag{42}$$

Following Gallic and Vermandel (2020), we assume that in the absence of specific sectoral shocks, all sectoral prices in the foreign economy are perfectly synchronized; that is, $P_t^* = P_t^{A*} = P_t^{N^*}$. This assumption simplifies the calculation of the real exchange rate, s_t.

The foreign CPI P_t^* is defined as:

$$\begin{aligned} P_t^* &= \left[(1-\varphi)\left(P_{C,t}^{N*}\right)^{1-\mu} + \varphi\left(P_{C,t}^{A*}\right)^{1-\mu}\right]^{\frac{1}{1-\mu}} \\ 1 &= (1-\varphi)\left(p_{C,t}^{N*}\right)^{1-\mu} + \varphi\left(p_{C,t}^{A*}\right)^{1-\mu} \end{aligned} \tag{43}$$

The foreign agricultural and non-agriculture price indices $P_{C,t}^{N*}$ and $P_{C,t}^{A*}$ are given by:

$$P_{C,t}^{N*} = [(1-\alpha_N)(P_t^{N*})^{1-\mu_N} + \alpha_N(e_t^* P_t^{N**})^{1-\mu_N}]^{\frac{1}{1-\mu_N}} \tag{44}$$

$$P_{C,t}^{A*} = [(1-\alpha_A)(P_t^{A*})^{1-\mu_A} + \alpha_A(e_t^* P_t^{A**})^{1-\mu_A}]^{\frac{1}{1-\mu_A}} \tag{45}$$

4.10 Market clearing and Equilibrium

The market clearing condition for non-agricultural goods is determined when the aggregate supply is equal to aggregate demand. The aggregate demand for goods, encompassing both domestic and foreign markets, is captured by the integrals $\int_0^1 c_{jt}\, \mathrm{d}j = C_t$ for domestic demand and $\int_0^1 c_{jt}^*\, \mathrm{d}j = C_t^*$ for foreign demand, with the parameters $1-\alpha_N$ and α_N representing the respective shares of domestic and foreign produced non-agricultural goods.

$$y_{Ht} = (1-\varphi)\left[(1-\alpha_N)\left(\frac{P_t^N}{P_{C,t}^N}\right)^{-\mu_N}\left(p_{c,t}^N\right)^{-\mu} c_t\right] + G_t + I_t + \phi_{Lt} + \frac{\kappa_{PH}}{2}(\pi_{Ht}-\bar{\pi})^2 y_{Ht} + \frac{\kappa I}{2}\left(\frac{i_t}{i_{t-1}}-1\right)^2 i_t \tag{46}$$

$$y_{Xt} = (1-\varphi)\left[\alpha_N\left(\frac{p_t^N}{s}\right)^{-\mu_N}\left(p_{c,t}^{N*}\right)^{-\mu} c_t^*\right] + \frac{\kappa_{PX}}{2}(\pi_{Xt}-\pi^*)^2 y_{Xt} \tag{47}$$

The equilibrium in the agricultural goods market is established by

$$y_t^A = \varphi\left[(1-\alpha_A)\left(\frac{p_t^A}{p_{C,t}^A}\right)^{-\mu_A}\left(p_{c,t}^A\right)^{-\mu} c_t + \alpha_A\left(\frac{p_t^A}{s}\right)^{-\mu_A}\left(p_{C,t}^{A*}\right)^{-\mu} c_t^*\right] \tag{48}$$

The aggregate real non-agricultural production of the economy is given by

$$y_N = y_{Ht} + y_{Xt} \tag{49}$$

We can get the market clearing condition for the domestic non-agricultural goods:

$$\begin{aligned} y_N &= k_{t-1}^{\alpha} h_t^{N\,1-\alpha} \\ y_t &= p_t^N y^N + p_t^A y_t^A \end{aligned} \tag{50}$$

Given the presence of intermediate inputs, the GDP through production approach is given by:

$$gdp_t = y_t - p_t^N \phi_{Lt} \tag{51}$$

Where ϕ_{Lt} is the land expenditure for aggregation.

Defining the trade balance (tb_t) as the difference between exports (xp_t) and imports (mp_t). The import is written as

$$\mathrm{im}_t = (1-\varphi)\left[\alpha_N\left(e_t^*\frac{p_t^{N*}}{p_{c,t}^N}\right)^{-\mu_N}\left(p_{c,t}^N\right)^{-\mu}c_t\right] + \varphi\left[\alpha_A\left(e_t^*\frac{p_t^{A*}}{p_{c,t}^A}\right)^{-\mu_A}\left(p_{c,t}^A\right)^{-\mu}c_t\right] \tag{52}$$

$$xp_t = (1-\varphi)\left[\alpha_N\left(\frac{1}{e_t^*}\frac{p_t^N}{p_{c,t}^{N*}}\right)^{-\mu_N}\left(p_{c,t}^{N*}\right)^{-\mu}c_t^*\right] + \varphi\left[\alpha_A\left(\frac{1}{e_t^*}\frac{p_t^A}{p_{c,t}^{A*}}\right)^{-\mu_A}\left(p_{c,t}^{A*}\right)^{-\mu}c_t^*\right] \tag{53}$$

$$tb_t = s_t * xp_t - im_t \tag{54}$$

In the labor market, equilibrium is achieved when the supply of labor from households matches the demand from firms in both non-agricultural and agricultural sectors. This framework allows for the calculation of total labor hours as

$$h_t = h_t^N + h_t^A \tag{55}$$

Aggregating the balance sheets of banks we get:

$$q_t k_t = d_t + n_t$$

Given that all banks choose the same leverage, aggregating over banks we get:

$$\phi_t = \frac{q_t k_t}{n_t} \tag{56}$$

Total net worth can be split between the net worth of new bankers n_{yt} and the net worth of old bankers $n_{ot}(n_t = n_{ot} + n_{yt})$. Given that only a fraction χ of bankers in period $t-1$ survive until period t and assuming that households transfer a share of assets $\frac{t_b}{1-\chi}$ from exiting bankers to new bankers (hence, $n_{yt} = \iota_b q_{t-1}k_{t-1}$), we can derive the following expression for the evolution of aggregate bank net worth:

$$\mathrm{n}_t = \chi\left[\left(r_{Bt} - \frac{r_{t-1}}{\pi_t}\right)q_{t-1}k_{t-1} + \left(\frac{r_{t-1}}{\pi_t}\right)s_{t-1}d_{t-1}\right] + \chi\frac{r_{t-1}}{\pi_t}n_{t-1} + \iota_b q_{t-1}k_{t-1} \tag{57}$$

The equilibrium of the model is described by equations (1)-(57), which form a system of 57 equations in 57 variables:

$\{ y_{Ht}, y_{Xt}, y_{Nt}, y_t^A, gdp_t, y_t, a_t, xp_t, \mathrm{im}_t, k_t, i_t, mc_{t,}r_t^k, r_t, r_t^*, r_t^B\ h_t^{\mathrm{A}}, h_t^{\mathrm{N}}, h_t, x_t, w_t, l_t, \lambda_t^L, m_{t,}b_{G,t}, FR_t, \Delta FR_t^{in}, \Delta FR_t^{out}, c_t, p_t^N, p_t^X, p_t^{\mathrm{A}}, p_C^A, p_C^N, P_{C,t}^{A*}P_{C,t}^{N*}, e_t, s_t, q_t, \pi_{Ht,}\pi_{Xt,}, \pi_t, \pi_t^*, \phi_{t,} v_{t,}, \mu_t, \phi_t, n_{t,} C_t^*, G_t, \epsilon_t^C, \varepsilon_t^Z, P_t^{w,g}, P_t^{d,s}, \Omega(\epsilon_t^C), tb_t, \phi_{Lt}\}$

5 Estimation

The model is estimated using Bayesian methods and annual data for China. We estimate the structural parameters and the sequence of shocks following the seminal contributions of Smets and Wouters (2007) and An and Schorfheide (2007). In a nutshell, a Bayesian approach can be followed by combining the likelihood function with prior distributions for the parameters of the model to form the posterior density function. The posterior distributions are drawn through the Metropolis-Hastings sampling method. We solve the model using a linear approximation to the model's policy function and employ the Kalman filter to form the likelihood function and compute the sequence of errors.

5.1 Data and Data Source

For Bayesian estimation, we utilize six observed variables since we have six shocks in the DSGE model: climate shock (ϵ_t^C), technological shock (ϵ_t^Z), government spending shock $\left(\epsilon_t^g\right)$, silver price shock $\left(\epsilon_t^{pds}\right)$, gold price shock $\left(\epsilon_t^{pwg}\right)$, and foreign consumption shock (ϵ_t^E). These include annual data for China from 1912 to 1936, comprising the following key time series: per capita output, per capita imports, per capita exports, the real exchange rate, the real price of silver, and a scPDSI climate index (Table 3).

Table 3: Data Variables and Sources

Variable name	Data sources
GDP per capita	(Liu and Chen, 2012)
Consumption	(Cui, 2012)
Exports	Global Financial Data
Imports	Global Financial Data
Real exchange rate	International Institute of Social History
scPDSI climate index	van der Schrier et al. (2013)

All data are real values, adjusted to 1929 constant prices and exchange rates, and presented on a per capita basis. [7] To ensure stationarity, the non-stationary data are transformed into a stationary model. For trend-observed variables, such as output, imports and exports, a two-step method is applied to detrend the data. First, these variables are logged; then, a quadratic trend is removed. The vector of observed variables is as follows:

$$Y_t^{\text{obs}} = 100 \times [\hat{y}_t, i\hat{m}_t, \hat{x}p_t, \Delta(\text{re})_t, \hat{p}s_t, \hat{\omega}_t]^T$$

where $\hat{y}_t$ represents the per capita output gap, $i\hat{m}_t$ and $\hat{x}p_t$ are per capita imports and exports respectively, Δ (rêr) $_t$ represents the change in real exchange rate, $\hat{p}s_t$ denotes the real price of domestic silver, $\hat{\omega}_c$is the climate index.

5.2 Calibration

In this model, each time period corresponds to one year. We adopt a hybrid estimation approach, where a subset of the parameters is calibrated based on historical economic literature and prior studies, while the remaining parameters are estimated using formal techniques that rely on full-information Bayesian estimation methods. The calibrated parameters can be divided into two

[7] The nominal variables were converted to real variables using the wholesale price index (Wang, 1996). The total variables were adjusted to per capita terms using population data from Maddison and Global Financial Data.

categories: those governing the model's dynamic properties and those determining steady-state relationships.

5.2.1 Dynamic Properties Calibration

Table 4 summarizes the parameters governing the model's dynamic properties. The capital depreciation rate δ_K is set to 0.1, consistent with Lei and Zhou (2022). The land share parameter ω is calibrated to 0.3, highlighting the importance of land in agricultural production, as noted by Lei and Zhou (2022). The shape parameter of the land cost function ϕ is set to 1.5, following Gallic and Vermandel (2020). The land-climate elasticity θ is modeled as a Gamma distribution with a mean of 2 and a standard deviation of 0.5.

The elasticity of substitution between differentiated goods ε is calibrated to 6, following Moro and Landi (2021), which corresponds to a 20% price markup. This value is within the typical range of 5 to 11, as suggested by Gali (2000). The investment adjustment cost parameter κ_I also adopts this value, consistent with Smets and Wouters (2007). The price adjustment cost κ_P is calibrated to 157, reflecting a scenario where 84% of firms exhibit sticky prices, as described in Akinci and Queralto (2018). The inverse Frisch elasticity of labor supply ϕ_H is set to 1, based on Moro and Landi (2021). Similarly, the inverse elasticity of money holdings with respect to the interest rate ϕ_L is set to 1, following Benchimol and Fourçans (2012).

Labor and capital output elasticities, α_H and α_K, are calibrated to 0.45. This value balances the range of estimates from Liu and Liu (1998) and Zhang (1991), which suggest a labor-to-capital output ratio of 0.3:0.7, and Chen (2021), which reports a ratio of 0.78:0.22. The chosen value reflects the significant regional and structural differences within China's economy during the 1930s and the dual economic structure, where labor-intensive agriculture dominated rural areas while urban regions such as the Yangtze River Delta increasingly relied on capital. The elasticity of agricultural input is set to 0.1, reflecting the relatively smaller contribution of agricultural output to non-agricultural production. The elasticity of foreign reserves ϕ_{f_T} and government bonds ϕ_{b_G} are calibrated to 1.8 and 1.2, respectively, reflecting Yan's (2015) observation that 60% of currency issuance was backed by silver reserves and 40% by bonds.

For the counterfactual analysis, the silver standard was replaced with a modern monetary policy framework guided by the Taylor rule. The Taylor rule parameters, ϕ_π and ϕ_y, are set to 1.5 and 0.5, respectively, based on Taylor (1993) and Clarida, Gali, and Gertler (1999). The survival rate of bankers x is calibrated to 0.3, reflecting the high default rates during the Great Depression, which peaked at 74% during the Great Depression period, as documented in the National Bank Yearbook (1937). The leverage ratio of banks φ is set to 5, following the Fiscal Science Research Institute of the Ministry of Finance (1997).

Table 1 Calibrated parameters on an annual basis.

Variable	Description	Value	Source
δ_k	Capital depreciation rate	0.1	Lei and Zhou (2022)

ω	Share of land in agricultural production	0.3	Lei and Zhou (2022)
ϕ	Shape of the land cost function	1.5	Gallic and Vermandel (2020)
θ	Land-climate elasticity	2	Gallic and Vermandel (2020)
ε	Elasticity of substitution between differentiated goods	6	Moro and Landi (2021)
κ_I	Investment adjustment cost	6	Smets and Wouters (2007)
κ_P	Price adjustment cost	157	Akinci and Queralto (2018)
φ_H	Inverse of Frisch elasticity	1	Galí (2008)
φ_L	The inverse of the elasticity of money holdings with respect to the interest rate	1.25	Benchimol and Fourçans (2012)
α_k	Capital Output Ratio in the production function	0.45	Liu and Yan (2012); Liu and Liu (1998); Zhang (1991); Chen (2021)
α_h	Labor Output Ratio in the production function	0.45	Liu and Yan (2012); Liu and Liu (1998); Zhang (1991); Chen (2021)
ϕ_{f_r}	Elasticity of foreign reserves and government bonds	1.8	Yan (2015)
ϕ_{bG}	Elasticity of government bonds	1.2	Yan (2015)
ϕ_π	Taylor parameter on inflation	1.5	Taylor (1993); Clarida, Gali and Gertler (1999);

ϕ_y	Taylor parameter on output	0.5	Taylor (1993); Clarida, Gali and Gertler (1999);
x	Survival rate of bankers	0.3	National Bank Yearbook
φ	Leverage ratio of banks	5	The Fiscal Science Research Institute of the Ministry of Finance (1997)

5.2.2 Steady-State Calibration

Table 5 summarizes the key steady-state characteristics of the model. The annualized real domestic and foreign policy rates are set to 3.76% (Kong, 1988) and 4.16% (Hamilton, 1987), respectively, implying a domestic discount factor β of 0.962. The steady-state lending spread $\frac{r_B - r}{\pi}$ is 6%, reflecting Li's (1996) estimate of a 10% borrowing rate and a 3.76% deposit rate during the Great Depression.

The steady-state labor supply h is standardized to 1, rather than the conventional 1/3 to simplify the model (Cantore et al., 2014). The steady-state inflation rate π is set to 1, with domestic inflation estimated at -0.002, a value close to zero, consistent with Wang (1996). Government spending as a share of GDP $\frac{G}{GDP}$ is set to 14% (Liu and Li, 2012), and government bonds as a share of GDP $\frac{b}{\text{GDP}}$ is 1.76% (Fiscal Finance and Taxation Records, 1997). The agricultural output share of GDP $\frac{y_A}{GDP}$ is 61% (Wu,1947), and land per capita $\bar{l}$ is set to 0.443 hectares (Rawski, 1989).

Table 5 Steady-State Calibration

SS Values	Description	Value	Source
r^*	Foreign interest rate	0.0416	Hamilton (1987)
r	Domestic interest rate	0.0376	Kong (1988)
β	Discount factor	0.962	Kong (1988)
Π	Gross inflation rate	1	Wang (1996)
sp	Annualized domestic spread	0.6	Li（1996）
h	Hours worked	1	(Cantore et al.,2014).

G/GDP	Share of government spending in GDP	0.14	Liu and Li (2012)
$\bar{b}$/GDP	Government bonds as share of GDP	0.0176	Fiscal Finance and Taxation Records of the Nationalist Government:1927-1937 (1997)
yA/GDP	Share of agricultural output in GDP	0.61	Wu (1947)
$\bar{l}$	Land per capita (hectares)	0.443	Rawski (1989)

5.3 Bayesian estimated parameters and posterior distributions

The rest of the parameters are estimated using Bayesian methods. Table 6 and Figure 7 report the prior and posterior distributions of the parameters for China.

Bayesian estimation was applied to determine the coefficients of the $AR(1)$ processes, the magnitude of shocks, and six structural parameters: specifically α_A and α_N (trade openness of agricultural and nonagricultural goods), μ_A and μ_N (foreign elasticity of substitution for agricultural and non-agricultural goods), μ (home elasticity of substitution), and the land-climate elasticity θ.

We employed relatively uninformative priors or those consistent with previous Bayesian studies, such as Smets and Wouters (2007). Persistence parameters for AR(1) processes followed a Beta distribution with a mean of 0.5 and a standard deviation of 0.2 , while innovation standard errors were modeled using an inverse Gamma distribution with a mean of 0.1 and a standard deviation of 0.05 . For the agricultural sector, prior distributions were based on Gallic and Vermandel (2000), using Gamma distributions for substitution elasticities μ, μ_A, μ_N . Consistent with empirical findings from Yilmazkudax (2018), Ruhl (2008), and Obstfeld and Rogoff (2000), we set a Gamma (2,1) distribution for international substitution elasticities, centering the mean at 2 but allowing flexibility above 0. The land-climate elasticity, constrained to be positive, followed a Gamma distribution with a mean of 2 and a standard deviation of 0.5.

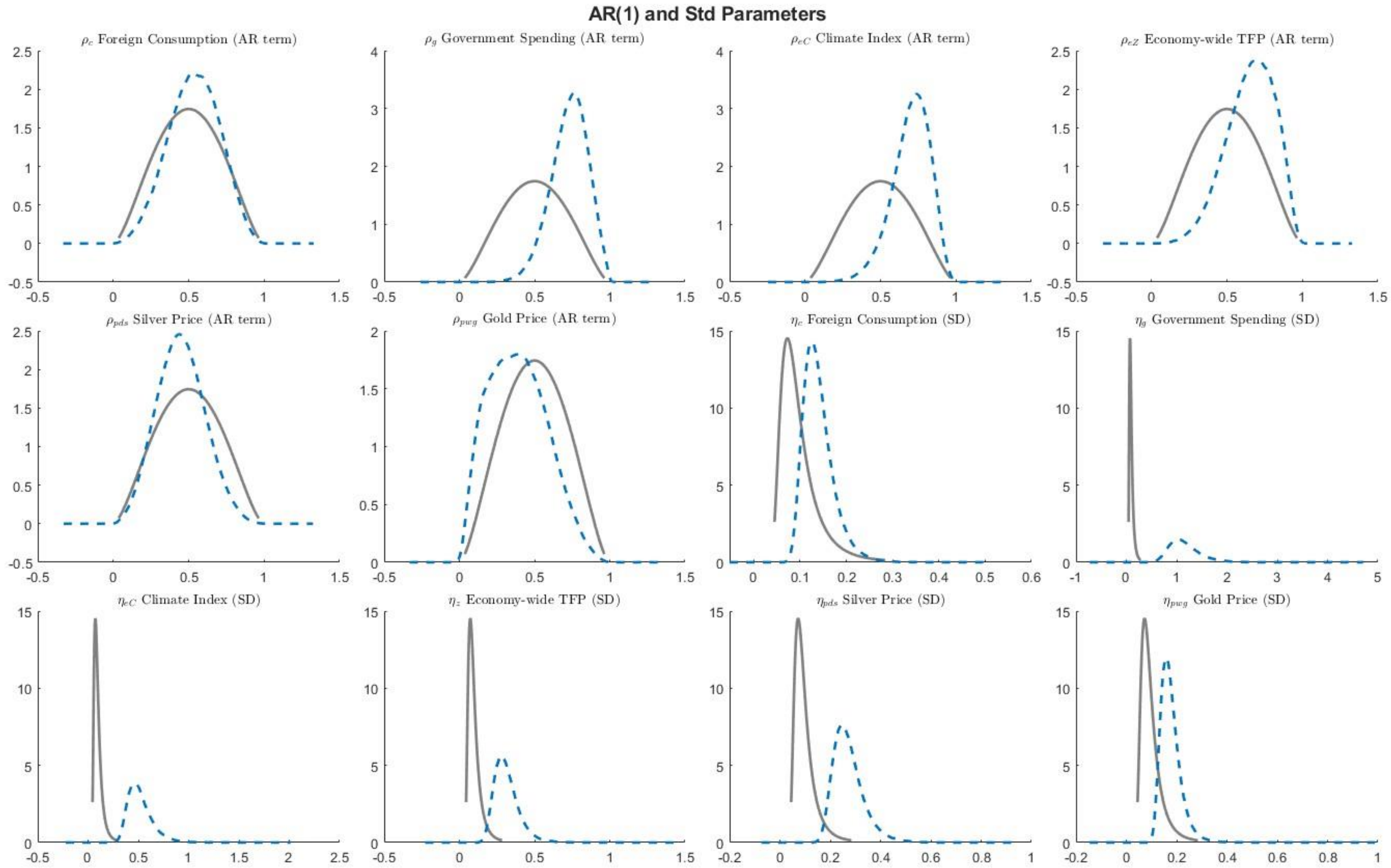
Table 6 summarizes the means and the 5 th and 95 th percentiles of the posterior distributions, while Appendix III illustrates these results in detail. The data proved highly informative, as evidenced by the substantial updates in the posterior distributions compared to their priors (Figure 7), highlighting the model's ability to capture meaningful dynamics from the underlying data.

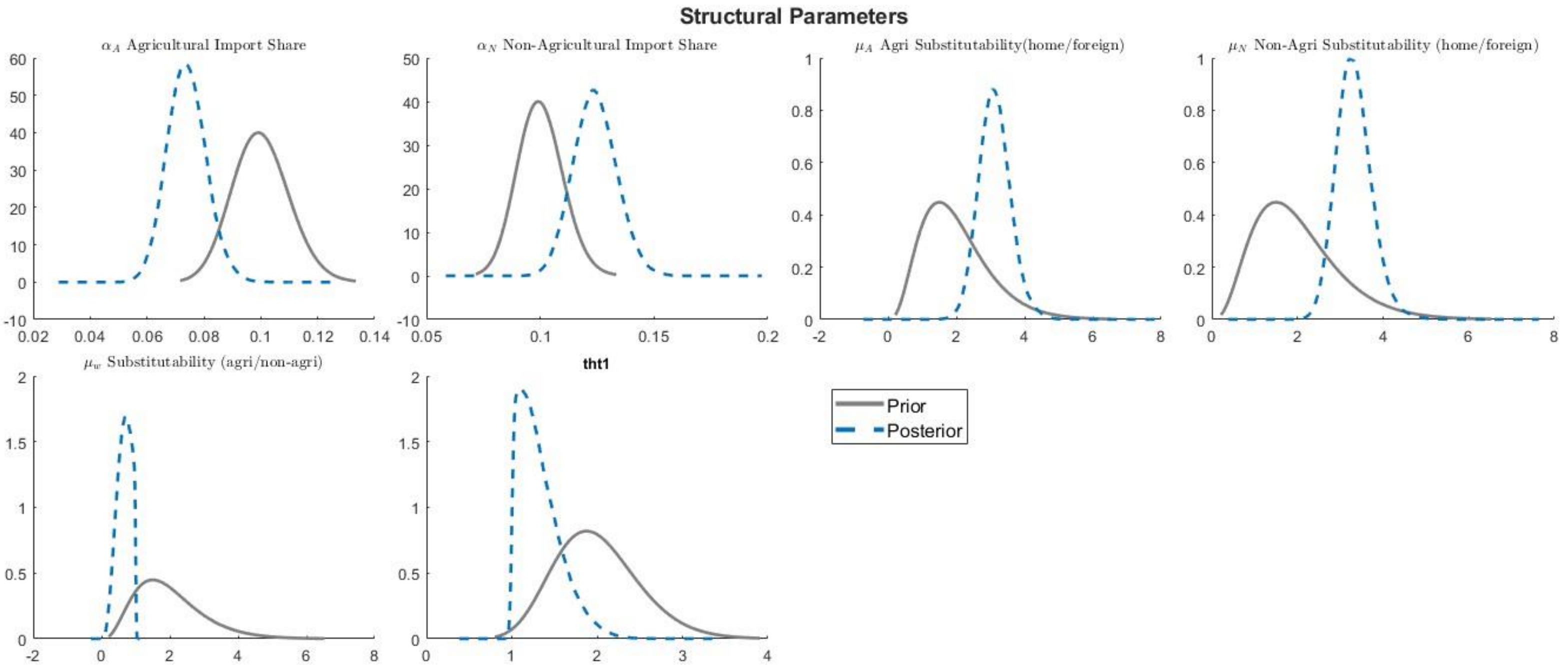
Table 6 Prior and posterior distributions of structural parameters and shock processes.

	Prior distributions			Posterior distribution	
	Shape	Mean	Std.	Mean	[5%:95%]
Shock Process AR (1)					

Foreign Consumption (AR term)	ρ_c	B	0.50	0.20	0.53	0.20	0.85
Government Spending (AR term)	ρ_G	B	0.50	0.20	0.73	0.49	0.96
Climate Index (AR term)	ρ_w	B	0.50	0.20	0.70	0.45	0.93
Economy-wide TFP (AR term)	ρ_z	B	0.50	0.20	0.65	0.35	0.94
Silver Price (AR term)	ρ_s	B	0.50	0.20	0.45	0.14	0.75
Gold Price (AR term)	ρ_g	B	0.50	0.20	0.39	0.05	0.74
Shock Process SD							
Foreign Consumption (SD)	σ_c	W	0.50	0.20	0.14	0.09	021
Governement Spending (SD)	σ_G	W	0.10	2.00	1.16	0.62	1.80
Climate Index (SD)	σ_W	W	0.10	2.00	0.52	0.31	0.77
Economy-wide TFP (SD)	σ_z	W	0.10	2.00	0.31	0.17	0.48
Silver Price (SD)	σ_s	W	0.10	2.00	0.27	0.17	0.40
Gold Price (SD)	σ_g	W	0.10	2.00	0.17	0.11	0.25
Structural Parameters							
Agricultural Goods Substitutability (home/foreign)	μ_A	G	2.00	1.00	3.11	2.20	4.04
Non-agricultural Goods Substitutability (home/foreign)	μ_N	G	2.00	1.00	3.31	2.53	4.15
Domestic Goods Substitutability (by type of goods)	μ	G	2.00	1.00	0.66	0.30	1.00
Market Openness (non-agricultural market)	α_N	B	0.50	0.10	0.12	0.10	0.14
Market Openness (agricultural market)	α_A	B	0.50	0.10	0.07	0.06	0.09
Land-climate elasticity	θ	G	2	0.5	1.33	1.00	1.81

Figure 7. Prior and posterior distributions of shocks (top) and structural parameters (bottom) for China





Structural Parameters
α_A Agricultural Import Share
α_N Non-Agricultural Import Share
μ_A Agri Substitutability(home/foreign)
μ_N Non-Agri Substitutability (home/foreign)
μ_w Substitutability (agri/non-agri)
tht1
Prior
Posterior

5.4 Model diagnostics

Based on the model diagnostics, the Dynare Identification tool confirms that all parameters are well-identified, meaning the model can uniquely estimate each parameter with sufficient information from the data. The mode check plots further indicate a stable estimation process, successfully locating the optimal parameter values without convergence issues. Together, these diagnostics demonstrate the model's robustness, calibration accuracy, and reliability for further analysis. (Detailed figures for model diagnostics are available upon request.)

The model performs well in replicating key steady-state values and capturing the dynamic properties of core macroeconomic variables. For instance, the agricultural output share (0.61), non-agricultural output share (0.39), and real interest rate (0.37) perfectly align with the target steady-state values, which were pre-specified in the model rather than estimated, as reported in Table 5. While some discrepancies exist for non-targeted variables, such as the consumption-to-output ratio (0.71 in the model vs. 0.83 in real data) and trade shares (e.g., an export-to-output ratio of 0.04 in the model vs. 0.05 in real data, and an import-to-output ratio of 0.04 in the model vs. 0.06 in real data), these differences are relatively minor and do not compromise the model's robustness.

To further Comparison of theoretical business cycles moments with their empirical counterpart, Table 7 provides a comprehensive comparison of simulated and observed moments, covering key indicators like volatility (SD), autocorrelation (AC), and correlation (COR) with real GDP across several macroeconomic variables, including real GDP, imports, exports, the real exchange rate, the real silver price, consumption, and agricultural prices. The first six variables are directly incorporated into the Bayesian estimation as observed variables, enabling the model to closely replicate their SD, AC, and COR with high accuracy. For example, real GDP and trade-related variables consistently match empirical data in terms of both volatility and persistence.

The remaining two variables—consumption and agricultural prices—are not explicitly included in the estimation process. Despite this, the model achieves notable consistency in their SD, AC, and COR, demonstrating its ability to capture key macroeconomic dynamics beyond the directly calibrated targets. While a minor deviation is observed in the autocorrelation of consumption (0.07 in the model vs. -0.38 in the data), this difference does not significantly detract from the model's reliability, as both the SD (0.35 vs. 0.12) and COR (0.47 vs. 0.85) of consumption remain within acceptable ranges. Similarly, agricultural prices show slight discrepancies in SD (0.24 vs. 0.13) and COR (0.36 vs. 0.17), reflecting the model's sensitivity to sector-specific fluctuations. However, their autocorrelation (-0.18 vs. -0.16) aligns closely with observed data. Overall, these results validate the model's robustness in replicating steady-state values and dynamic trends of key macroeconomic variables, even for non-targeted indicators, and demonstrate its effectiveness in simulating historical crises.

Table 7 Comparison of theoretical business cycles moments with their empirical counterpart

Variable	1912-1936		
	SD	AC	COR
Real Output	0.07 vs 0.07	-0.15 vs -0.15	1.00 vs 1.00
Import	0.21 vs 0.21	-0.28 vs -0.28	-0.09 vs -0.09
Export	0.21 vs 0.21	0.10 vs 0.10	0.05 vs 0.05

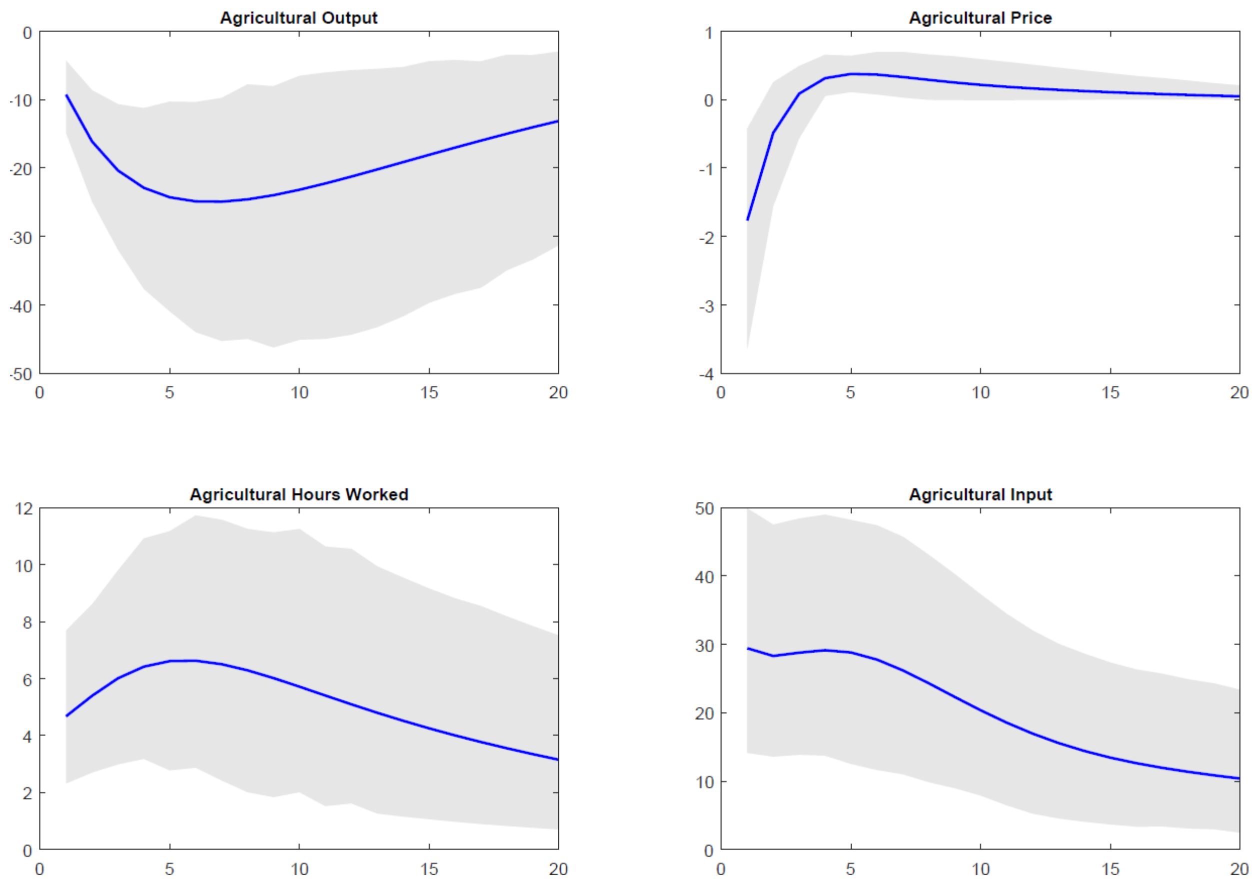
Real Exchange Rate	0.14 vs 0.14	-0.15 vs -0.15	-0.01 vs -0.01
Real Silver Price	0.22 vs 0.22	0.32 vs 0.32	-0.10 vs -0.10
Climate Index	0.62 vs 0.62	0.78 vs 0.78	0.11 vs 0.11
Consumption	0.35vs 0.12	0.07 vs -0.38	0.47 vs 0.85
Agricultural Price	0.24 vs 0.13	-0.18 vs -0.16	0.36 vs 0.17

Note: All metrics are model/data observation. The data represents annual growth rates of selected observable variables, with all values demeaned.

6 Model Results of Climate Shock

6.1 Agriculture: Impacts and Responses to Climate Shock

Figure 8 Responses of Key Macroeconomic Variables in the Agricultural Sector to Climate Shock



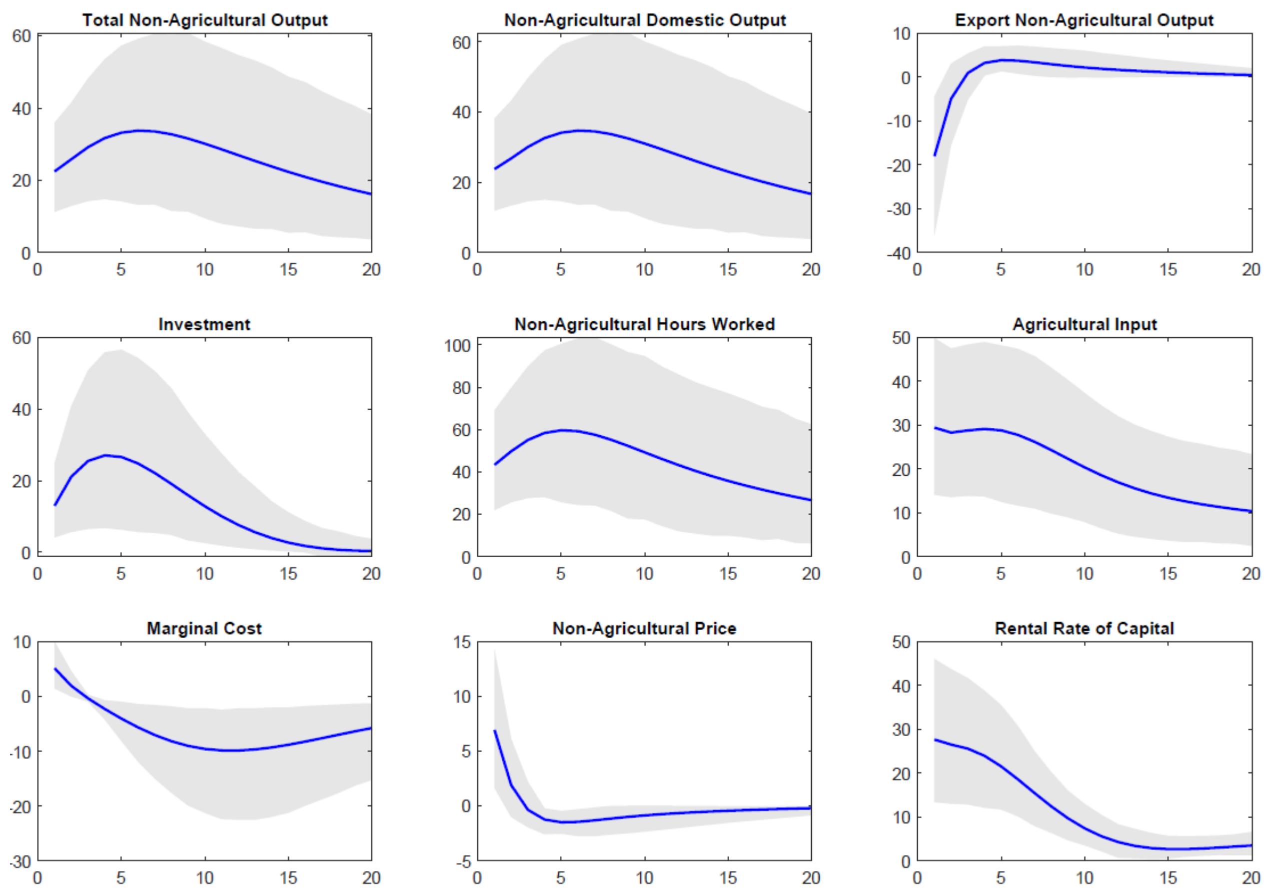
Note: All responses to shocks are measured as deviations from the steady state.

Impulse response functions (IRFs) plots demonstrate that climate shocks have significant and lasting impacts on the agricultural sector (Figure 8). Agricultural output initially drops by 10%, peaking at a 25% decline by the third period, reflecting immediate production disruptions. Moreover, agricultural prices decline relative to the overall price level despite the supply shock. This can be explained by a combination of demand elasticity, substitution effects, and income effects, aligning with historical empirical data.

The demand for agricultural goods, especially non-essential products, is elastic, allowing consumers to reduce consumption or substitute with cheaper alternatives like imports or non-agricultural goods. Additionally, the income effect from reduced farm incomes lowers overall demand, reinforcing the downward pressure on prices. Together, these effects explain why agricultural prices fall even amid reduced supply. On the supply side, farmers adapt by increasing labor hours and using more non-agricultural inputs, such as fertilizers, to partially restore production, which help partially restore production and mitigate further price declines.

6.2 Resilience and Growth in the Non-Agricultural Sector

Figure 9 Responses of Key Macroeconomic Variables in the Non-Agricultural Sector to a Climate Shock



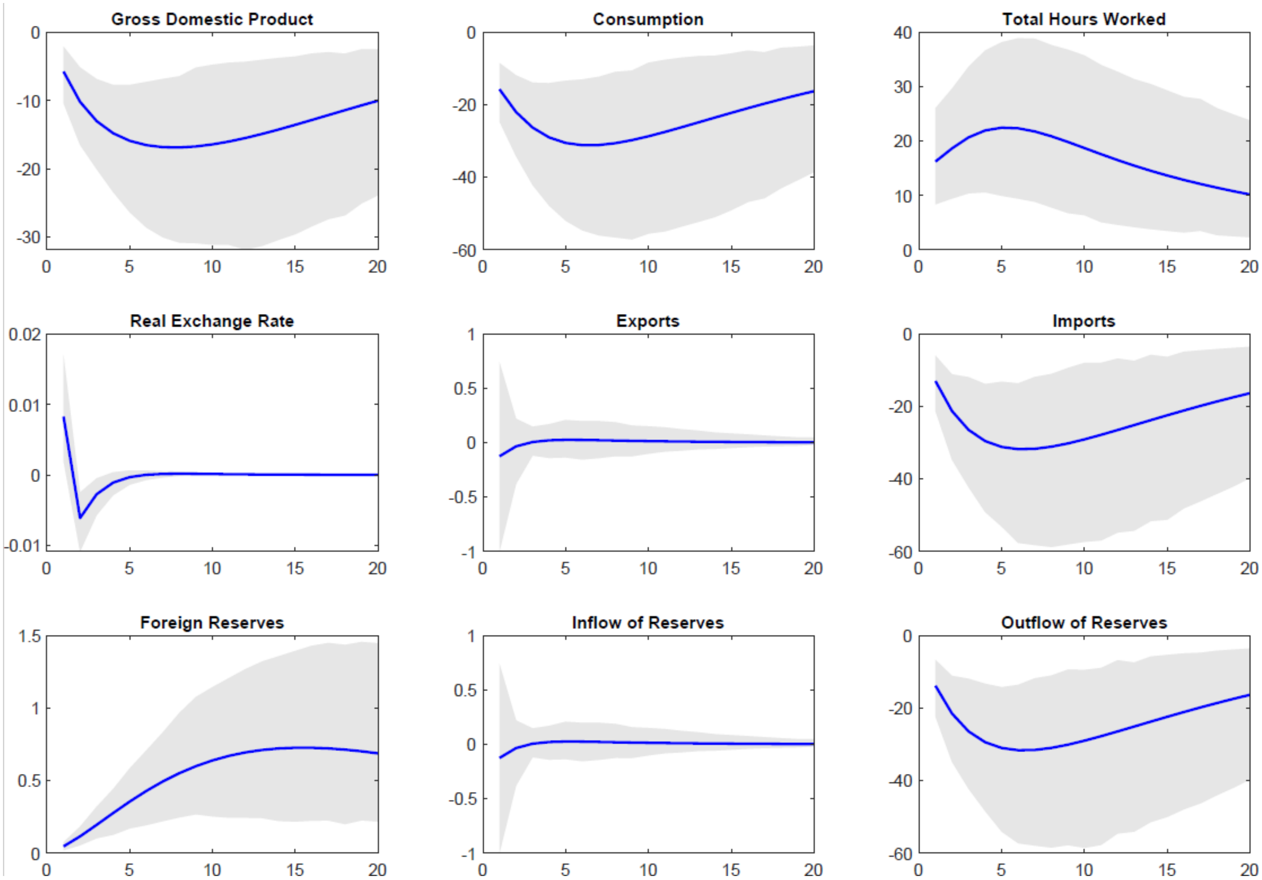
Note: All responses to shocks are measured as deviations from the steady state.

In contrast to the decline in agriculture, the non-agricultural sector demonstrates notable resilience (Figure 9). A climate shock reduces agricultural productivity, leading to a reallocation of resources, particularly labor and capital, from the agricultural to the non-agricultural sector. As a result, domestic non-agricultural output initially rises by 20%, supported by a 10% increase in investment, driven by higher marginal returns on capital. Non-agricultural hours worked increase by 40% relative to the steady state as labor shifts from the agricultural sector. However, non-agricultural exports decline by approximately 10% as higher non-agricultural prices reduce international competitiveness. The increase in non-agricultural prices and marginal costs is driven by higher wages resulting from labor reallocation, despite a decrease in agricultural input prices.

These factors push up the rental rate of capital and further stimulate investment and output within the non-agricultural sector, while export production contracts due to cost-related price pressures.

6.3 Macroeconomy and Trade

Figure 10 Responses of Key Macroeconomic Variables in the Overall Macroeconomic Sector to a Climate Shock



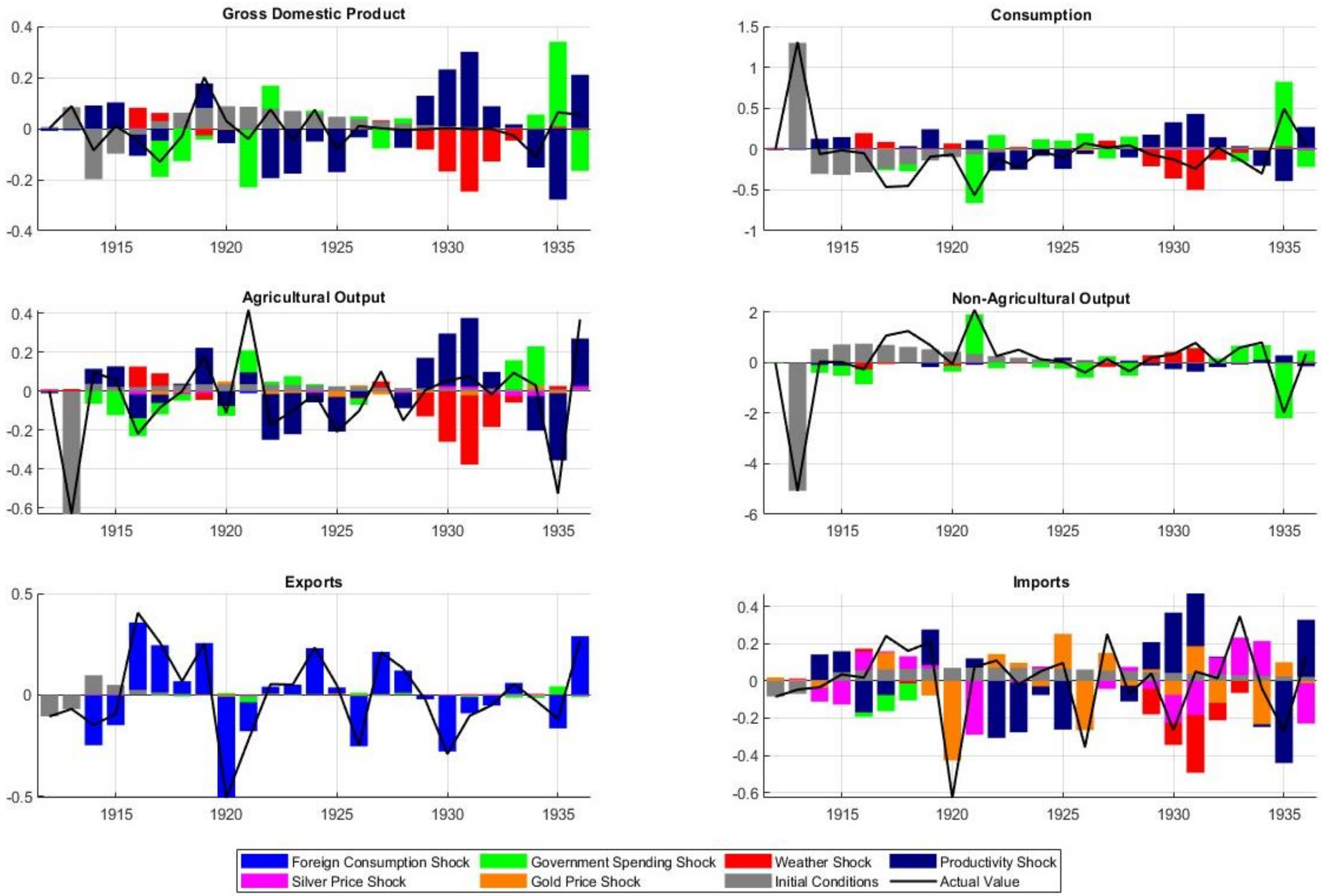
Note: All responses to shocks are measured as deviations from the steady state.

Figure 10 shows the responses of key macroeconomic variables in the overall macroeconomic sector to climate shock. Despite the gradual development of the non-agricultural sector, agriculture continued to dominate China's GDP during the climate shock, contributing to an overall GDP decline of 5% initially and peaking at 17% around fifth period. This decline was accompanied by a sharp 18% drop in consumption, while total working hours increased by 15%, likely reflecting efforts to mitigate the economic downturn through greater labor input.

The climate shock also had profound effects on trade. Imports experienced a steep initial decline of over 10%, driven primarily by reduced national income. In contrast, exports remained relatively stable, declining by only 0.1%, as they were largely determined by international demand and exchange rate rather than domestic conditions. Additionally, the limited marketization of domestic production, particularly in climate-sensitive agricultural sectors, further insulated exports from significant disruption. The real exchange rate exhibited limited fluctuations in response to the climate shock, as the silver standard imposed constraints on nominal exchange rate adjustments.

7 Historical Decomposition

Figure 11 Historical Decomposition of Key Macroeconomic Variables (1912-1936)



Historical decomposition reveals that climate shocks were the primary driver of China's economic fluctuations between 1912 and 1936, especially during the Great Depression.

As shown in Figure 11, China's per capita GDP experienced modest growth until 1933, but faced a sharp decline in 1934, marking a delayed yet severe economic contraction compared to the immediate downturns in the U.S. and the U.K. Between 1929 and 1933, climate shocks (represented in red) exerted sustained downward pressure on GDP by disrupting agricultural output and reducing household consumption. Although increased government spending temporarily supported GDP recovery in 1934 and 1935, resource misallocation—primarily from excessive military expenditures—began crowding out private investment, especially in non-agricultural sectors. Combined with weakening technological gains, this misallocation contributed to the contraction of GDP during 1935 and 1936.

The limited impact of external demand shocks, silver price fluctuations, and exchange rate instability had a minimal effect on China's overall GDP decline. However, external shocks significantly affected China's trade sector. Reduced foreign consumption diminished exports, although their overall contribution to GDP decline remained limited. The early 1930s depreciation of silver initially enhanced China's export competitiveness, but this advantage was short-lived due to collapsing global demand during the Great Depression.

On the import side, the combined effects of climate and external shocks were more pronounced. Silver depreciation from 1929 to 1931 raised import costs, while declining domestic incomes—driven by severe climate shocks, including the catastrophic 1931 Yangtze River flood—further weakened purchasing power and reduced imports. The situation worsened in 1931 when the U.K. and Japan abandoned the gold standard, leading to heightened volatility in silver prices. President Roosevelt's New Deal in 1933, with its expansion of the U.S. money supply, further fueled global commodity price increases, including silver. The 1934 Silver Purchase Act intensified this trend, causing silver prices to peak in 1935 and marking a significant policy-driven shift.

As indicated by the historical decomposition, silver appreciation after 1931 temporarily eased import costs until 1934, when the negative effects of rising silver prices on imports became more apparent. These findings align closely with historical events, demonstrating the model's effectiveness in capturing the key transmission mechanisms and economic dynamics underpinning China's compound crisis during the Great Depression.

8 Counterfactual Analysis

8.1 The analysis of compound shocks

To evaluate the competing perspectives on the drivers of China's economic dynamics during the 1930s, we construct three distinct hypothetical scenarios to quantify the relative importance of various shocks, answering the question: "What would happen if specific shocks occurred?" These scenarios include: (1) the Climate Shock, (2) the Great Depression Shock, and (3) the Combined Shocks scenario. By isolating and comparing the impacts of different shocks, these scenarios provide a comprehensive understanding of their respective contributions to China's economic performance.

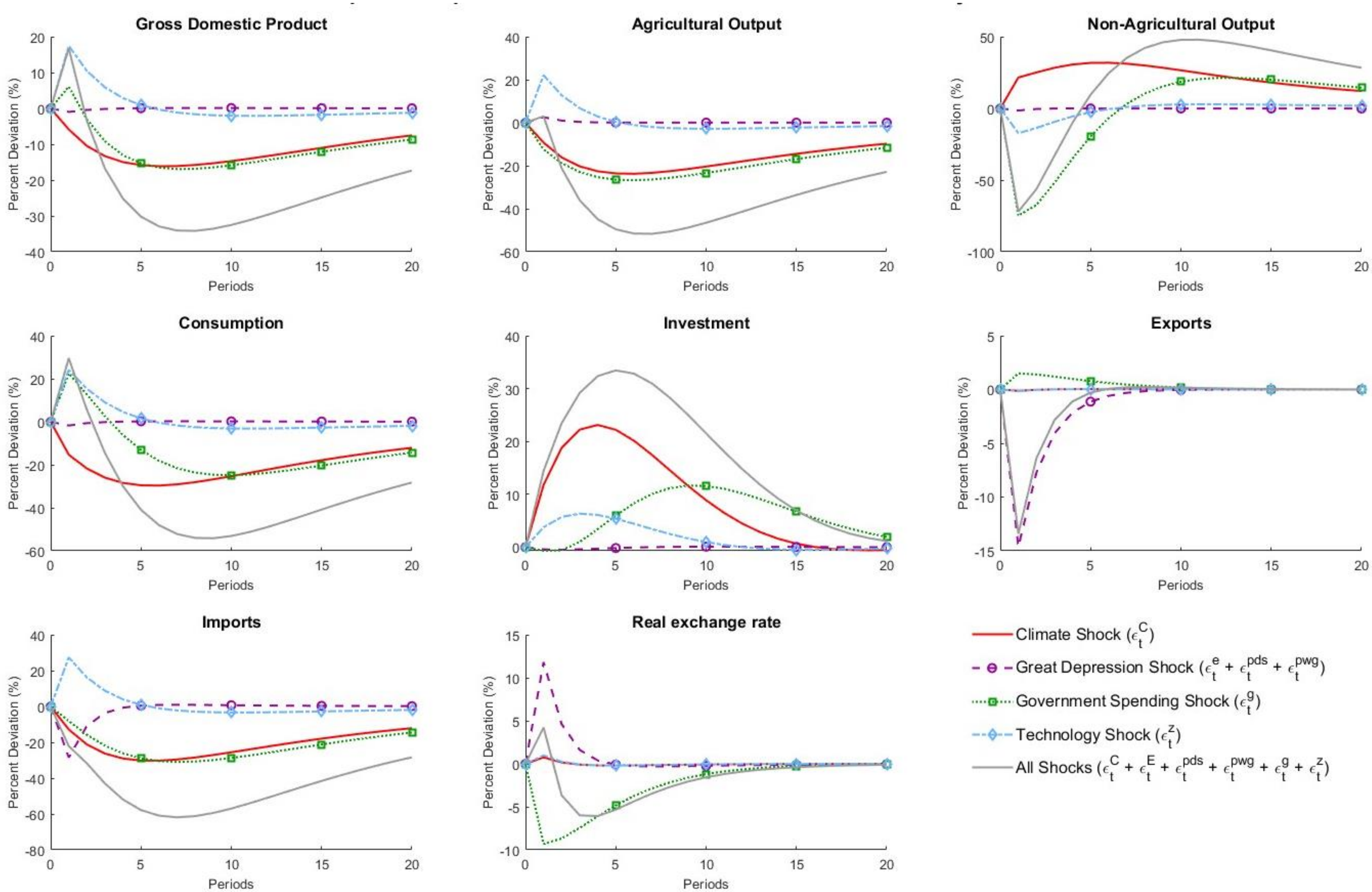
The first scenario focuses on the Climate Shock (ϵ_t^C), isolating the effects of climate-induced disruptions. Only the climate shock is introduced in this case, with all other shocks set to zero. This design allows for an exclusive examination of the adverse impacts of climate-induced declines in agricultural productivity and their spillover effects on other sectors, such as non-agricultural consumption and imports. The second scenario investigates the Great Depression Shock $\left(\epsilon_t^E + \epsilon_t^{pds} + \epsilon_t^{pwg}\right)$, capturing the external disruptions stemming from the global economic downturn. Specifically, ϵ_t^c represents global demand contraction, ϵ_t^{pds} reflects silver price shocks, and ϵ_t^{pwg} corresponds to gold price shocks. This allows us to assess the effect of these external shocks on the economy while excluding all other shocks. The third scenario examines the combined effect of All Shocks $\left(\epsilon_t^C + \epsilon_t^E + \epsilon_t^{pds} + \epsilon_t^{pwg} + \epsilon_t^G + \epsilon_t^Z\right)$, encompassing climate, Great Depression, government spending (ϵ_t^G), and technological shocks (ϵ_t^Z). This scenario captures the full spectrum of internal and external disruptions, along with fiscal and technological responses. In the model, these shocks are introduced separately or in combination. The responses of key variables are measured as percentage deviations from their steady-state values.

Figure 12 illustrates the evaluation of competing perspectives on the drivers of China's economic fluctuations through hypothetical DSGE model scenarios. The Climate Shock scenario (red line) demonstrates that natural disasters had the most significant and prolonged adverse effects on GDP, agricultural output, and consumption, as discussed in section 6 and section 7. These findings align with the climate shock hypothesis (Xu and Wu, 2003; Lai Cheng, 2009; Zhao and Sui, 2011), which emphasizes the dominant role of internal climatic factors in China's economic downturn. However, unlike previous qualitative studies, our model provides quantitative evidence of the scale and persistence of climate shocks, demonstrating their macroeconomic significance beyond the agricultural sector.

In contrast, the Great Depression Shock scenario (purple line) reveals that external financial shocks—such as global demand contraction and exchange rate fluctuations—had only modest impacts on overall GDP and non-agricultural output. The results show that while trade was significantly affected—exports contracted by nearly 15% and imports by approximately 30%—overall GDP effects remained modest. This outcome supports the low-impact perspective (Brandt, 1989; Myers, 2014), which contends that China's reliance on a largely self-sufficient agrarian economy and the silver standard shielded it from the full force of the Great Depression. However, our findings add an important nuance: financial shocks primarily affected imports rather than exports, which prior studies have often overlooked.

Finally, the Combined All Shocks scenario (grey line) captures the interaction between the Great Depression and climate shocks, while also incorporating government spending and technological shocks as additional factors. This scenario closely aligns with historical patterns, as GDP does not decline immediately but begins to contract two to three periods after the shocks. The results suggest that while short-term government spending and technological advancements provided initial economic relief, these positive effects were ultimately outweighed by persistent climate shocks. These findings refine and extend the compound crisis perspective proposed by Shiroyama (2021). Unlike Shiroyama's primarily descriptive approach, this study provides a quantitative demonstration of how climate and financial shocks interacted asymmetrically, with climate shocks exerting the most prolonged and severe pressure on GDP. This underscores the importance of considering differential shock persistence when analyzing historical economic crises.

Figure 12 Analysis of Compound Shocks (Measured by Percent Deviations from Steady State)



8.2 Counterfactual Modern Monetary Policies and Polices Recommendations

Although the silver standard has long been abandoned, the economic structure and macroeconomic shocks experienced by China in the 1930s remain relevant today, particularly in light of climate shocks. Understanding how modern monetary policy could mitigate such crises is crucial. To evaluate policy responses under modern conditions, we simulate four scenarios: the silver standard (base model, $r = 3.76\%$), modern monetary policy using the same interest rate (, $r = 3.76\%$), a lower interest rate scenario ($r = 1\%$), and a higher interest rate scenario ($r = 6\%$). The last three scenarios follow the standard Taylor rule:

$$\frac{r_t}{r^{ss}} = \left(\frac{\pi_t}{\pi^{ss}}\right)^{\phi_\pi} \cdot \left(\frac{Y_t}{Y_{t-1}}\right)^{\phi_y}$$

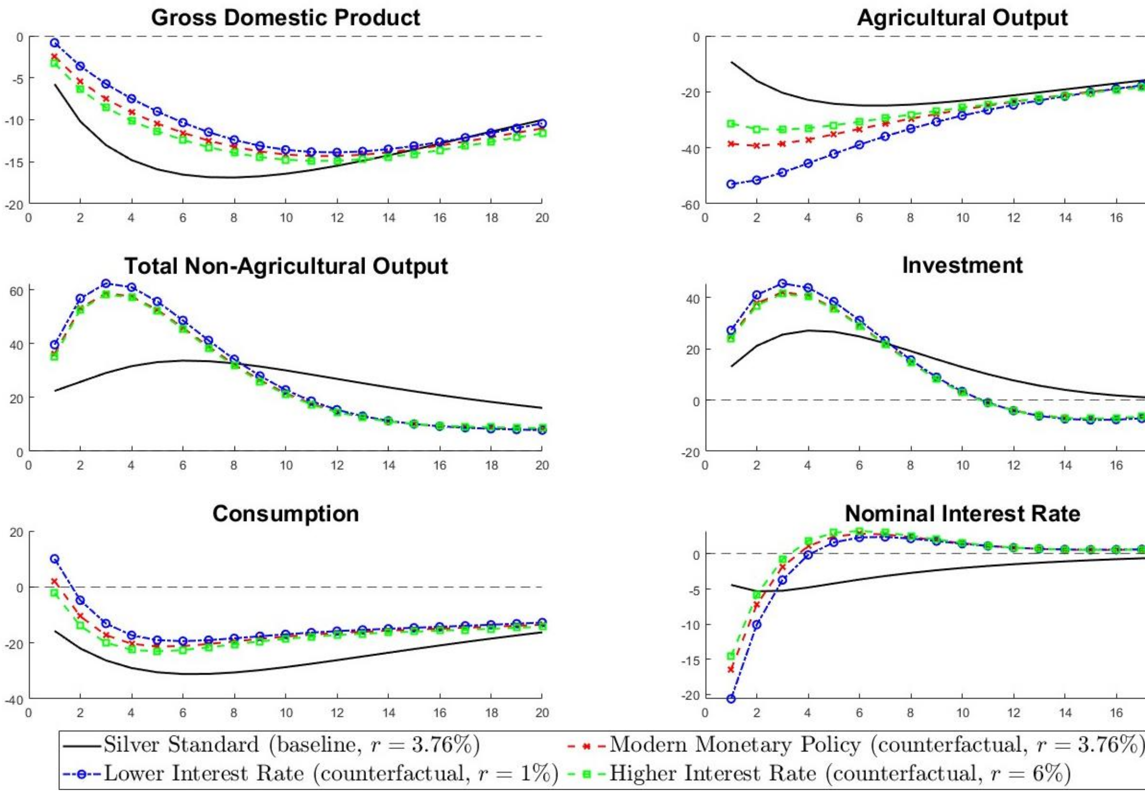
where ϕ_π reflects the sensitivity to inflation, and ϕ_y captures output growth responses.

As illustrated in Figure 13, the black curve (representing the silver standard) exhibits "passive stability" in agricultural output. This stability stems from the limited monetary flexibility inherent in the silver standard regime. While this constraint maintained stability, it also limited the economy’s ability to implement countercyclical measures during downturns, leaving it vulnerable to external and internal shocks. In contrast, modern monetary policy scenarios—depicted by the red (baseline), blue (lower interest rate), and green (higher interest rate) lines—offer significantly greater short-term stabilization through investment and consumption adjustments.

Among these scenarios, the lower interest rate policy (blue line) stimulates economic activity by reducing borrowing costs, leading to a sharper recovery in GDP, non-agricultural output, and investment. However, this approach risks resource misallocation, as cheaper credit encourages disproportionate capital inflows into non-agricultural sectors, further exacerbating underinvestment in agriculture. This effect is particularly evident in the model, where we assume limited agricultural investment, resulting in rising input costs and declining agricultural output. Conversely, a higher interest rate (green line) mitigates resource misallocation by restraining excessive capital concentration in non-agricultural sectors but at the cost of dampening overall economic growth due to higher borrowing costs.

Compared to the silver standard, modern monetary policy provides greater flexibility in managing economic fluctuations but requires careful coordination with fiscal policy to prevent structural imbalances. A low-interest environment should be accompanied by targeted agricultural support to counteract capital flight from the sector. Public investment in agricultural infrastructure—such as irrigation systems and technological advancements—can enhance productivity and stabilize agricultural output, ensuring a more balanced economic response to monetary interventions.

Figure 13 Counterfactual Modern Monetary Policies



9 Conclusion

This study investigates the "compound crisis" China faced in the 1930s under the dual pressures of the global Great Depression and natural disasters. By addressing four key research questions—how to identify compound crises under limited data, the relative importance of external versus climate shocks, the transmission of natural disasters from agriculture to other sectors, and the effectiveness of modern monetary policy under the silver standard—the study offers important insights into the macroeconomic dynamics of the period. Using a DSGE model, it reveals how external and domestic shocks together shaped China's economic performance during the Great Depression.

By integrating historical narratives, quantitative indices, and DSGE simulations, this study establishes that China's economic downturn during the early 1930s was not merely an external Great Depression crisis or a climate-induced recession, but a compound crisis where interacting shocks magnified economic distress. The findings indicate that climate shocks were the main drivers of economic fluctuations, amplified by the reallocation of labor and capital from agriculture to other sectors. External shocks primarily affected the export sector. Counterfactual simulations reveal the limitations of current academic perspectives, emphasizing the need to consider simultaneous shocks—including climate, Great Depression shocks, government spending, and technological disruptions—for a comprehensive understanding of the downturn. The analysis further shows that the silver standard, which restricted the use of monetary policy for economic adjustment, worsened GDP, investment, and consumption growth. Under a modern monetary system, while flexible interest rates could alleviate short-term shocks, they risk resource misallocation without fiscal and industrial coordination. Effective stabilization requires integrating interest rate policies with targeted agricultural support, public investment, and structural reforms.

Future research should incorporate remittances into the analysis of silver flows to better understand cross-border capital dynamics and their effects on investment. Additionally, exploring how the U.S. compound crisis, including both financial and climate shocks, propagated internationally would provide lessons for modern economies facing similar risks.

Appendix A

Table 1 Natural Disasters and Their Impact on China during Great Depression (1929-1932)

Year	Disaster Type	Affected Region	Total Deaths	Total Affected
1929	Flood	Three Provinces (including Sichuan)	-	-
1929	Pests	Eight Provinces (including Jiangsu)	-	-
1929	Drought	Eight Provinces (including Gansu)	-	65068208
1930	Flood	15 Provinces (including Liaoning, Hebei, Anhui)	-	51246752
1931	Flood	Yangtze and Huaihe River Basins (8 Provinces)	3700000	61026707
1931	Drought	Four Provinces (including Shaanxi)	-	-
1931	Pests	Three Provinces (including Shaanxi)	-	-
1932	Drought	Six Provinces (including Henan)	-	27583012
1932	Hail	Three Provinces (including Shanxi)	-	-
1932	Flood	12 Provinces (including Jilin)	-	-
1932	Pests	Three Provinces (including Shandong)	-	-
1932	Drought	Six Provinces (including Henan)	-	-

Data source: Compiled from EM-DAT, Liu and Yang (2012), and The Third Series of Modern Chinese Agricultural History (1927-1937).

Reference