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Climate Change and the Chinese Economy, Three Essays on Macroeconomic Model

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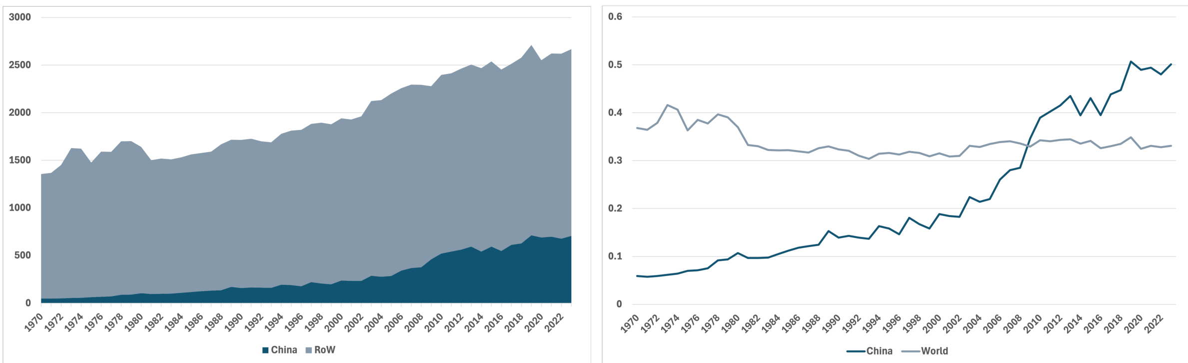
Contents

Chapter 1

Introduction

Climate change has become an urgent issue for humanity. Due to global warming, we are experiencing much more frequent extreme weather and catastrophes, such as extreme heat waves causing drought and extreme precipitation causing floods (Pachauri, Reisinger, et al., 2007). China is one of the largest carbon emitters in the world, accounting for 26.5% of the world's emissions in 2023. The scale becomes much smaller for the emission per capita, but shows a dramatic increasing trend in the past two decades (Figure 1.1).

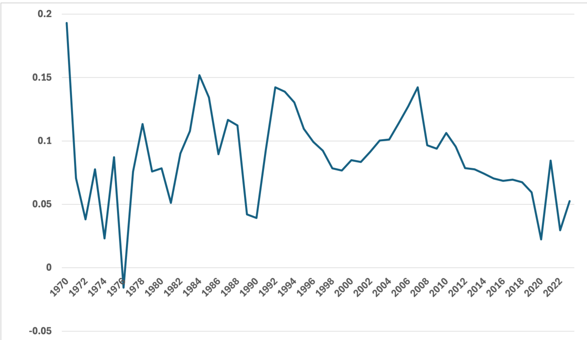


(a) Carbon emissions (Mt) (b) Carbon emissions per capita

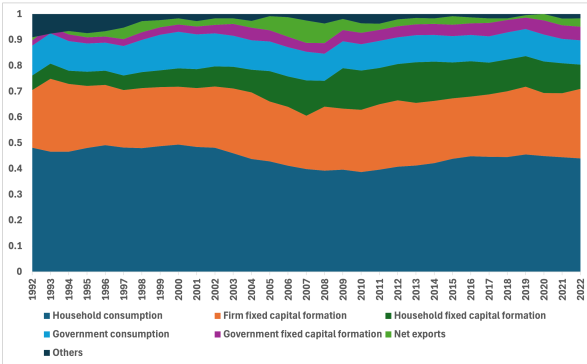
Figure 1.1: Carbon emissions of China and the rest of the world

Source: World Bank

After the Great Recession, Chinese economic growth slowed down (Figure 1.2a). This was first attributed to external factors and cycles (Renard, 2018). Due to the decline in international demand, the growth rate of exports decreased to 6.1% in 2014 and became negative at -1.8% in 2015, whereas from 1979 to 2013, the average remained at 16.8% per year (Lin, 2016). The government announced a reorientation of the economy to avoid an extreme slowdown in economic growth and combat structural imbalance. In 2013, President Xi Jinping introduced a policy change, known as the New Normal (Renard, 2018). The policy has focused on reducing overcapacity, decreasing the production of heavy industries (e.g., coal and steel), and promoting innovation. On the demand side, the Chinese economic growth regime has shifted from profit-led to wage-led, promoting domestic private consumption, which increased from 38.8% of GDP in 2010 to 45.6% in 2019 (Figure 1.2b). A pro-labour policy may contribute to rebalance China's growth and make it less dependent on exports, overinvestment, and carbon-intensive industries (Jetin & Reyes Ortiz, 2020).



(a) Real GDP growth



(b) Aggregate demand components to GDP

Source: World Bank, National Bureau of Statistics of China

This thesis comprises three essays on macroeconomic models for China, examining the country's economic growth, climate policies and social imbalance. The following chapter presents a stock-flow consistent (SFC) model with an energy sector to examine the impact of climate policies, such as carbon pricing and green subsidies, on China's green transition and their economic side effects. The energy sector comprises conventional energy producers (i.e., fossil energy) and renewable energy producers. Conventional and renewable energy allocation depends on the relative prices of these energy sources. Then we ask what the complements to climate policies are? Do social policies help reduce carbon emissions and reduce social imbalances, such as income inequality? In chapter 3, we present an empirical ecological SFC model of China, which integrates the macroeconomy with the energy and material balance, and investigates the effect of institutional policies, such as working hours reduction, wage policy, and income redistribution policy, on income inequality and material emissions. We validate the model using historical data and run scenarios to make future predictions. In the last chapter, we addressed this research question: "What if we employ a supply-led model? Does it perform better than our SFC model? What could be the differences?" We constructed a New Keynesian model and compared it to the empirical SFC model presented in Chapter 3, which supports our choice of modelling methodology.

Chapter 2

Modelling the Green Transition of the Chinese Economy

Abstract

This paper develops a stock-flow consistent (SFC) macroeconomic model with an energy sector for China to investigate the effect of green policies on green transition and the economy. We provide an analytical solution for the green transition that illustrates the relative cost of using conventional energy compared to renewable energy, enabling the determination of the optimal share of renewable energy. The development of the energy sector, in turn, promotes the green transition. Our solution also underscores the importance of green policies in facilitating a green transition. We calibrate the model to the National Determined Contributions (NDCs) scenarios from the Network for Greening the Financial System (NGFS) and run simulations from 2019 to 2035. The results indicate that carbon taxes stimulate the green transition but harm the economy, resulting in reduced economic growth, a current account deficit, and increased inflation. Carbon taxes deteriorate firms' balance sheets. Governments benefit from carbon taxes in the short term but face a higher public debt-to-GDP ratio in the long term. Carbon taxes reduce carbon intensity and carbon emissions. We also compared the effect of green fiscal policy to conventional fiscal policies financed by carbon taxes (carbon rebate). Green subsidies benefit economic growth more effectively. They reduce inflation caused by carbon taxes and stimulate the green transition further.

Keywords: *stock-flow consistent modelling, open economy, energy pricing, renewable energy, climate policy*

JEL codes: *E12, F41, Q41, Q42, Q58*

2.1 Introduction

China, the world's largest carbon emitter, has recently formulated a series of policy targets to reduce carbon emissions, summarised in Table 2.1. According to the "14th Five-Year Plan", carbon emissions to GDP in 2025 and 2030 must not surpass 18% of the level in 2020 and 65% of the level in 2005, respectively. Total carbon emissions are expected to peak in 2030 and reach carbon neutrality by 2060. The share of non-fossil energy consumption in total energy consumption is expected to reach approximately 25% by 2030 and exceed 80% by 2060.

Table 2.1: China climate change policy targets

	2025	2030	2060
Carbon emission to GDP	18% less than the level in 2020	65% less than the level in 2005	
Carbon emission		Peak	Carbon neutrality
Non-fossil energy consumption		25% of total	80%+ of total

Source: *Responding to Climate Change: China's Policies and Actions*

China has been planning and implementing economic policies to achieve these goals, promoting green bonds and green loans, providing subsidies and tax cuts in green industrial sectors, establishing a carbon emission rights market (launched on July 16, 2021), and increasing public green consumption. This paper attempts to model the green transition of the Chinese economy within a stock-flow consistent (SFC) framework, developing scenarios and evaluating the effectiveness of these policies.

Several studies have employed various modelling techniques to address ecological issues in China. Carraro and Massetti (2013) examines future energy and emissions scenarios in China using an Integrated Assessment Model (IAM) called WITCH (World Induced Technical Change Hybrid model) under a Ramsey-Cass-Koopmans optimal growth framework with an endogenous technical change in the energy sector. Yang and Teng (2018) evaluates the co-benefit of carbon mitigation in local air pollution reduction by using the China-MAPLE model, a bottom-up optimising model that solves the linear optimal problem of the energy system. Huang et al. (2021) investigates the effect of tightening environmental regulation on non-green firms' balance sheets and the financial risk in the banking system by building an environmental dynamic stochastic general equilibrium (E-DSGE) model. Su et al. (2022) estimates the macroeconomic cost of a deep decarbonisation pathway for China by integrating the China-MAPLE with KLEM-

CHN, a dynamic recursive Solow-Swan growth type model. However, all of these studies lack attention to the aggregate demand and are modelled theoretically.

SFC models differ from mainstream models in that the economy is demand-driven. The equilibrium of the final goods market is closed by aggregate output, whereas in mainstream (DSGE) models, the production technology predetermines output, and the equilibrium is closed by private demand, consumption, or investment through the intertemporal consumption behaviour of agents, i.e., the Euler equation.

The demand-driven model of economic growth has the advantage of studying social transformation to achieve sustainable growth, including sustainable consumption, reduced working hours, and the rebound effect. Respecting the 2-degree goal, neo-classical models display an instantaneous drop in capital stock that guarantees full employment of capital and labour under output contraction, which is not observed in history, e.g., the Great Recession (Rezai et al., 2013). Another advantage of the SFC approach is its explicit attention to macro-financial feedback loops. The balance sheets in SFC models can reflect a society's wealth and debt levels, enabling them to study the financial stability and sustainability of economic growth (Bezemer, 2010). It is not the primary goal of this paper to argue which method is superior to the other. A more explicit discussion on this issue could be found in Lavoie (2022).

Studies on ecological SFC models have been flourishing in recent years. A brief summary and classification of these literatures can be found in Carnevali et al. (2020). Most studies build a theoretical model and calibrate it using a few series of historical data or projections from other models, such as IPCC scenarios. This paper, unlike theirs, attempts to model the economy's system empirically.[1]. The model setups are based on the national balance sheet and transaction flow matrix, which enables it to capture the specific features of the Chinese economy (G. Zezza and Zezza, 2019). Behaviour equations are designed based on economic theory but adjusted to the empirical estimation of the data.

The theoretical framework of this paper primarily refers to the DEFINE (Dynamic Ecosystem-FINance-Economy) model developed by Dafermos et al. (2017; 2018). In DEFINE, endogenous ecological efficiency and technology improvement are characterised by the increase in the share of green capital. It reduces energy intensity and raises the share of renewable energy, resulting in fewer carbon emissions. Our model focuses on the green transition in the energy sector, which reduces carbon emissions per unit of energy consumption.

This paper is structured as follows: Section 2 describes the model. Section 3 presents and discusses the results of the scenarios. Lastly, Section 4 concludes with remarks.

[1] More precisely, the methodology of this paper is not fully empirical but hybrid because it does not study the empirical fact of the Chinese economy.

2.2 The Model

Energy production is driven by aggregate demand. There are two types of capital in the energy sector: capital for conventional energy production (k_{ce}) and capital for renewable energy (k_{re}). Technology progress is characterised by an increase in the share of renewable energy production capital that reduces carbon emissions per unit of energy used. The economy comprises five sectors: households, firms, banks, governments, and the rest of the world (RoW). Households and governments consume the final good according to their consumption functions. Investments are made by households (mainly through real estate acquisition), firms (in the production of final goods and energy), and governments (in the production of final goods) through their investment decisions. Banks receive deposits and issue bonds and loans to fulfil money demand, and they adjust the interest rate in accordance with an inflation-biased Taylor Rule. The private sector pays carbon taxes to the government based on their emissions, which depend on their value-added and carbon intensity. Accounting equations, such as changes in loans and bonds, and the accumulation of assets and liabilities, are modelled to guarantee stock-flow consistency. Behavioural equations, such as consumption and investment decisions, and financial instruments like saving and borrowing, follow Post-Keynesian economic theory and adjust to the econometric regression results. Prices are endogenous and depend on production costs.

2.2.1 Energy Sector

Energy consumption depends on aggregate demand,

$$ENER_t = EI_t y_t, \tag{2.1}$$

where $ENER_t$ denotes energy consumption, EI_t, energy intensity and y_t, real GDP. For simplicity, we set energy intensity exogenous. We calibrate its growth rate to our baseline scenario discussed in Section 2.3. This implies that there is an exogenous technical progress in energy efficiency or structural change moving to low-energy-intensive economic activities,

$$EI_t = EI_{t-1}(1 + g_{ei,t}),\ g_{ei,t} < 0, \tag{2.2}$$

where $g_{ei,t}$ is the energy intensity growth we are going to calibrate.

Capitals for energy production, $k_{e,t}$, are required, giving the level of energy consumption, followed by a simple technology,

$$ENER_t = e_0 k_{e,t-1}^{e_1},\ e_1 > 0. \tag{2.3}$$

We assume that energy producers' expectations are static, and future energy demand grows at the current growth rate,

$$k_{e,t} = \left(\frac{ENER_{t+1}^{exp}}{e_0}\right)^{\frac{1}{e_1}} = \left(\frac{ENER_t(1+g_{ei,t})(1+g_{y,t})}{e_0}\right)^{\frac{1}{e_1}}, \tag{2.4}$$

where $g_{y,t} = \frac{\Delta y_t}{y_{t-1}}$ denotes real GDP growth rate at period t.

There is imperfect substitution between conventional energy and renewable energy because energy users/producers need capital, i.e. facilities, to consume/produce renewable energy, and these initial capitals demand conventional energy to produce. When the capital for renewable energy production does not exist, conventional energy complements renewable energy. As renewable energy production expands, conventional energy and renewable energy become substitutes. The consumption preference/ production technology between conventional energy, CE_t, and renewable energy, RE_t, follows a Variable Elasticity of Substitution (VES) function as in Revankar (1971), suggested by Aleti and Hochman (2020),

$$\begin{aligned} ENER_t = V(CE_t,\, RE_t) = \gamma CE_t^{\omega(1-\delta\rho)}\left[RE_t + (\rho-1)CE_t\right]^{\omega\delta\rho}, \\ \gamma > 0,\ \omega > 0,\ 0 < \delta < 1,\ 0 \le \delta\rho \le 1,\ \frac{RE_t}{CE_t} > \frac{1-\rho}{1-\delta\rho}. \end{aligned} \tag{2.5}$$

The allocation between conventional energy and renewable energy is solved by an expenditure minimization problem,

$$\min_{CE_t,\, RE_t} P_{ce,t}CE_t + P_{re,t}RE_t, \tag{2.6}$$

constrained by equation (2.5). From the first-order condition, we get the price ratio between conventional energy and renewable energy equals their marginal rate of substitution,

$$\frac{P_{ce,t}}{P_{re,t}} = \frac{\frac{\partial V}{\partial CE_t}}{\frac{\partial V}{\partial RE_t}} = \beta_{re} + \alpha_{re}\frac{RE_t}{CE_t}, \tag{2.7}$$

where $\alpha_{re} = \frac{1-\delta\rho}{\delta\rho}$ and $\beta_{re} = \frac{\rho-1}{\delta\rho}$[2]. We define the share of capital for renewable energy production as $\Gamma_{k_{re},t} = \frac{k_{re,t}}{k_{e,t}}$, and assume the same energy production technology (equation 2.3) for the two types of energy, then the share of renewable energy, $\Gamma_{re,t} = \frac{RE_t}{E_t}$, follows

$$\Gamma_{re,t} = (\Gamma_{k_{re},t-1})^{e_1} = \left(\frac{k_{re,t-1}}{k_{e,t-1}}\right)^{e_1}. \tag{2.8}$$

[2]Notice that the elasticity of substitution of renewable energy with respect to conventional energy is, $\varepsilon_t = \frac{\frac{dRE_t}{RE_t}}{\frac{dCE_t}{CE_t}} = -\beta_{re}\frac{CE_t}{RE_t} - \alpha_{re}$. At the early stage, when the share of renewable energy is small, the elasticity of substitution is small, and conventional energy and renewable energy are complemented (if $RE_t \to 0$, $\varepsilon \to +\infty$, perfect complementarity). As the share of renewable energy increases, the elasticity of substitution increases to $-\alpha_{re}$ when the share of renewable energy approaches 1.

Combining equation (2.7) with equation (2.8) and using the static expectation assumption that energy suppliers believe the price ratio in the next period will follow the same as in the current period, then we obtain a function that governs the share of capital for renewable energy production,

$$\Gamma_{k_{re},t} = \left[\frac{\alpha_{re}}{\frac{P_{ce,t} + \frac{CT_t}{CE_t}}{P_{re,t}} - \beta_{re}} + 1 \right]^{-\frac{1}{e_1}}, \ \alpha_{re} > 0, \ \beta_{re} < 0. \tag{2.9}$$

Here, we have an additional element, $\frac{CT_t}{CE_t}$, the unit cost of carbon tax (CT_t) for producing conventional energy. Equation (2.9) tells us the share of capital for producing renewable energy depends on the relative cost of using conventional energy to renewable energy, $\frac{P_{ce,t}+\frac{CT_t}{CE_t}}{P_{re,t}}$. Since e_1 and α_{re} are positive when the price of conventional energy or carbon tax per unit of conventional energy increases or the price of renewable energy decreases, firms tend to allocate more capital for producing renewable energy.

We assume perfect competition among firms that produce conventional energy, and they bear a linear variable production cost, $r_{k_{ce}} k_{ce,t}$[3]. Conventional energy producers face the following profit maximization problem,

$$\begin{aligned} &\max_{k_{ce,t}} P_{ce,t+1} CE_{t+1} - r_{k_{ce}} k_{ce,t} \\ &s.t. \; CE_{t+1} = e_0 k_{ce,t}^{e_1}. \end{aligned} \tag{2.10}$$

The first-order condition gives us the conventional energy pricing,

$$P_{ce,t+1} = \frac{r_{k_{ce}}}{e_0 e_1} k_{ce,t}^{1-e_1}, \ e_1 < 1. \tag{2.11}$$

For firms producing renewable energy, they bear a fixed cost (i.e., fixed operating & management cost), F_{re}, as in Lorenczik et al. (2020), a significant share of renewable energy has zero short-run marginal cost, and the interest payment of borrowing for the construction of the facilities, $r_{k_{re},t} K_{re,t}$. The government can subsidize a proportion of the total cost, $GS_t = \gamma_{GS,t}(F_{re} + r_{k_{re},t} K_{re,t})$. Assuming they earn zero profit, the price of renewable energy equals the unit cost of renewable energy production, i.e. the levelized cost (Monnin et al., 2015),

$$P_{re,t+1} = \frac{F_{re} + r_{k_{re},t} K_{re,t} - GS_t}{e_0 k_{re,t}^{e_1}}, \tag{2.12}$$

where $r_{k_{re},t} = \mu r_{pf,t}$ with $\mu \in [0, 1]$ is the interest rate for financing investment in renewable

[3]This assumption is convenient for solving the solution. Also, Chinese energy companies are state-owned. They try to maximize the market efficiency as if in a perfect competition market, though they have high market power.

energy production. $\mu = 1$ in our baseline scenario, which means that the renewable energy producers bear the same loan rate as the other firms, $r_{pf,t}$. If commercial banks implement green finance for renewable energy firms, they ask for a lower interest rate for financing them[4]. And $K_{re,t} = \max\{P_{k,t}k_{re,t}, \frac{P_{k,t}K_{re,t-1}}{P_{k,t-1}}\}$ is the existing capital stock in value for renewable energy production.[5]

From equation (2.11) and (2.12), it is obvious that price and quantity for conventional energy production are positively correlated and negatively correlated for renewable energy (in the short-run). This is consistent with the data from 2013 to 2018 in China (see Figure 2.1). The electric price generated by coal co-moves with its quantity, falling before 2016 and rising after 2016. The rise of electric production by wind, nuclear, and solar is accompanied by a significant drop in electricity prices generated. A potential interpretation of this phenomenon is that the conventional energy industries are already well established. They do not bear fixed costs but only variable costs, such as buying coals and paying wages and rents. Thus, the marginal production decreases as the quantity increases and the price increases. However, in the short run, the renewable energy sectors bear only small variable costs in the short-run, but they face a major fixed cost for the operation & management. As the production expands, the fixed cost is amortized, and renewable energy becomes cheaper.

[4]Unfortunately, we do not find a significant effect of this shock under this setup when we run our simulations because the financing cost of renewable energy production is negligible within the simulation period. It becomes significant only when there is a sufficiently large scale of renewable energy production.

[5]$k_{re,t}$ is the capital stock in volume utilized, which is determined by the renewable energy demand. Whereas $K_{re,t}$ is the total capital stock in value for renewable energy production. It includes both the capital utilized and non-utilized.

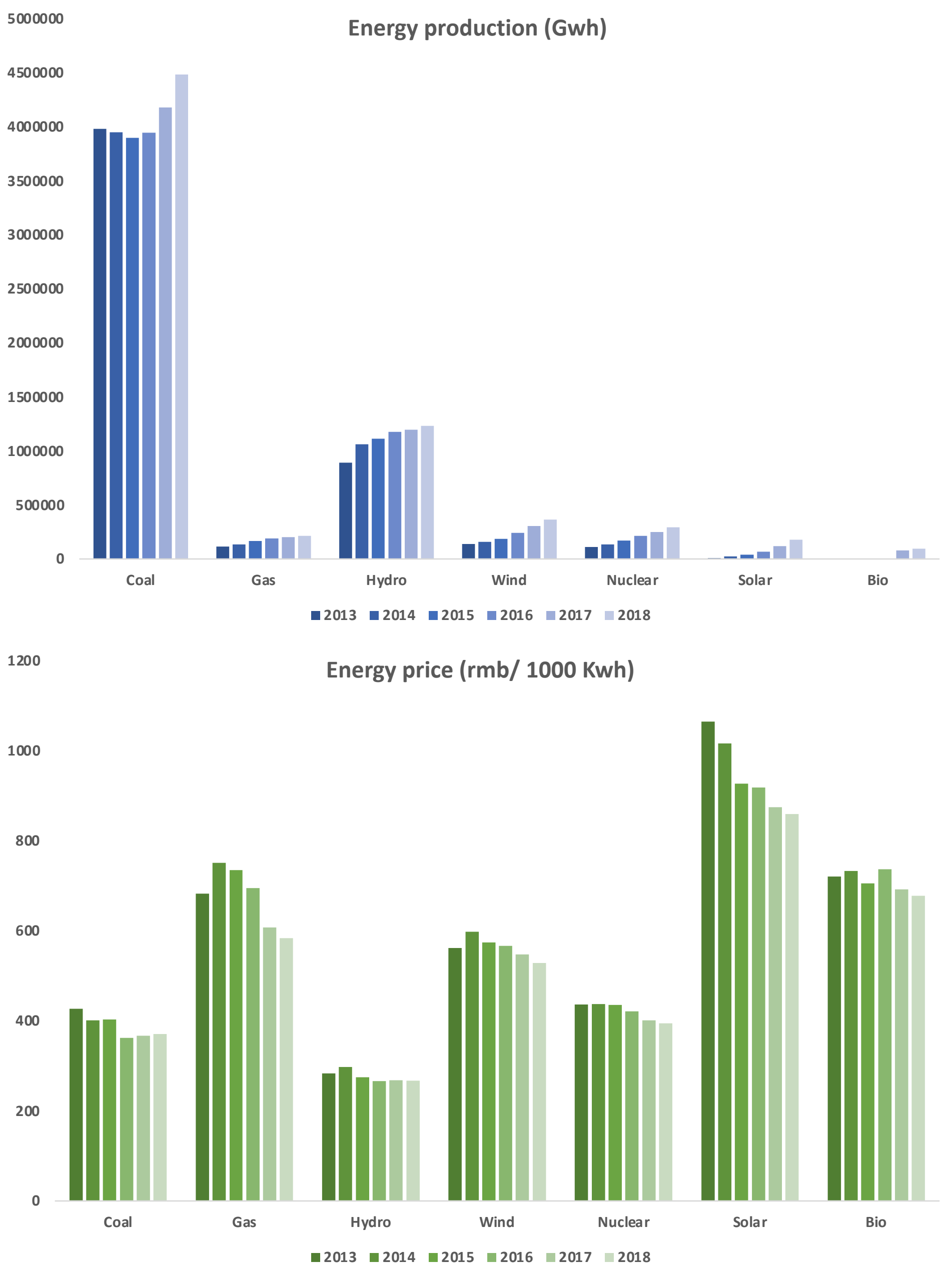


Figure 2.1: Electric production and price by energy type

Data source: China Energy Portal

Based on the above settings, we make the following propositions,

Proposition 1: *Green transition takes place as the energy sector develops.*

Proposition 2: *Without any green policy, the green transition itself would stagnate in the long run.*

Proposition 3: *Green policies accelerates green transition at the early stage.*

Proof:

For simplicity, we assume the price of firms' capital is fixed at its steady-state value, i.e.

$P_{k,t} = 1$, and a steady growth regime for the energy sector (i.e. a constant growth rate of energy consumption), so that the capital in value equals the capital in volume utilized, $K_{re,t} = k_{re,t}$. Dividing equation (2.11) by (2.12), we get the price ratio,

$$\frac{P_{ce,t+1}}{P_{re,t+1}} = \frac{r_{k_{ce}} k_{e,t}(1-\Gamma_{k_{re},t})^{1-e_1}\Gamma_{k_{re},t}^{e_1}}{e_1(F_{re} + r_{k_{re},t}k_{e,t}\Gamma_{k_{re},t})}. \tag{2.13}$$

Without considering carbon tax, i.e. $CT_t = 0$, substituting equation (2.13) with 1 lag into equation (2.9) and take the partial derivative of the share capital for renewable energy production, $\Gamma_{k_{re},t}$, with respect to the total capital for energy production, $k_{e,t-1}$, we get

$$\begin{aligned}\frac{\partial \Gamma_{k_{re},t}}{\partial k_{e,t-1}} &= \frac{\alpha_{re}\Gamma_{k_{re},t}^{1+e_1}}{e_1}\left[\frac{r_{k_{ce}}k_{e,t}(1-\Gamma_{k_{re},t})^{1-e_1}\Gamma_{k_{re},t}^{e_1}}{e_1(F_{re}+r_{k_{re},t}k_{e,t}\Gamma_{k_{re},t})} - \beta_{re}\right]^{-2}\frac{r_{k_{ce}}F_{re}(1-\Gamma_{k_{re},t-1})^{1-e_1}\Gamma_{k_{re},t-1}^{e_1}}{(F_{re}+r_{k_{re},t}k_{e,t-1}\Gamma_{k_{re},t-1})^2} \\ &> 0. \end{aligned} \tag{2.14}$$

It shows that as the energy sector expands, $k_{e,t-1}$ increases, and the share of capital for renewable energy production increases. However, in the long run, when the total capital for energy production becomes very large, $k_{e,t-1} \to \infty$, the speed of green transition slows down, $\frac{\partial \Gamma_{k_{re},t}}{\partial k_{e,t-1}} \to 0$. Figure 2.2 shows the dynamic motion of the share of renewable energy, $\Gamma_{re,t}$. It is a simulation under a constant growth rate of energy consumption with a real GDP growth of around 0.06 and an energy intensity growth of around -0.02. The horizontal axis is the number of years. As can be observed, the share of capital for renewable energy production increases over time but hits a ceiling in the long run. Without any policy intervention, e.g. carbon tax, green subsidies, green regulations or green finance, the green transition stagnates in the long run.

From equation (2.13), we take the partial derivative of the price ratio with respect to the share of capital for renewable energy production,

$$\begin{aligned}\frac{\partial \frac{P_{ce,t+1}}{P_{re,t+1}}}{\partial \Gamma_{k_{re},t}} = &\left[\left(e_1\frac{1-\Gamma_{k_{re},t}}{\Gamma_{k_{re},t}} + e_1 - 1\right)(F_{re} + r_{k_{re},t}k_{e,t}\Gamma_{k_{re},t}) - (1-\Gamma_{k_{re},t}r_{k_{re},t}k_{e,t})\right] \\ &\frac{r_{k_{ce}}k_{e,t}}{e_1(F_{re}+r_{k_{re},t}k_{e,t})^2}\left(\frac{\Gamma_{k_{re},t}}{1-\Gamma_{k_{re},t}}\right)^{e_1}. \end{aligned} \tag{2.15}$$

One can show that if $\Gamma_{k_{re}} \leq \frac{e_1 F_{re}}{F_{re}+(1-e_1)r_{k_{re},t}k_{e,t}}$, $\frac{\partial \frac{P_{ce,t+1}}{P_{re,t+1}}}{\partial \Gamma_{k_{re},t}} \geq 0$; and if $\Gamma_{k_{re}} > \frac{e_1 F_{re}}{F_{re}+(1-e_1)r_{k_{re},t}k_{e,t}}$, vice versa. The price ratio in the future, $\frac{P_{ce,t+1}}{P_{re,t+1}}$, increases as the current share of green capital, $\Gamma_{k_{re},t}$, increases when the share of green capital is not greater than this threshold,

$\frac{e_1 F_{re}}{F_{re}+(1-e_1)r_{k_{re},t}k_{e,t}}$, which depends on the elasticity of energy production with respect to capital, e_1, and the relative size of the fixed cost of renewable energy production, F_{re}, to its financing cost, $r_{k_{re},t}k_{e,t}$.

Combining with equation (2.9), we know that there is a positive feedback loop between the price ratio and the share of capital for renewable energy production when the share of renewable energy production is not fairly large. And, the larger the elasticity of energy production with respect to capital or the smaller the financing cost of renewable energy production relative to its fixed cost, the more likely green transition is sustainable.

Ignoring the carbon tax term, $\frac{CT_t}{CE_t}$, in equation (2.9), and take the second-order derivative of the share of capital for renewable energy production with respect to the price ratio,

$$\frac{\partial^2 \Gamma_{k_{re},t}}{\partial \left(\frac{P_{ce,t}}{P_{re,t}}\right)^2} = \frac{\alpha_{re}}{e_1}(\Gamma_{k_{re},t})^{1+e_1}\left(\frac{P_{ce,t}}{P_{re,t}} - \beta_{re}\right)^4 \left[\frac{1+e_1}{e_1}\alpha_{re}(\Gamma_{k_{re},t})^{e_1} - 2\left(\frac{P_{ce,t}}{P_{re,t}} - \beta_{re}\right)\right]. \quad (2.16)$$

Notice that when the price ratio is small enough, the second-order partial derivative is positive, the share of capital for renewable energy production, $\Gamma_{k_{re},t}$, is a convex function with respect to the price ratio, $\frac{P_{re,t}}{P_{re,t}}$, which depends on the lagged share of capital for renewable energy production, $\Gamma_{k_{re},t-1}$. Therefore, when the share of capital for renewable energy production is small enough, it is an increasing convex function of its own lag, and it grows exponentially over time (see Figure 2.2). Green policies can be seen as a positive shock to green transition, which lets it jump to a higher increasing speed, i.e. jumping from the flat part to a steeper part of the curve in Figure 2.2.

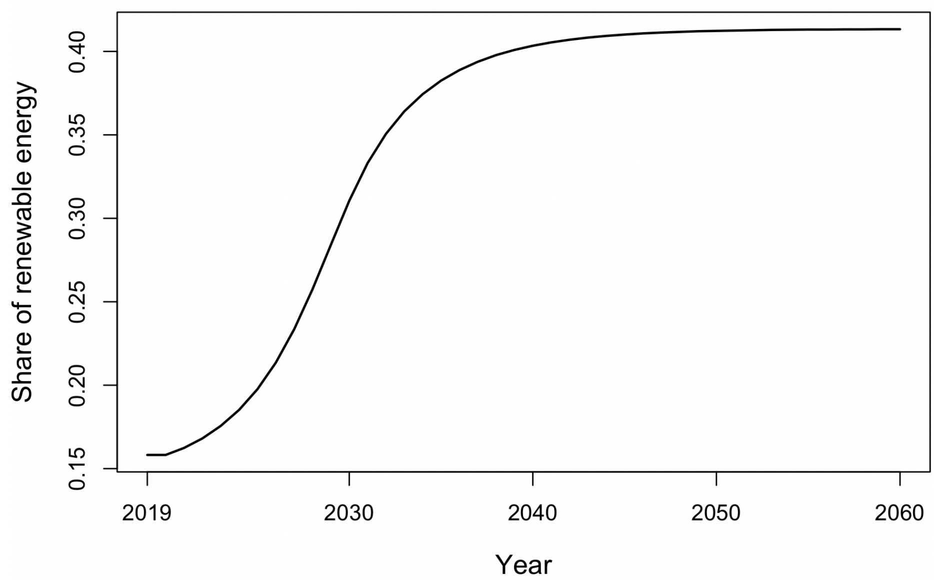


Figure 2.2: The dynamic motion of the share of green capital for renewable energy production

Note: Simulation result without a carbon tax and the impact of energy price on CPI, with $g_{y,t} = 0.05950501$ and $g_{ey,t} = -0.021913503$.

We summarize and interpret all the above. Under a steady growth regime of the energy sector, the price of renewable energy is mainly determined by the fixed O&M cost and decreases because of the scale effect. Whereas the price of conventional energy increases because of its increasing marginal cost. The cheaper the price of renewable energy to conventional energy, the more demand for renewable energy. The speed of the green transition accelerates. In the long run, as the financing cost of renewable energy production accumulates, the price of renewable energy production stops decreasing and starts increasing over time. The increasing speed of the price of both types of energy is the same because they depend on their capital for the same power, $1-e_1$. Thus, the price ratio will be fixed in the long run. And green transition stagnates.

One caveat of the proposition is that it does not consider the feedback effect of green policies on economic growth and energy sector development. For example, the negative effect of carbon taxes on economic growth will reduce the speed of capital accumulation for renewable energy production, slowing down the green transition. Nevertheless, this indirect effect would not exceed the direct effect of green policies on green transitions, which we will show in our scenario results.

2.2.2 Carbon Emissions

Carbon emission, $EMIS_t$, is determined by the ratio of emission per unit of energy consumption, θ_t, and the level of energy consumption,

$$EMIS_t = \theta_t ENER_t. \tag{2.17}$$

The ratio of emission per unit of energy consumption decreases as the share of renewable energy increases,

$$\theta_t = ce_0 + ce_1 \Gamma_{re,t},\ ce_1 < 0. \tag{2.18}$$

Carbon intensity, CI_t, by definition, is carbon emission per real GDP,

$$CI_t = \frac{EMIS_t}{y_t}. \tag{2.19}$$

Carbon tax or carbon price is paid under a uniform tax rate or price,

$$CT_t = \tau_{ct,t} EMIS_t, \tag{2.20}$$

where $\tau_{ct,t}$ is the carbon price or carbon tax rate, its value depends on the scenario that we will discuss in Section 2.3.

Since governments do not pay carbon taxes or they pay to themselves. Carbon tax received by the government is the sum of the private sector carbon tax payment,

$$CT_{g,t} = \sum_i CT_{i,t} = \tau_{ct,t} CI_t Y_{i,t},\ i = f,\ b,\ h, \tag{2.21}$$

where $i = f,\ b,\ h$ that represents firms, banks and households, respectively.

2.2.3 Macroeconomy

The economy comprises five sectors: firms, banks, governments, households, and the rest of the world (RoW) (see Table 2.2). Firms, banks, governments, and households hold fixed capital, K_{1f}, K_{1b}, K_{1g} and K_{1h}, respectively. Within firms, energy industries hold capital for energy production, K_e, and part of the capital for renewable energy production, K_{re}. Firms and governments hold inventories, K_{2f} and K_{2g}, respectively, which include both output and input inventories. Firms, banks, and governments hold other non-financial assets (NFA), K_{3f}, K_{3b}, and K_{3g}, respectively, which include patents and nationally owned construction land, etc. Banks hold international reserves, G. Households hold currencies issued by the central bank, H. Banks issue deposits, D. Sectors borrow money from each other through bonds or loans, B and L. Firms' and banks' equity on the liability side account for both equity issued and net assets, so their net worth is 0 (*China's National Balance Sheet 2018*). In this case, the net worth of firms and banks is transferred to their owners (the other sectors) through equities holding, E. Investing banks issue investment fund shares to investors, IFS. Firms and households buy insurance from banks, A_f and A_h, respectively. Other accounts payable/receivables, Z, capture the statistic misallocation and net position of all the other instruments by sectors that are not included in the model.[6] Net worth represents the net asset position of the sectors, in other words, wealth. The total wealth of the economy should equal total physical capital, aggregate fixed capitals, inventories, and other NFA, $V_g + V_h + V_r = K = K_1 + K_2 + K_3$.

Table 2.2: The national balance sheet

	Firms	Banks	Governments	Households	RoW	Total
Fixed capitals	$+K_{1f}$	$+K_{1b}$	$+K_{1g}$	$+K_h$		$+K_1$
Capitals for energy production	$+K_e$					
Capitals for renewable energy production	$+K_{re}$					
Inventories	$+K_{2f}$		$+K_{2g}$			$+K_2$
Other NFA	$+K_{3f}$	$+K_{3b}$	$+K_{3g}$			$+K_3$
International reserves		$+G$			$-G$	0
Currencies		$-H$		$+H$		0
Deposits	$+D_f$	$+D_b - D$	$+D_g$	$+D_h$		0
Bonds	$-B_f$	$+B_{ab} - B_{lb}$	$-B_g$	$+B_h$		0
Loans	$-L_f$	$+L_b$		$-L_h$	$+L_{ar} - L_{lr}$	0
Equities	$+E_{af} - E_{lf}$	$+E_{ab} - E_{lb}$	$+E_g$	$+E_h$	$+E_r$	0
Investment funds shares		$+IFS_{ab} - IFS_{lb}$	$+IFS_g$	$+IFS_h$		0
FDI	$+FDI_{out}$ $-FDI_{in}$				$+FDI_{in}$ $-FDI_{out}$	0
Insurance	$+A_f$	$-A$		$+A_h$		0
Other accounts payable/receivable (+/-)	$+Z_f$	$+Z_b$	$+Z_g$	$+Z_h$	$+Zr$	0
Networth	0	0	V_g	V_h	V_r	$+K$

Note: + denotes assets, - denotes liabilities.

The transaction flow matrix shows the transactions received and paid between sectors (see Table 2.3). Each column has to sum up to zero to satisfy the vertical consistency, meaning that transactions received and paid have to even out in every sector (e.g., household budget constraint). Each row also has to sum up to zero for horizontal consistency. It guarantees that there is no black hole; any transaction received/paid by a sector has to be paid/received by another sector.

[6] For simplicity, we drop net positions of the instruments held by sectors that are negligible in their size, for example, currencies held by sectors other than households and foreign bonds held and issued.

Table 2.3: Transaction flow matrix

	Production	Firms	Banks	Governments	Households	RoW	Total
GDP	$-Y$	$+Y_f$	$+Y_b$	$+Y_g$	$+Y_h$		0
Consumption	$+C$			$-C_g$	$-C_h$		0
Fixed capital formation	$+I_1$	$-I_{1f}$	$-I_{1b}$	$-I_{1g}$	$-I_h$		0
Change in inventories	$+I_2$	$-I_{2f}$		$-I_{2g}$			0
Acquisition less disposals of other NFA		$-I_3$		$+I_3$			0
Export	$+X$					$-X$	0
Import	$-M$					$+M$	0
Wages		$-W_f$	$-W_b$	$-W_g$	$+W - W_h$	$-W_r$	0
Net taxes on production		$-TL_f$	$-TL_b$	$+TL$	$-TL_h$		0
Carbon taxes		$-CT_f$	$-CT_b$	$+CT$	$-CT_h$		0
Interest on deposits		$+INT_{df}$	$+INT_{db}$ $-INT_d$	$+INT_{dg}$	$+INT_{dh}$		0
Interest on bonds		$-INT_{bf}$	$+INT_{brb}$ $-INT_{bpb}$	$-INT_{bg}$	$+INT_{bh}$		0
Interest on loans		$-INT_{lf}$	$+INT_{lb}$		$-INT_{lh}$	$+INT_{rr}$ $-INT_{pr}$	0
Distributed income of Corporations		$+DIV_{rf}$ $-DIV_{pf}$	$+DIV_{rb}$ $-DIV_{pb}$	$+DIV_g$	$+DIV_h$	$+DIV_{rr}$	0
Other income from properties		$+OIP_f$	$-OIP_b$	$+OIP_g$	$+OIP_h$	$-OIP_r$	0
Taxes on income and wealth		$-T_f$	$-T_b$	$+T$	$-T_h$		0
Social contributions				$+SC$	$-SC$		0
Social benefits				$-SB$	$+SB$		0
Other current transfers		$-O_f$	$+O_b$	$+O_g$	$-O_h$	$-O_r$	0
Capital transfers		$+TRK$		$-TRK$			0
Green subsidies		$+GS$		$-GS$			0
International reserves			$-\Delta G$			$+\Delta G$	0
Currencies			$+\Delta H$		$-\Delta H$		0
Deposits		$-\Delta D_f$	$-\Delta D_b$ $+\Delta D$	$-\Delta D_g$	$-\Delta D_h$		0
Bonds		$+\Delta B_f$	$-\Delta B_{ab}$ $+\Delta B_{lb}$	$+\Delta B_g$	$-\Delta B_h$		0
Loans		$+\Delta L_f$	$-\Delta L_b$		$+\Delta L_h$	$-\Delta L_{ar}$ $+\Delta L_{lr}$	0
Investment fund shares			$-\Delta IFS_{ab}$ $+\Delta IFS_{lb}$	$-\Delta IFS_g$	$-\Delta IFS_h$		0
FDI inward		$+\Delta FDI_{in}$				$-\Delta FDI_{in}$	0
FDI outward		$-\Delta FDI_{out}$				$+\Delta FDI_{out}$	0
Insurance		$-\Delta A_f$	$+\Delta A$		$-\Delta A_h$		0
Other account payable /receivables (+/-)		$-\Delta Z_f$	$-\Delta Z_b$	$-\Delta Z_g$	$-\Delta Z_h$	$-\Delta Z_r$	0
Total	0	0	0	0	0	0	0

Note: + denotes transactions received, - denotes transactions paid. According to the National Bureau of Statistics of China, acquisition less disposals of other NFA are mainly transfers from firms to governments, and there are no data for banks, which are inconsistent with the balance sheet.

Notice that firms' and banks' equity on the liability side account for both equity issued and net assets, so their net worth is 0 (*China's National Balance Sheet 2018*, see Table 2.2). Equity flows reported by *National Bureau of Statistics* of China are 0 (see Table 2.3). Therefore, we have the following treatment for equity liabilities of firms and banks, i) the value of firms' and banks' equity on the liability side of the balance sheet satisfied the following conditions to guarantee their net worth is zero,

$$E_{lf,t} = K_{1f,t} + K_{2f,t} + K_{3f,t} + D_{f,t} - B_{f,t} - L_{f,t} + E_{af,t} + FDI_{out,t} - FDI_{in,t} + A_{f,t} + Z_{f,t} \quad (V_{f,t} = 0), \quad (2.22)$$

$$E_{lb,t} = K_{1b,t} + K_{3b,t} + G_t - H_t + D_{b,t} - D_t + B_{ab,t} - B_{lb,t} + L_{b,t} + E_{ab,t} + IFS_{ab,t} - IFS_{lb,t} - A_t + Z_{b,t} \quad (V_b = 0), \quad (2.23)$$

ii) since there are no equity flows, the revaluation effect accounts for all the changes in value,

$$REV_{e_{lj},t} = E_{lj,t} - E_{lj,t-1},\ j = b, f, \quad (2.24)$$

iii) we derive the implicit equity price indices,[7]

$$P_{e_{lj},t} = P_{e_{lj},t-1} \frac{REV_{e_{lj},t}}{E_{lj,t-1}},\ j = b, f. \quad (2.25)$$

The following subsections present the main equations of the sectors. Behaviour equations follow the standard Post-Keynesian macroeconomic theory (e.g. Godley and Lavoie, 2006) and are pragmatically verified by econometrics employing historical annual data from 2000 to 2019 (National Bureau of Statistics of China, China's National Balance Sheet and World Bank).[8] Other simplified behaviour equations and accounting equations are shown in detail in the Appendix.

Final good equilibrium

Final good production, Y_t, fulfills the aggregate demand, which consists of households consumption, $C_{h,t}$, government consumption, $C_{g,t}$, fixed capital formation by firms, banks and governments, $I_{1f,t}$, $I_{1b,t}$ and $I_{1g,t}$, respectively, fixed capital formation by households (mainly dwelling acquisition), $I_{h,t}$, change in inventories by firms and governments, $I_{2f,t}$ and $I_{2g,t}$, and net exports, $X_t - M_t$,

$$Y_t = C_{h,t} + C_{g,t} + I_{1f,t} + I_{1b,t} + I_{1g,t} + I_{h,t} + I_{2f,t} + I_{2g,t} + X_t - M_t. \quad (2.26)$$

[7] We have tried using the stock market price index to estimate equity flows, but it would increase the mismatch of net financial investment between the real account and financial account in the transaction-flow matrix.

[8] Our method is pragmatic in the sense that we try to follow economic theories as closely as possible but drop the determinants in the behaviour equations that are not statistically significant.

Aggregate demand in real term (in volume),

$$y_t = c_{h,t} + c_{g,t} + i_{1f,t} + i_{1b,t} + i_{1g,t} + i_{h,t} + i_{2f,t} + i_{2g,t} + x_t - m_t, \tag{2.27}$$

where $c_{h,t} = \frac{C_{h,t}}{P_{c,t}}$, $c_{g,t} = \frac{C_{g,t}}{P_{c,t}}$, $i_{f,t} = \frac{I_{1f,t}}{P_{k_1,t}}$, $i_{1b,t} = \frac{I_{1b,t}}{P_{k_1,t}}$, $i_{1g,t} = \frac{I_{1g,t}}{P_{k_1,t}}$, $i_{h,t} = \frac{I_{h,t}}{P_{k_h,t}}$, $i_{2f,t} = \frac{I_{2f,t}}{P_{k_{2f},t}}$, $i_{2g,t} = \frac{I_{2g,t}}{P_{k_{2g},t}}$, $x_t = \frac{X_t}{P_{x,t}}$ and $m_t = \frac{M_t}{P_{m,t}}$ are the aggregate demand components in volume.[9] $P_{c,t}$ is the consumer price index (CPI). $P_{k_1,t}$ is the general capital price index. $P_{k_h,t}$ is the capital price index of households. $P_{k_{2f},t}$ and $P_{k_{2g},t}$ are the price of inventories held by firms and governments, respectively. Lastly, $P_{x,t}$ and $P_{m,t}$ are the export and import price index, respectively. By definition, then, GDP deflator is $P_{y,t} = \frac{Y_t}{y_t}$.

Production technology follows a Leontief production function, which gives us the supply constraint of the economy,

$$y_t \leq \min\{\omega_0 y_{t-1}^{\omega_1} k_{1f,t}^{\omega_2} k_{1f,t-1}^{\omega_3} fdi_{in,t-1}^{\omega_4},\ y_{N,t} LF_t\}, \tag{2.28}$$

where $\omega_0 = e^{\frac{\beta_2\beta_3-\beta_0}{\beta_1}}$, $\omega_1 = 1 + \frac{\beta_2\beta_4}{\beta_1}$, $\omega_2 = \frac{1}{\beta_1}$, $\omega_3 = -\frac{1+\beta_2}{\beta_1}$, and $\omega_4 = \frac{\beta_2\beta_5}{\beta_1}$. The first term on the right-hand side of equation (2.28) is the potential real GDP produced by capital, where k_{1f} is firms‘ fixed capital in volume, and fdi_{in} inward FDI stock in volume. β_0 denotes autonomous utilized fixed capital growth. $\beta_1 > 0$ is the short-run elasticity of firms' fixed capital utilized to real GDP. $-1 < \beta_2 < 0$ is the parameter of firms' fixed capital utilized long-run correction. β_3 is the autonomous firms' fixed capital utilized in logarithm. $\beta_4 > 1$ is the long-run elasticity of firms' fixed capital utilized to real GDP, which shows a decreasing marginal productivity of capital in the long run.. And $\beta_5 < 0$ captures the technology spillover effect of inward FDI on capital productivity (Cheung & Ping, 2004).[10] The second term is the potential real GDP by labour, where $y_{N,t}$ denotes labour productivity, measured in real GDP per labour, referring to Reati (2001), and LF_t denotes labour force. Labour productivity depends on exogenous productivity improvement over time (i.e. human capital accumulation) and the technology spillover from inward FDI (Cheung & Ping, 2004),

$$\Delta \ln y_{N,t} = y_{n_0} + y_{n_1} \Delta \ln fdi_{in,t} + y_{n_2}[\ln y_{N,t-1} - y_{n_3} - y_{n_4} \ln fdi_{in,t-1} - y_{n_5}(t-1)], \tag{2.30}$$

where y_{n0} is the short-run autonomous labour productivity growth, $y_{n1} > 0$ captures the short-

[9] Capital letters denote variables in value (nominal term), and small letters denote variables in volume (real term).

[10] The first term of equation (2.28) comes from this estimation,

$$\Delta \ln (k_{1f,t} U_{k,t}) = \beta_0 + \beta_1 \Delta \ln y_t + \beta_2[\ln (k_{1f,t-1} U_{k,t-1}) - \beta_3 - \beta_4 \ln y_{t-1} - \beta_5 \ln fdi_{in,t-1}], \tag{2.29}$$

where $U_{k,t}$ denotes capacity utilization.

run technology spillover effect of inward FDI on labour productivity, $-1 < y_{n2} < 0$ is the parameter of labour productivity long-run correction, y_{n3} is the initial labour productivity level in logarithm, $y_{n4} > 0$ captures the long-run technology spillover effect of inward FDI on labour productivity and $y_{n5} > 0$ captures the exogenous labour productivity improvement over time.

If the economy hits the supply constraints, firms' investment would be constrained by residual savings, as in supply-led models (e.g. Solow, 1956),

$$i_{1f,t} = y_t - c_{h,t} - c_{g,t} - i_{1b,t} - i_{1g,t} - i_{h,t} - i_{2f,t} - i_{2g,t} - x_t + m_t. \tag{2.31}$$

The capacity utilisation of the firms' fixed capital, $U_{k,t}$, is derived based on the capital productivity from equation (2.28),

$$U_{k,t} = \frac{1}{k_{1f,t}} \left[\frac{y_t}{\omega_0 y_{t-1}^{\omega_1} (k_{1f,t-1} U_{k,t-1})^{\omega_3} fdi_{in,t-1}^{\omega_4}} \right]^{\frac{1}{\omega_2}}. \tag{2.32}$$

Labour market

Following Keynes (1937), the employment level is determined by aggregate demand. Then, employment in our model, N_t, is simply real GDP over labour productivity,

$$N_t = \frac{y_t}{y_{N,t}}. \tag{2.33}$$

Real wage, w_t, is determined by labour productivity,

$$\Delta \ln w_t = w_0 + w_1 \Delta \ln y_{N,t},\ w_1 > 0, \tag{2.34}$$

where w_0 is the autonomous real wage growth, and w_1 denotes the elasticity of real wage growth to labour productivity growth[11].

The total wage bill, W_t, equals the nominal wage times labour,

$$W_t = P_{y,t} w_t N_t, \tag{2.35}$$

where $P_{y,t} w_t$ is the nominal wage.

Unit labour cost, by definition, is the total wage bill divided by real GDP,

$$ULC_t = \frac{W_t}{y_t}. \tag{2.36}$$

[11] We did not find any statistical evidence of a significant effect of unemployment on real wage from our data. It suggests a flat Philips curve from 2000 to 2021 in China.

Prices

Producers fulfill aggregate demand but set their prices based on their cost of production. The consumer price index (CPI), $P_{c,t}$, is determined by unit labour cost, ULC_{t-1}, and the price of aggregate energy, $P_{ener,t}$ (see Appendix), which captures the Microeconomic rebound effect (Sorrell and Dimitropoulos 2008),

$$\Delta \ln P_{c,t} = p_{c0} + p_{c1} \Delta \ln ULC_{t-1} + p_{c2}(\ln P_{c,t-1} - p_{c3} - p_{c4} \ln ULC_{t-1} - p_{c5} \ln P_{ener,t-1}), \quad (2.37)$$

where $p_{c0} > 0$ is the long-run mark-up, $p_{c1} > 0$ is the short-run elasticity of CPI to unit labour cost, $-1 < p_{c2} < 0$ is the coefficient of long-run correction, $p_{c3} > 0$ is the long-run mark-up, $p_{c4} > 0$ is the long-run elasticity of CPI to unit labour cost, and $p_{c5} > 0$ captures the Microeconomic rebound effect.[12]

The price of productive fixed capital depends on unit labour cost, CPI and capacity utilization (Yoo 1995),

$$\Delta \ln P_{k1,t} = \alpha_0 + \alpha_1 \Delta \ln P_{c,t-1} + \alpha_2(\ln P_{k1,t-1} - \alpha_3 \ln ULC_{t-1} - \alpha_4 U_{k,t-1}), \quad (2.38)$$

where α_0 is the short-run markup, $\alpha_1 > 0$ is the short-run elasticity of the price of fixed capital to CPI, $0 < \alpha_2 < 1$ is the long-run correction parameter, $\alpha_3 > 0$ is the long-run elasticity of the price of fixed capital to unit labour cost and $\alpha_4 > 0$ is the long-run elasticity of the price of fixed capital to capacity utilization.

The price of housing correlates to CPI,

$$\Delta \ln P_{k_h,t} = p_{kh1} \Delta \ln P_{c,t}, \quad (2.39)$$

where $p_{kh1} > 0$ is the elasticity of housing price growth to inflation.[13]

Exports' price is determined by unit labour cost,

$$\Delta \ln P_{x,t} = p_{x1} \Delta \ln ULC_{t-1}, \quad (2.40)$$

where $p_{x1} > 0$ denotes the elasticity of exports' price growth to unit labour cost growth.

[12] The lag for $\Delta \ln ULC_{t-1}$ is to prevent simultaneity in the model, the coefficient are estimated without lag. Same reason for other determinants we show in the other parts of the paper.

[13] We have tried a series of regressors for the price of housing, such as housing acquisition, capacity utilization for demand components, and unit labour cost, interest rates for supply components, etc. Only inflation is a significant regressor for housing price growth. Equation (2.37) and (2.39) build an indirect path for unit labour cost and energy price to the price of housing through CPI.

GDP deflator, by definition, is GDP in value over GDP in volume,

$$P_{y,t} = \frac{Y_t}{y_t}. \tag{2.41}$$

For simplicity, we assume the price of inventories, other non-financial assets and imports equal to GDP deflator in one lag, i.e. $P_{i,t} = P_{y,t-1}$, where $i = k_{2f}, k_{2g}, k_3, m$ denote firms' inventories, governments' inventories, other non-financial assets and imports, respectively.

Households

Households earn revenues, wages, interest from deposits, dividends, other income from properties, and social benefits. They pay taxes, interest on loans, and social contributions.

Households' consumption depends on their consumption level in the past (habit formation), their disposable income deflated by consumption price, $\frac{YD_{t-1}}{P_{c,t-1}}$ (income effect),

$$\Delta \ln c_{h,t} = c_0 + c_1 \Delta \ln \frac{YD_{t-1}}{P_{c,t-1}} + c_2 \left(\ln c_{h,t-1} - c_3 \ln c_{h,t-2} - c_4 \ln \frac{YD_{t-1}}{P_{c,t-1}} \right), \tag{2.42}$$

where c_0 denotes the short-run autonomous consumption, $c_1 > 0$ is the short-run income effect, c_2 is the long-run correction parameter, $c_3 > 0$ captures consumption habit formation and $c_4 > 0$ is the long-run income effect.

Households' fixed capital formation (housing demand) depends on net worth deflated by the price of housing, $\frac{V_{h,t-1}}{P_{k_h,t-1}}$,

$$\Delta \ln i_{h,t} = i_{h0} + i_{h1} \Delta \ln \frac{V_{h,t-1}}{P_{k_h,t-1}}, \tag{2.43}$$

where i_{h0} is the autonomous housing demand growth and $i_{h1} > 0$ captures the wealth effect.

Financial assets and liabilities follow Tobin's portfolio theory (Tobin, 1982) as in Godley and Lavoie, 2006. Households have liquidity preferences on currencies. They keep a proportion of their net worth as cash in hand and hold more when income increases,

$$\frac{H_t}{V_{h,t-1}} = h_0 + h_1 \frac{YD_{t-1}}{V_{h,t-1}}, \tag{2.44}$$

where $h_0 > 0$ is the liquidity preference for currencies and $h_1 > 0$ captures the income effect.

Households also have a liquidity preference for deposits. They save proportionally of net worth as deposits and earn real interest at a rate of $r_{rh,t} - \pi_{y,t-1}$, where $r_{rh,t}$ is the rate of interest received by households, and $\pi_{y,t-1}$ denotes GDP deflator inflation. But they bear an opportunity cost of not repaying loans at a rate of $r_{ph,t} - \pi_{y,t-1}$, where $r_{ph,t}$ is the rate of interest paid by households,

$$\frac{D_{h,t}}{V_{h,t-1}} = d_{h0} + d_{h1}(r_{rh,t} - \pi_{y,t-1}) + d_{h2}(r_{ph,t} - \pi_{y,t-1}), \tag{2.45}$$

where $d_{h0} > 0$ is the liquidity preference for deposits. $d_{h1} > 0$ is the sensitivity of household deposits to real interest received, and $d_{h2} < 0$ is the sensitivity of household deposits to real interest received.

Households invest in bonds to earn interest but bear the opportunity cost of not repaying loans and not investing in investment fund shares at a rate of $\frac{DIV_{h,t}+REV_{e_h,t-1}+REV_{ifs_h,t}}{E_{h,t-1}+IFS_{h,t-1}} - \pi_{y,t-1}$, where $REV_{e_h,t-1}$ is the revaluation effect of households' equity, and $REV_{ifs_h,t}$ is the revaluation effect of households' investment fund shares.

$$\frac{B_{h,t}}{V_{h,t-1}} = b_{h0} + b_{h1}(r_{rh,t} - \pi_{y,t-1}) + b_{h2}(r_{ph,t} - \pi_{y,t-1}) + b_{h3}\left(\frac{DIV_{h,t} + REV_{e_h,t-1} + REV_{ifs_h,t}}{E_{h,t-1} + IFS_{h,t-1}} - \pi_{y,t-1}\right), \tag{2.46}$$

where b_{h0} is the preference for bonds, $b_{h1} > 0$ is the sensitivity of households' bonds to real interest received, $b_{h2} < 0$ is the sensitivity of households' bonds to real interest paid and $b_{h3} < 0$ is the sensitivity of households' bonds to real equity and investment fund shares return.

Households invest in investment fund shares with a proportion of their net worth. Their behaviour performs auto-correlation, chasing the winner and cutting the loser. And they would invest with a higher ratio when they have a lower income-wealth ratio.

$$\frac{IFS_{h,t}}{V_{h,t-1}} = ifs_{h0} + ifs_{h1}\frac{IFS_{h,t-1}}{V_{h,t-1}} + ifs_{h2}\frac{YD_{t-1}}{V_{h,t-1}}, \tag{2.47}$$

where ifs_{h0} is the preference for investment fund shares, $ifs_{h1} > 0$ is the one-lag auto-correlation coefficient, and ifs_{h2} is the sensitivity of household investment fund shares to disposable income.

Households buy insurance at a proportion of their net worth but bear the opportunity cost of not buying investment fund shares and less when their income increases (inferior good),

$$\frac{A_{h,t}}{V_{h,t-1}} = a_{h0} + a_{h1}\left(\frac{DIV_{h,t} + REV_{e_h,t-1} + REV_{ifs_h,t}}{E_{h,t-1} + IFS_{h,t-1}} - \pi_{y,t-1}\right) + a_{h2}\frac{YD_{t-1}}{V_{h,t-1}}, \tag{2.48}$$

where a_{h0} is the preference for insurance, $a_{h1} < 0$ is the sensitivity of households insurance to real equity and investment fund shares return, $a_{h2} < 0$ is the sensitivity of households insurance to disposable income.

Firms

Firms earn revenue from production, interest from deposits, and dividends from equity ownership. They also pay taxes, wages, and interest on debt and distribute profit through dividends.

Firms fixed capital formation rate, $\frac{\Delta k_{1f,t}}{k_{1f,t-1}}$, is driven by the gross profit rate, $\frac{\Pi_{f,t-1}-INT_{pf,t-1}}{P_{k1,t}k_{1f,t-1}}$ (*Kaleckian*), and capacity utilization (*Sraffian*),

$$\frac{\Delta k_{1f,t}}{k_{1f,t-1}} = i_{f0} + i_{f1}\frac{\Pi_{f,t-1} - INT_{pf,t-1}}{P_{k_1,t}k_{1f,t-1}} + i_{f2}U_{k,t-1}, \tag{2.49}$$

where i_{f0} is the autonomous capital formation rate, $i_{f1} > 0$ is the sensitivity to the net profit rate, and $i_{f2} > 0$ is the sensitivity to capacity utilization.

Firms hold deposits as a proportion of their net worth, i.e. $E_{lf,t-1}$, in need of operation expenditure. They increase savings in deposits as the real interest they receive increases, $r_{rf,t} - \pi_{y,t-1}$, and their net cash flow increases, $\frac{FP_{t-1}}{E_{lf,t-1}}$.

$$\frac{D_{f,t}}{E_{lf,t-1}} = d_{f0} + d_{f1}(r_{rf,t} - \pi_{y,t-1}) + d_{f2}\frac{FP_{t-1}}{E_{lf,t-1}}, \tag{2.50}$$

where $d_{f0} > 0$ denotes the liquidity preference of firms, $d_{f1} > 0$ is the sensitivity of firms' deposits to the real rate of interest received, and $d_{f2} > 0$ is the sensitivity of firms' deposits to net disposable income.

Firms issue bonds to finance and less when they have sufficient cash flow,

$$\frac{B_{f,t}}{E_{lf,t-1}} = b_{f0} + b_{f1}\frac{FP_{t-1}}{E_{lf,t-1}}, \tag{2.51}$$

where $b_{f0} > 0$ is the preference for issuing bonds and $b_{f1} < 0$ is the sensitivity of firms' bonds to net disposable income.

Firms hold other firms' equities as parent companies. The price of equities held by firms depends on the price of equities other firms issued,[14]

$$P_{e_{af},t} = P_{e_{lf},t}. \tag{2.52}$$

Firms would invest abroad in the form of outward foreign direct investment (FDI) when domestic investment is less profitable,

$$\frac{FDI_{out,t}}{E_{lf,t-1}} = fdi_{out0} + fdi_{out1}\frac{\Pi_{f,t-1} - INT_{pf,t-1}}{P_{k1,t}k_{1f,t-1}}, \tag{2.53}$$

[14]It comes from the empirical results, the implicit price growth of firms' equity held can only be statically explained by the price of firms equity issued.

where $fdi_{out0} > 0$ is the preference for outward FDI and $fid_{out1} < 0$ is the sensitivity of outward FDI to the net profit rate of domestic investment.

Firms buy insurance but less when they receive sufficient cash flows,

$$\frac{A_{f,t}}{E_{lf,t-1}} = a_{f0} + a_{f1} + \frac{FP_{t-1}}{E_{lf,t-1}}, \tag{2.54}$$

where $a_{f0} > 0$ is the preference for insurance and $a_{f1} < 0$ is the sensitivity of firms' insurance to net disposable income.

Banks

Banks earn revenue and interest from lending. They also pay wages, taxes, interest on deposits and inter-banks lending, dividends, and insurance indemnity. As the closing sector of the model, the vertical consistency of the banks' transaction flows, i.e. budget constraint is inherently fulfilled.

The central bank is included in the banking sector and runs an inflation-biased Taylor rule monetary policy by adjusting the 10-year government bond yield and targeting housing prices, in addition,

$$r_{10,t} = r_0 + (1 - r_1 - r_2)r_{10,t-1} + r_1 \Delta \ln P_{k_h,t} + r_2 \pi_t, \tag{2.55}$$

where $\pi_t = \frac{\Delta P_{c,t}}{P_{c,t-1}}$ denotes the CPI inflation, $r_0 > 0$ is the 10-year government bond yield lower bound, $r_1 > 0$ is the sensitivity of 10-year government bond yield to housing price growth and $r_2 > 0$ is the sensitivity of 10-year government bond yield to CPI inflation.

The banks' rate of interest received, i.e. lending rate, is positively correlated to capacity utilization (counter-cyclical),

$$\ln r_{rb,t} = r_{rb0} + r_{rb1} U_{k,t-1}, \tag{2.56}$$

where r_{rb0} is the lower bound in logarithm and $r_{rb1} > 0$ is the semi-elasticity of banks' rate of interest received to capacity utilization.

Firms' rate of interest paid comoves with banks' rate of interest received.[15]

$$r_{pf,t} = r_{pf0} + (1 - r_{pf1})r_{pf,t-1} + r_{pf1} r_{rb,t}, \tag{2.57}$$

where $r_{pf0} > 0$ is the interest rate premium and $r_{pf1} > 0$ is the sensitivity of firms' rate of interest paid to banks' rate of interest received.

Other domestic interest rates positively correlate to 10-year government bond yield (see

[15] The largest proportion of interest received by banks is paid by firms in terms of bonds and loan interest.

Appendix).

Banks' fixed capital formation rate, $\frac{\Delta k_{1b,t}}{k_{1b,t-1}}$, depends on banks' net profit rate, $\frac{BP_{g,t-1}+DIV_{pb,t-1}}{P_{k_1,t}k_{1b,t-1}}$,

$$\frac{\Delta k_{1b,t}}{k_{1b,t-1}} = i_{b0} + i_{b1}\frac{BP_{g,t-1} + DIV_{pb,t-1}}{P_{k_1,t}k_{1b,t-1}}, \tag{2.58}$$

where i_{b0} is banks' autonomous fixed capital formation rate and $i_{b1} > 0$ is the sensitivity of banks' fixed capital formation rate to net profit rate.

Banks have liquidity preference for holding deposits and increase their holding if the real rate of interest received increases, $r_{rb,t} - \pi_{y,t-1}$,

$$\frac{D_{b,t}}{E_{lb,t-1}} = d_{b0} + d_{b1}(r_{rb,t} - \pi_{y,t-1}), \tag{2.59}$$

where $d_{b0} > 0$ is banks' liquidity preference for holding deposits and $d_{b1} > 0$ is the sensitivity of banks' deposits to the real rate of interest received.

Banks issue bonds in case of shortage of funds because banks face liquidity risk by holding long-term assets, e.g. firm loans, and short-term debts, e.g. household deposits, and would issue less if the real rate of interest paid rises, $r_{pb,t} - \pi_{y,t-1}$,

$$\frac{B_{lb,t}}{E_{lb,t-1}} = b_{lb0} + b_{lb1}(r_{pb,t} - \pi_{y,t-1}), \tag{2.60}$$

where $b_{lb0>0}$ is banks' liquidity demand for issuing bonds and $b_{lb1} < 0$ is the sensitivity of banks' bonds issued to the real rate of interest paid.

Banks, including financial corporations, would invest in investment fund shares for risky profits, and they would invest more if it's more profitable, $\frac{DIV_{rb,t}+REV_{e_{ab},t}+REV_{ifs_{ab},t}}{E_{ab,t-1}+IFS_{ab,t-1}} + \pi_{y,t-1}$, and less when they have sufficient cash flows, $\frac{BP_{t-1}}{E_{lb,t-1}}$,

$$\frac{IFS_{ab,t}}{E_{lb,t-1}} = ifs_{ab0} + ifs_{ab1}(\frac{DIV_{rb,t} + REV_{e_{ab},t} + REV_{ifs_{ab},t}}{E_{ab,t-1} + IFS_{ab,t-1}} + \pi_{y,t-1}) + ifs_{ab2}\frac{BP_{t-1}}{E_{lb,t-1}}, \tag{2.61}$$

where $ifs_{ab0} > 0$ is the preference for holding investment fund shares, $ifs_{ab1} > 0$ is the sensitivity of banks' investment fund shares held to the real rate of investment fund shares return, and $ifs_{ab2} < 0$ is the sensitivity of banks' investment fund shares held to net disposable income.

Governments

Governments receive taxes, including carbon taxes, interest rates from deposits, dividends and social contributions. They pay wages, interest for bonds and social benefits.

Governments' consumption consists of goods and services provided to society. It is procyclical because when economic activity increases, demand for public goods and services increases. For simplicity, we assume it is proportional to real output,

$$c_{g,t} = c_{g0} y_{t-1}. \tag{2.62}$$

Similarly, we also assume government investments are proportional to real output,

$$i_{g,t} = i_{g0} y_{t-1}. \tag{2.63}$$

The Chinese commercial banks are mainly state-owned. The price of government equities held depends largely on the price of banks' equities issued,

$$\Delta \ln P_{e_g,t} = p_{eg0} + p_{eg1}(\ln P_{e_g,t-1} - p_{eg2} - p_{eg3} \ln P_{e_{lb},t-1}), \tag{2.64}$$

where $p_{eg0} > 0$ is the return premium of government equities, $0 < p_{eg1} < 1$ is the long-term correction of the price of government equities, p_{eg2} is the price premium of government equities in logarithm, $p_{eg3} > 0$ is the elasticity of the price of governments' equities held to the price of banks' equities issued.

The rest of the world

The rest of the world demands export goods, supplies import goods, and other current transfers and financial transfers between the domestic sectors.

The nominal effective exchange rate (rise = appreciation), XR_t, follows the uncovered interest parity, which depends on the 10-year government yield, $r_{10,t}$ and federal funds rate, FFR_t,

$$\Delta \ln XR_t = xr_0 + xr_1 \ln \left(\frac{1 + r_{10,t}}{1 + FFR_t}, \right) \tag{2.65}$$

where $xr_0 < 0$ is the preference premium for domestic currencies compared to foreign currencies, $xr_1 > 0$ is the elasticity of nominal effective exchange rate to interest parity.

The federal funds rate, ffr_t and foreign GDP (nominated in US dollar), $Y_{r,t}$, are exogenous in the model and calibrated for the baseline scenario we would discuss in Section 2.3.

Due to the conversion of currencies, the rate of interest paid by the foreign sector includes the change in exchange rate within the maturity,

$$r_{pr,t} = r_{pr0} + (1 - r_{pr1} - r_{pr2}) r_{pr,t-1} + r_{pr1} \Delta \ln XR_t + r_{pr2} FFR_t, \tag{2.66}$$

where $r_{pr0} > 0$ is the interest rate premium, $r_{pr1} < 0$ is the sensitivity of the interest rate paid by the foreign sector to nominal effective exchange rate growth, $r_{pr2} > 0$ is the sensitivity to federal funds rate.

Equivalently, the rate of interest received by the foreign sector also includes the change in exchange rate,

$$r_{rr,t} = r_{rr0} + (1 - r_{rr1})r_{rr,t-1} + r_{rr1}\Delta \ln XR_t, \tag{2.67}$$

where $r_{rr0} > 0$ is the interest rate lower bound and $r_{rr1} > 0$ is the sensitivity of the interest rate received by the foreign sector to nominal effective exchange rate growth.

Exports depend on foreign demand converted into domestic currencies and deflated by export price, $\frac{Y_{r,t}}{P_{x,t}XR_t}$,

$$\Delta \ln x_t = x_0 + x_1 \Delta \ln \frac{Y_{r,t}}{P_{x,t}XR_t} + x_2 \left(\ln x_{t-1} - x_3 - x_4 \ln \frac{Y_{r,t-1}}{P_{x,t-1}XR_{t-1}} \right), \tag{2.68}$$

where x_0 is the short-run autonomous export demand, $x_1 > 0$ is the short-run elasticity of export to foreign demand, $-1 < x_2 < 0$ is the export long-run correction parameter, $x_3 > 0$ is the long-run autonomous export demand in logarithm, and $x_4 > 0$ is the long-run export demand elasticity.

For simplicity, imports are proportional to real GDP,

$$m_t = m_{0,t}y_{t-1}, \tag{2.69}$$

where $m_{0,t}$ is a moving parameter to calibrate the real GDP of our baseline scenario.

The foreign sectors lend loans to the domestic sectors depending on the rate of interest received, the higher the return, the more they supply,

$$\frac{\Delta L_{ar,t}}{L_{ar,t-1}} = l_{ar0} + l_{ar1}r_{rr,t}, \tag{2.70}$$

where l_{ar0} is the foreign loan autonomous accumulation rate and $l_{ar1} > 0$ is the sensitivity of foreign loan lending to the rate of interest received by the foreign sector.

The foreign sectors hold equities in both the real sector and the financial sector. The price of the rest of the world equity held, $P_{e_r,t}$, depends on the price of equities issued by firms and banks,

$$\Delta \ln P_{e_r,t} = p_{er0} + p_{er1}\Delta \ln P_{e_{lb},t-1} + p_{er2}(\ln P_{e_r,t-1} - p_{er3} \ln P_{e_{lf},t-1}), \tag{2.71}$$

where p_{er0} is the return premium of the rest of the world equity held, $p_{er1} > 0$ is the short-run elasticity of the price of the rest of the world equities held to the price of banks equity issued, $-1 < p_{er2} < 0$ is the long-run correction parameter, $p_{er3} > 0$ is the long-run elasticity of the price the rest of the world equities held to the price of firms equities issued.

Inward FDI depends on the domestic firms' gross profit, $\frac{\Pi_{f,t-1}}{P_{k_1,t}k_{1f,t-1}}$, with more domestic economic growth, cheaper labour, lower taxes, and cheaper fixed asset prices, the domestic sector will attract more inward FDI,

$$\frac{\Delta FDI_{in,t}}{FDI_{in,t-1}} = fdi_{in0} + fdi_{in1}\frac{\Pi_{f,t-1}}{P_{k_1,t}k_{1f,t-1}}, \tag{2.72}$$

where fdi_{in0} is the autonomous inward FDI accumulation rate and $fdi_{in1} > 0$ is the sensitivity of inward FDI to domestic firms' gross profit rate.

2.3 Simulation

We run the model to simulate different scenarios of carbon pricing from the Network for Greening the Financial System (NGFS) from 2019 to 2035. Our baseline scenario is the National Determined Contributions (NDCs) scenario from the NGFS, which follows the commitment of the country to the Paris Agreement. The baseline scenario only includes carbon pricing. Green subsidies are not implemented, $GS_t = 0$. We run two other scenarios for carbon prices to see their effects. One is the below 2°C scenario, and the other one is the net zero scenario (see Figure 2.3).

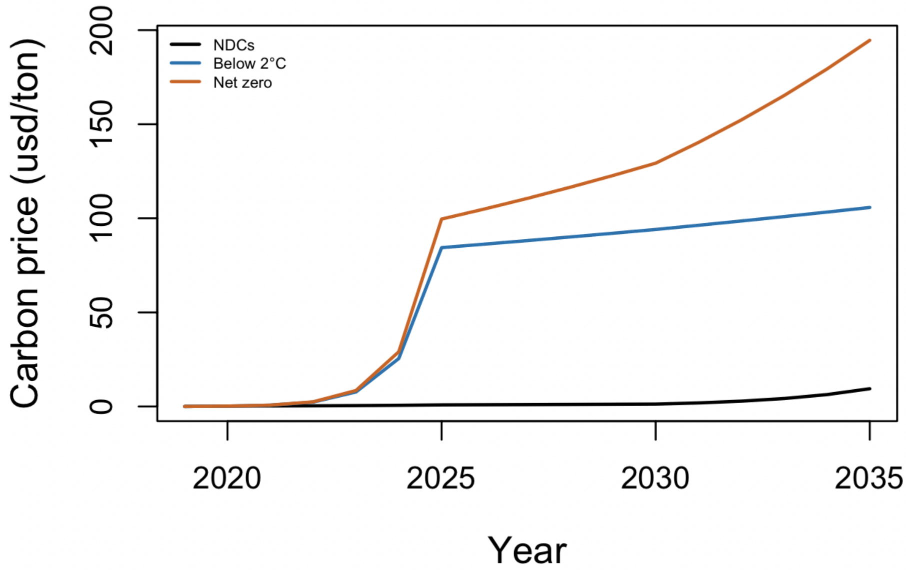


Figure 2.3: Carbon prices

Note: The NGFS scenarios are displayed every 5 years before 2060 and every decade afterward. Interpolations by assuming the same growth rate between grids. Converted using the US CPI and official exchange rate from the World Bank.

Source: NGFS

2.3.1 Initial values and parameters specifications

The initial values and parameters are obtained, calculated, estimated or calibrated from the real data or the NDCs scenario (see Table 2.4 and 2.5 in the Appendix). Our data covers from year 2000 to 2019. Stock data, e.g., non-financial assets and financial assets and liabilities, are obtained from China's National Balance. Transaction data are obtained from the National Bureau of Statistics of China (NBSC). Data for energy and emissions are obtained from the NBSC, China Energy Portal, World Bank, and Our World in Data.

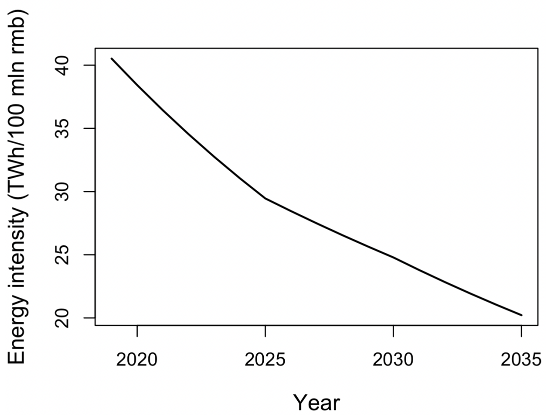
The GDP deflator is obtained from World Development Indicators. Other price variables are obtained or estimated from NBSC. The nominal effective exchange rate is obtained from the European Central Bank. Capacity utilization is obtained from Wang and Zeng (2021). Fiscal tax rates and interest rates are estimated using the transaction data and stock data, dividing the flows by the stocks. Employment data are obtained from the World Bank. The real wage is calculated by the wage bill payment over employment deflated by the GDP deflator. Equity price indices are calculated by the revaluation effect over the lagged stock in value. The revaluation effect of equities is calculated by the equity accumulation equation.

Capital for energy production is calculated by accumulating the fixed capital formation for energy production. We assume the same accumulation rate of capital for energy production as the accumulation rate of firms' fixed capital in 2000. So the share of capital for energy production is the same as the share of fixed capital formation for energy production in firms' fixed capital formation. Then we accumulate the flows by using the firms' capital depreciation rate and capital price. Green capital for renewable energy is calculated using equation (2.3).

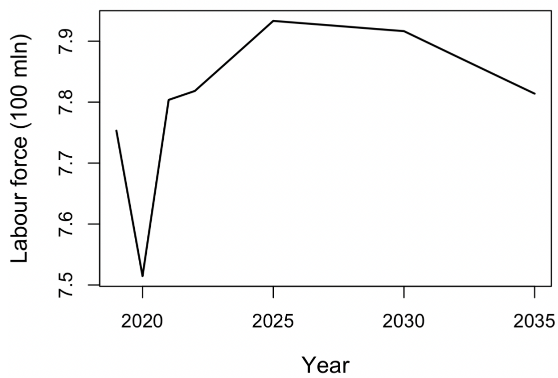
Parameters are mostly estimated by running simple OLS regressions with Durbin-Watson to ensure they do not reject the homoskedasticity hypothesis. Moreover, we run Augmented Dickey-Fuller (ADF) tests on the residuals to ensure co-integrations between the variables. β_{eg} is borrowed from Aleti and Hochman (2020). $ce_1 = -ce_0$ is calibrated from equation (2.18) to have $\theta = 0$ when $\Gamma_{re} = 1$, zero carbon emission when 100% use of renewable energy.

To avoid spikes in the initial period simulation, we assume the economy is at balanced growth in the initial period. Stock variables' initial values are set using the data. The initial value of foreign GDP is calculated using the world GDP substrates by China's GDP from the World Bank. Final goods prices are assumed to be 1 for the initial period. The balanced growth path requires stocks and flows to grow at the same rate as the initial GDP growth rate. Goods prices, interest rates and exchange rates are fixed. The price of equities grows at the real GDP growth rate. Energy consumption growth is assumed to be 0 in the initial period, so the energy prices remain constant. These conditions require some initial values of the variables and parameters to be calibrated using the equations.

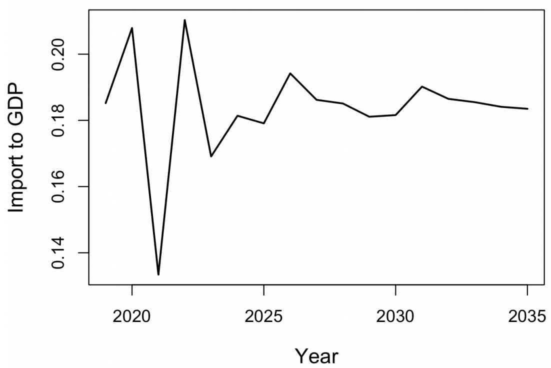
We calibrate real GDP growth, energy intensity growth, labour force and foreign GDP growth to historical data until 2022 and our baseline scenario afterwards. Energy intensity growth, $g_{ey,t}$, is an exogenous variable. We simply set its values to the time series (see Figure 2.4a). The labour force is estimated based on the labour force data of the World Bank and the Chinese population prediction of the NGFS scenario by simply assuming the labour force proportion is fixed at the level of 2022, which is around 55.98% (see Figure 2.4b). For real GDP growth, which is an endogenous variable, we let $m_{0,t}$ from the import equation, equation (2.69), to be a moving parameter to calibrate it (see Figure 2.4c). Foreign GDP growth is exogenous, and we employ the time series data (see Figure 2.4d).



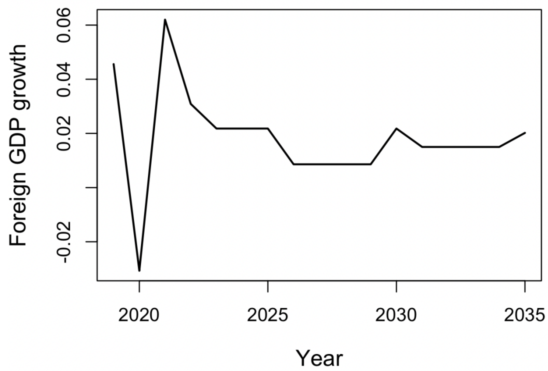
(a) Energy intensity



(b) Labour force



(c) Import to GDP, $m_{0,t}$



(d) Foreign GDP growth

Figure 2.4: Calibration variables

Note: we calibrate to historical data until 2022, and the NDCs of the NGFS scenario afterwards. The NGFS scenario is displayed every 5 years before 2060. Interpolations by assuming the same growth rate between grids.

Source: World Bank, NGFS

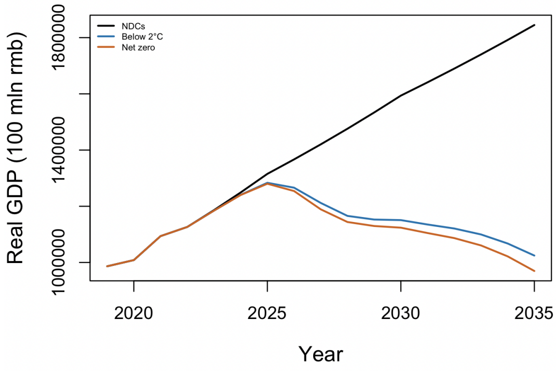
2.3.2 Results

Carbon pricing

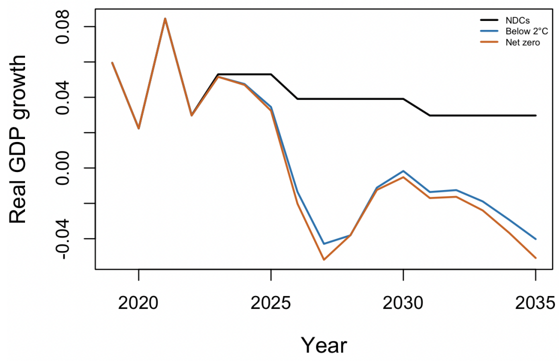
Figure 2.5 shows the main results of the simulations. The black line is our baseline scenario (NDCs). The blue and red lines are the results of carbon prices of the below 2°C scenario and the net zero scenario. Carbon pricing has a negative effect on real GDP (Figure 2.5a, 2.5b). Household consumption decreases due to higher carbon tax payments and also because of the inflation caused by the carbon tax (Figure 2.5c and 2.5d). Firms invest less under higher carbon tax payments because of lower profit rates and lower capacity utilization (Figure 2.5e and 2.5f).

Household investment decreases because of the rise of housing prices caused by carbon pricing (Figure 2.5g and 2.5h). Export decreases under higher carbon taxes because export goods become more expensive and less competitive (Figure 2.5i). Consequently, China runs a current account deficit under higher carbon taxes (Figure 2.5j). The real equity price of firms issued, which is the price of firms equities issued deflated by GDP deflator, decreases under a higher carbon tax, showing that the firm's balance sheet worsens in real term (Figure 2.5k). Public debt to GDP drops in the short run because of higher carbon tax revenue but rises in the long run because the denominator, GDP, decreases even more, and green transition reduces carbon tax revenue to GDP in the long run (Figure 2.5l and 2.5m). Households' net worth in real terms, deflated by GDP, increases slightly in the medium run, mainly because of the revaluation of housing. Although the model does not have heterogeneous agents to study inequality, the wealth inequality increases because only house owners benefit from this revaluation effect, and houses are less affordable for the unhoused people as shown household investment decreases (Figure 2.5n).

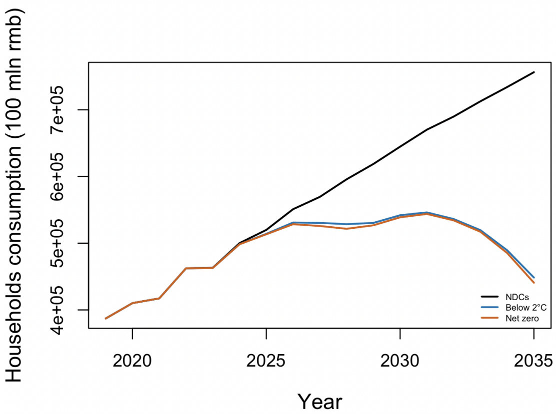
Energy consumption becomes smaller under higher carbon prices because of their negative impact on aggregate demand (Figure 2.5o). Carbon pricing stimulates green transitions as expected. Only the net-zero carbon pricing scenario achieves the policy target described in Table 2.1, 25% of renewable energy share by 2030. The below 2°C scenario shows a decline in renewable energy share in the long run because decreasing energy demand shrinks the energy sector and reduces the scale effect of renewable energy production. While the net zero scenario has a sufficient high carbon tax level to compensate for this negative effect (Figure 2.5p). Carbon intensity decreases over time as the energy intensity decreases. The positive effect of carbon pricing on green transition decreases carbon intensity further. Even the baseline scenario succeeds the policy target for carbon intensity described in Table 2.1, 65% less than the level of 2005 by 2030 (Figure 2.5q). Carbon pricing decreases carbon emission in two aspects, i. it stimulates green transition and reduces carbon intensity; ii. it deteriorates aggregate demand and reduces energy consumption. Surprisingly, our baseline scenario just matches the policy target described in Table 2.1, carbon emission peaks in 2030, which we did not calibrate in purpose (Figure 2.5r).



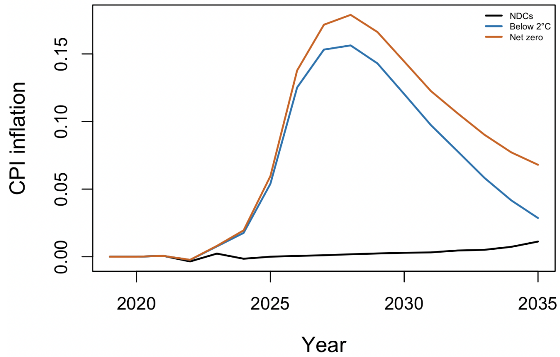
(a) Real GDP



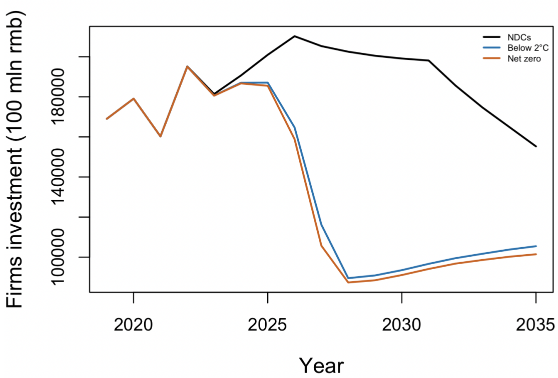
(b) Real GDP growth



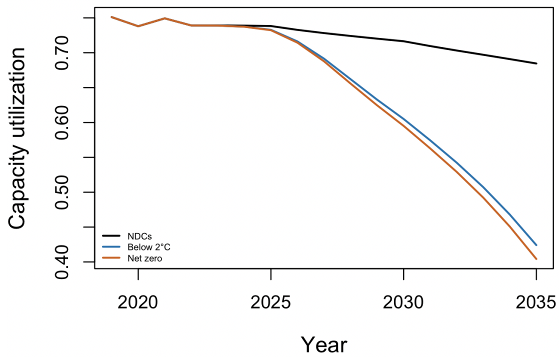
(c) Households consumption, volume



(d) Inflation



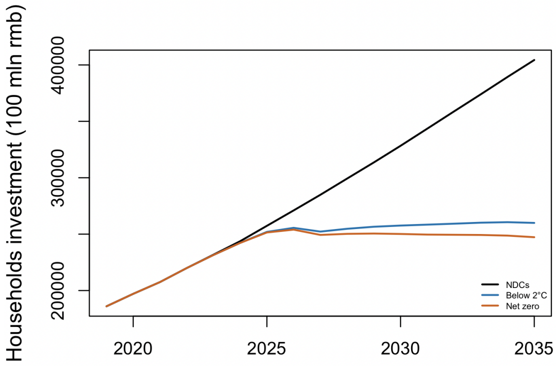
(e) Firms investment, volume



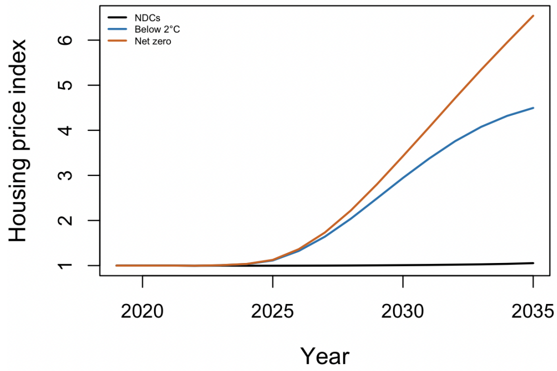
(f) Capacity utilization

Figure 2.5: Simulation results, carbon price scenarios

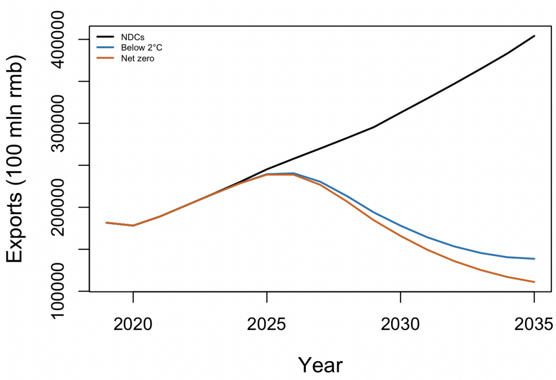
Note: The black line is our baseline scenario (NDCs). The blue and the red lines are results with carbon prices of the below 2°C scenario and the net zero scenario. The horizontal lines and vertical lines in (2.5p), (2.5q) and (2.5r) are the respective policy targets described in Table 2.1.



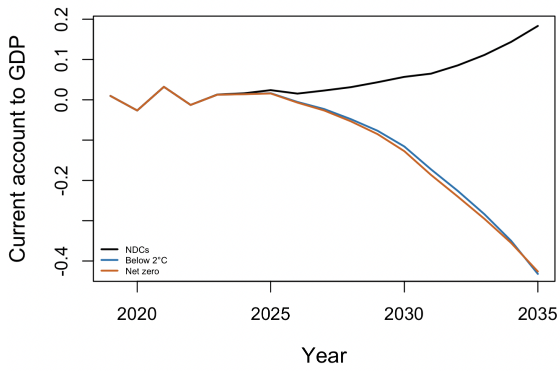
(g) Households investment, volume



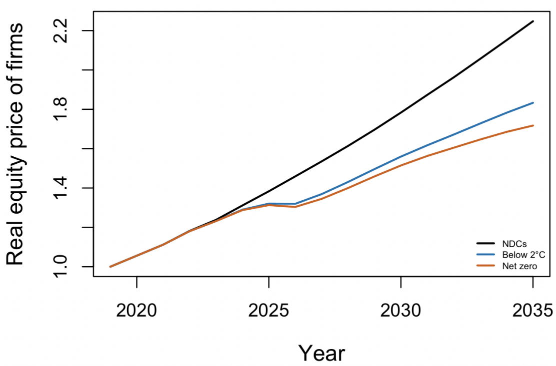
(h) Housing price index



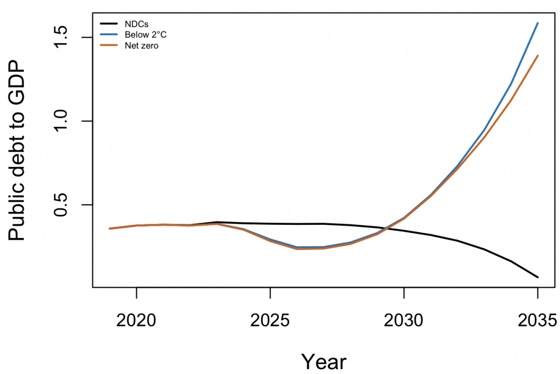
(i) Export, volume



(j) Current account to GDP



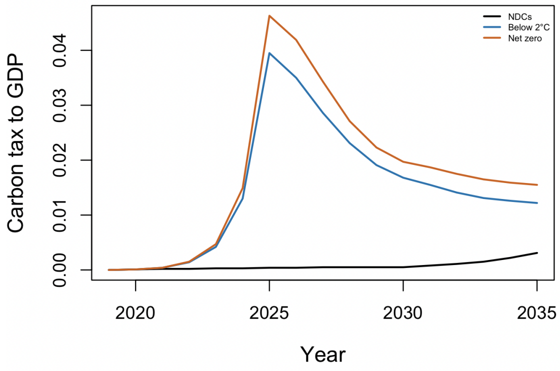
(k) Real equity price of firms



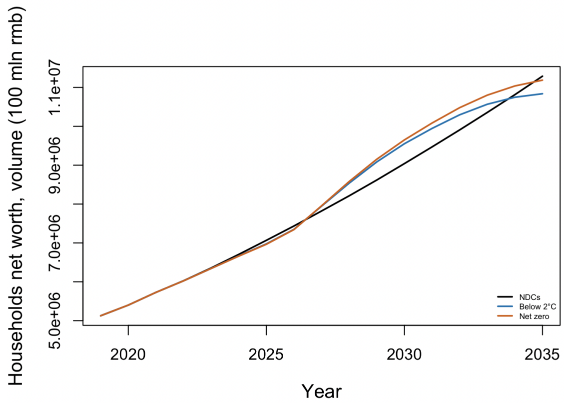
(l) Public debt to GDP

Figure 2.5: Simulation results, carbon price scenarios

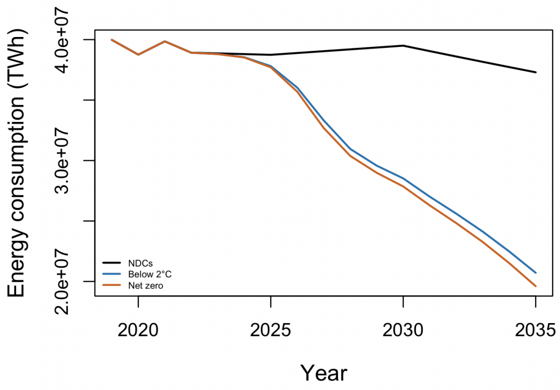
Note: The black line is our baseline scenario (NDCs). The blue and the red lines are results with carbon prices of the below 2°C scenario and the net zero scenario. The horizontal lines and vertical lines in (2.5p), (2.5q) and (2.5r) are the respective policy targets described in Table 2.1.



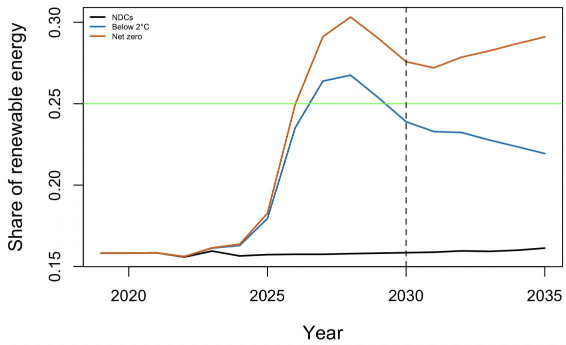
(m) Carbon tax to GDP



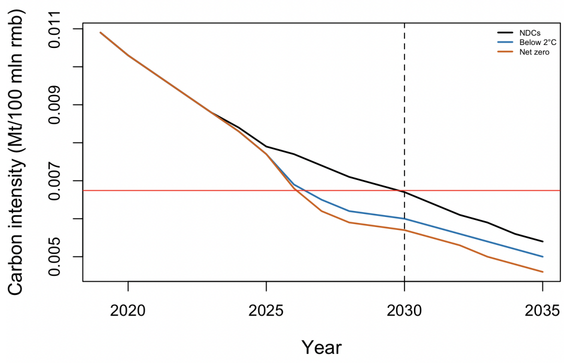
(n) Households net worth, volume



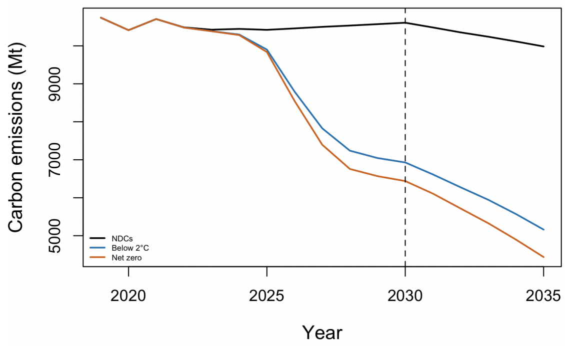
(o) Energy consumption



(p) Share of renewable energy



(q) Carbon intensity



(r) Carbon emission

Figure 2.5: Simulation results, carbon price scenarios

Note: The black line is our baseline scenario (NDCs). The blue and red lines are the results of carbon prices of the below 2°C scenario and the net zero scenario. The horizontal lines and vertical lines in (2.5p), (2.5q) and (2.5r) are the respective policy targets described in Table 2.1.

Green and conventional fiscal policy

In this section, we compare the effect of green fiscal policy, green subsidies to renewable energy producers, and two conventional fiscal policies, capital transfers to firms and social benefits to households (Figure 2.6). Based on our baseline scenario (NDCs), the government uses its carbon tax revenue to fund these policies (carbon tax rebate). Specifically, in the green subsidies scenario, green subsidies can only cover by maximum of 85% of the total cost of renewable energy production[16]. If carbon tax revenue exceeds this amount, the remaining revenues are transferred to firms in terms of regular capital transfers,

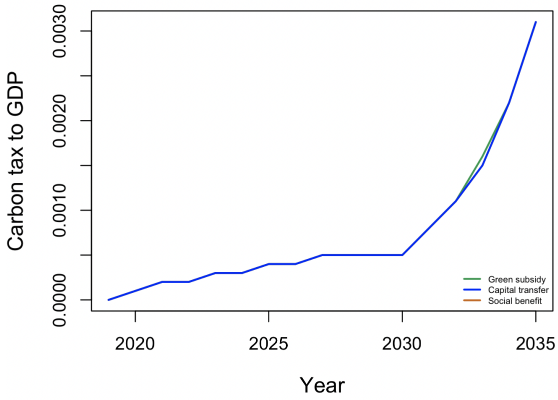
$$GS_t = \min\{CT_t,\ 0.85(F_{re} + r_{k_{re},t}K_{re,t})\}, \tag{2.73}$$

$$TR_{k,t} = CT_t - GS_t. \tag{2.74}$$

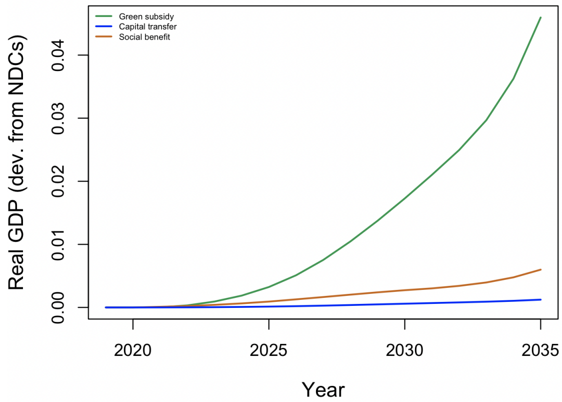
Figure 2.6a shows the carbon tax to GDP in these three scenarios. They stand for a maximum of around 0.3% of GDP, which are small shocks. To better understand the scale of their effect, the figures we show later are in deviation of the baseline, i.e. $\frac{Scenario_{shock}}{Scenario_{NDCs}} - 1$ for variables in level and $Scenario_{shock} - Scenario_{NDCs}$ for variables in rate. The green line is the green subsidies scenario, the blue line is the capital transfer scenario, and the orange line is the social benefits scenario. Green subsidies, compared to conventional fiscal policies, have a more significant positive impact on economic growth by reducing inflation (Figure 2.6b). Green subsidies reduce the price of renewable energy and increase the share of renewable energy (Figure 2.6c and 2.6d). As a consequence, the price of aggregate energy becomes cheaper, which reduces inflation (Figure 2.6e and 2.6f). Under the green subsidies scenario, household consumption increases more significantly than firms' investment because the energy price reduction transmits to CPI reduction directly through equation (2.37) (Figure 2.6g and 2.6h). Capital transfers do not show a significant effect on firms' investment because firms do not take it into account in their profit, but they reduce the accumulation of firms' debt (Figure 2.6i). Public debt over GDP increases under all of the three fiscal scenarios. Green subsidies increase public debt over GDP more because of the revaluation effect of government bonds in the short run. In the long run, public debt to GDP decreases because of the positive effect of green subsidies on GDP, the denominator, and generates additional fiscal revenues from production taxes and income taxes (Figure 2.6j and 2.6k). Government bond price rises because the interest rates fall, targeting to inflation (Figure 2.6l). Energy consumption with green subsidies increases because of the

[16] If we set an extreme cost coverage ratio for green subsidies, e.g. 90%, the simulation outcomes will be volatile, because if the share of renewable energy increases suddenly in one period, carbon tax revenue will shrink and cannot finance green subsidies in the next period.

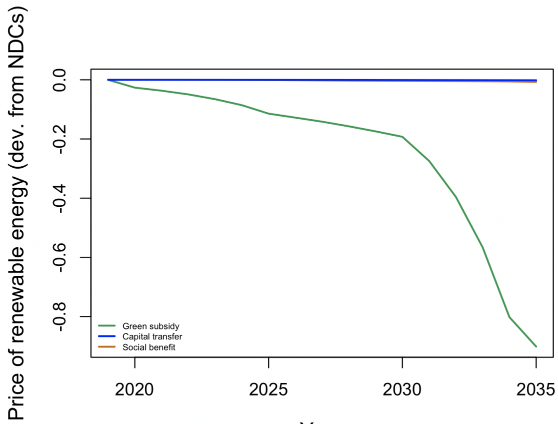
rebound effect (Figure 2.6m). As a consequence, carbon emissions increase in the medium run with green subsidies but decrease in the long run as the share of renewable energy increases significantly (Figure 2.6n).



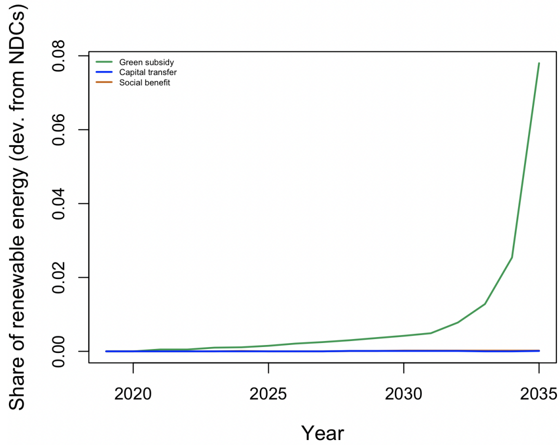
(a) Carbon tax to GDP



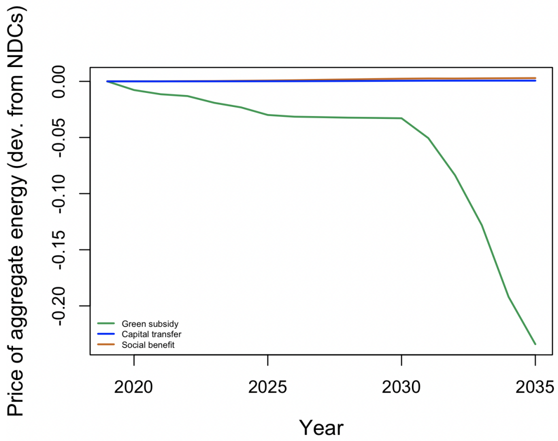
(b) Real GDP



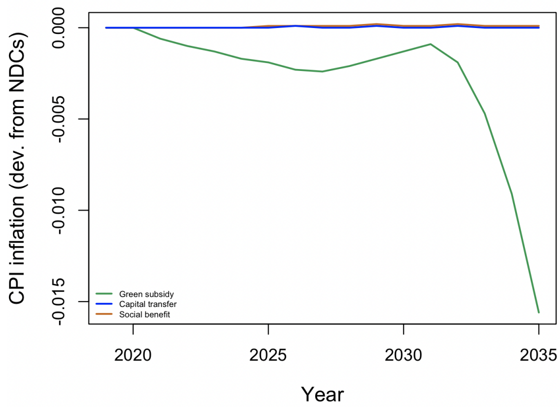
(c) Price of renewable energy



(d) Share of renewable energy



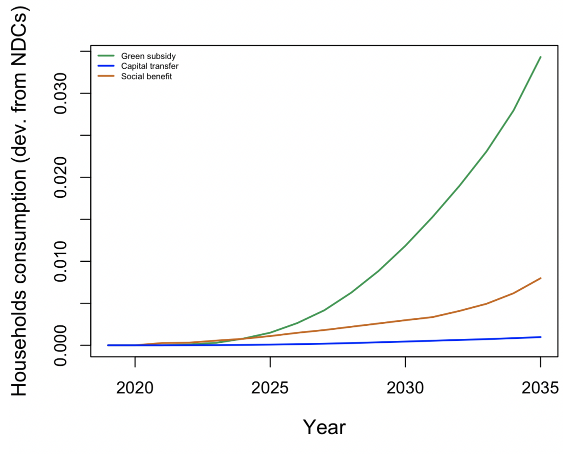
(e) Price of aggregate energy



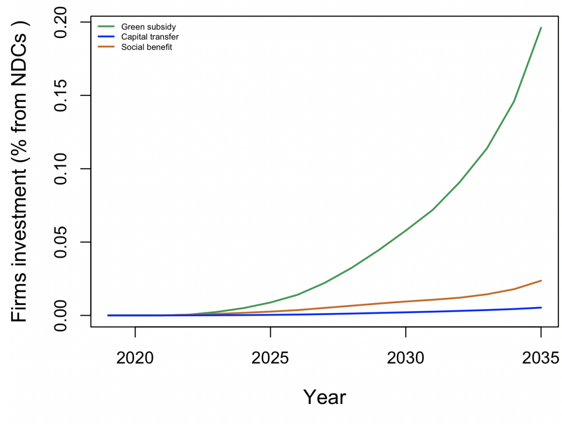
(f) Inflation

Figure 2.6: Simulation results, green and conventional fiscal policy scenarios

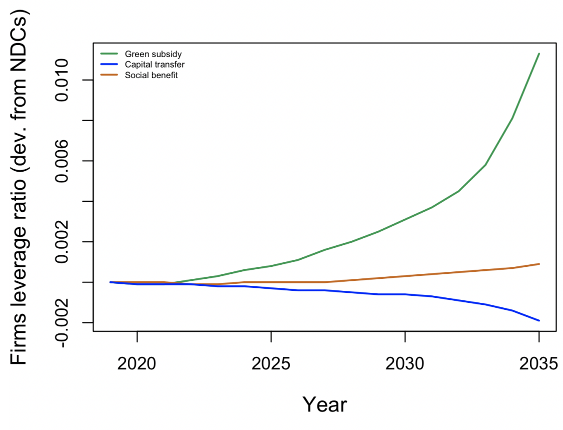
Note: The green line is the green subsidies scenario, in which the government subsidises 85% of the production cost of renewable energy funded by the carbon tax revenue. If carbon tax revenue exceeds this amount, the remaining revenues are transferred to firms in terms of regular capital transfers. The blue line is the capital transfer scenario, in which the government transfers all the carbon tax revenue to firms. The orange line is the social benefits scenario, in which the government increase social benefits to households by the amount of the carbon tax revenue.



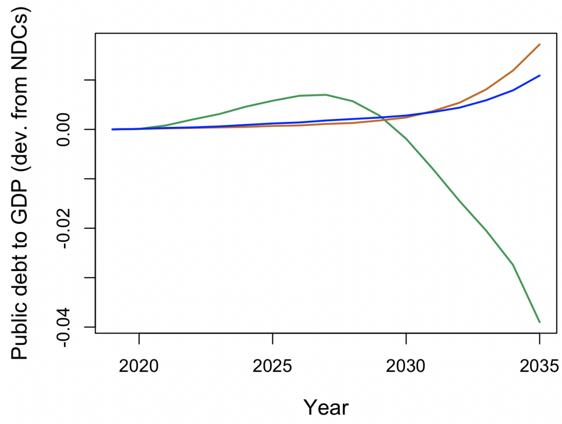
(g) Households consumption, volume



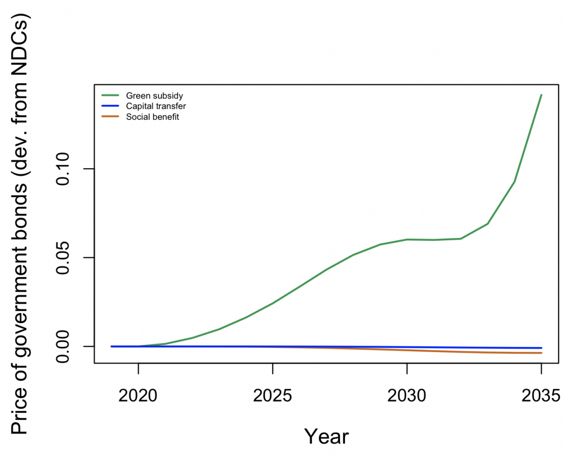
(h) Firms investment, volume



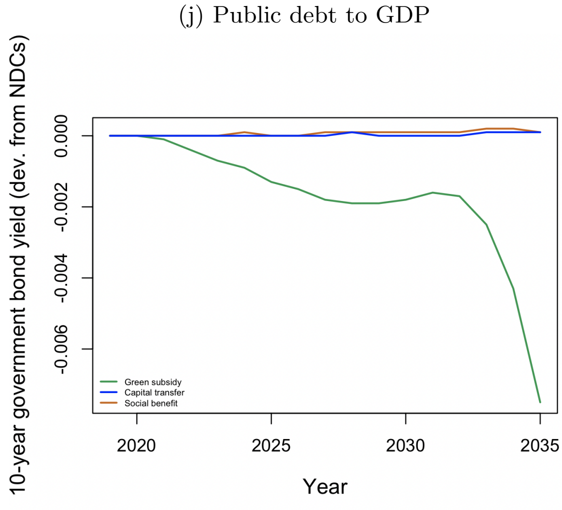
(i) Firms leverage ratio



(j) Public debt to GDP



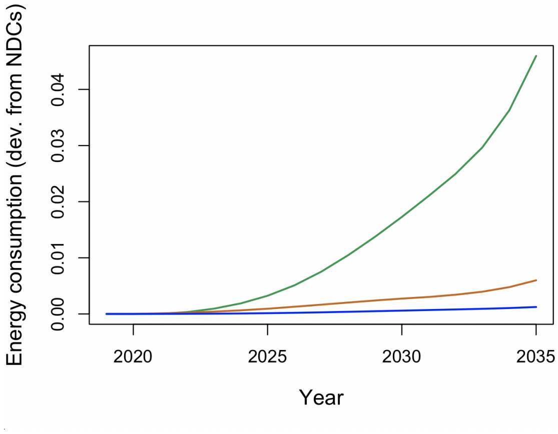
(k) Price of government bonds



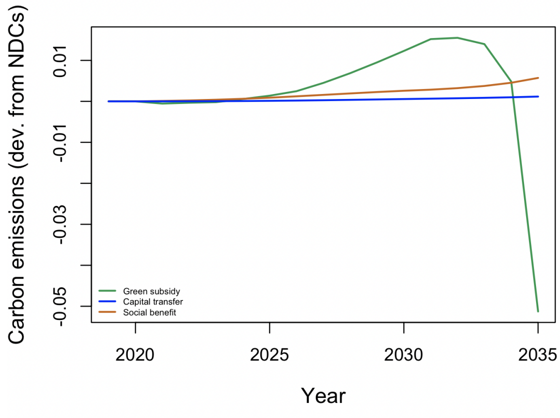
(l) 10-year government bond yield

Figure 2.6: Simulation results, green and conventional fiscal policy scenarios

Note: The green line is the green subsidies scenario, in which the government subsidises 85% of the production cost of renewable energy funded by the carbon tax revenue. If carbon tax revenue exceeds this amount, the remaining revenues are transferred to firms in terms of regular capital transfers. The blue line is the capital transfer scenario, in which the government transfers all the carbon tax revenue to firms. The orange line is the social benefits scenario, in which the government increase social benefits to households by the amount of the carbon tax revenue.



(m) Energy consumption



(n) Carbon emissions

Figure 2.6: Simulation results, green and conventional fiscal policy scenarios

Note: The green line is the green subsidies scenario, in which the government subsidises 85% of the production cost of renewable energy funded by the carbon tax revenue. If carbon tax revenue exceeds this amount, the remaining revenues are transferred to firms in terms of regular capital transfers. The blue line is the capital transfer scenario, in which the government transfers all the carbon tax revenue to firms. The orange line is the social benefits scenario, in which the government increase social benefits to households by the amount of the carbon tax revenue.

In summary, carbon pricing stimulates green transition, reduces carbon intensity and emissions at the cost of deteriorating GDP and causing inflation. Export good becomes more expensive and less competitive, results in huge current account deficit. As the share of renewable energy increases, the cost of carbon tax to GDP decreases, but the economy remains in recession. Firms' balance sheet worsen. Governments receive more fiscal revenues from carbon tax and bear less public debt in the short run, but face a higher public debt over GDP ratio in the long run. Green subsidies, compared to conventional fiscal policy, stimulate green transition and have more positive effects on the economy, higher economic growth and less inflation.

2.4 Conclusion and Remark

This paper develops a stock-flow consistent macroeconomy model with an energy sector for China to investigate the effect of green policies on green transition and aggregate demand. The model is built empirically based on the national balance sheet and transaction flow matrix of China. The energy sector is driven by aggregate demand and includes two types of energy production, conventional energy and renewable. The allocation of these two types of energy consumption/production depends on a VES consumption preference/production technology function for aggregate energy and cost functions. We provide an analytical solution for green transition that shows the relative cost of using conventional energy with respect to renewable energy determines the share of renewable energy, and the development of the energy sector promotes green transition. As the energy sector develops, green transition happens in the short run but hits a ceiling in the long run because the price of renewable energy stops decreasing as the financing cost accumulates. It calls for the necessity of green policies such as carbon taxes, green subsidies and green finance.

We calibrate the model to the NDCs scenarios from the NGFS and run simulations with different carbon pricing scenarios, below 2°C and net zero. The simulation results demonstrate carbon pricing stimulates green transition but has a negative impact on the economy, low growth and high inflation. Firms investment falls down sharply and their book value decreases. Governments benefit from carbon taxes in the short run by receiving additional fiscal revenue but bear a higher public debt over GDP in the long run because of the negative impact of carbon taxes on the economy. Carbon taxes reduce carbon intensity and carbon emissions. Only the net-zero scenario achieves the green share policy target in 2030. Then, we ran more scenarios to compare the effect of green fiscal policy, green subsidies to renewable energy producers, and two conventional fiscal policies, capital transfers to firms and social benefits to households, which are all financed by the carbon tax revenue from the baseline scenario. The results show that green subsidies stimulate green transition and have more positive effects on the economy, higher economic growth and less inflation.

One caveat of our model is the assumption in the energy sector is too strong due to lack of data. Renewable energy having the same production technology as conventional energy is unrealistic. The model also does not capture the effect of disaggregated investment. On one hand, the green transition requires investment in renewable energy production, which generates economic growth. On the other hand, it reduces investment in conventional energy production and deteriorates growth.

The model can also be extended in some directions. We could model the energy sector more realistically with more detailed data when they are available. We could explore the effect of green finance by disaggregating bonds/loans into green and brown bonds/loans, assuming that conventional energy producers are financially constrained by banks (credit rationing).

Appendix

The price of aggregate energy:

The price of aggregate energy is the weighted average of the price of conventional energy plus the unit of carbon price for conventional energy production and the price of renewable energy production,

$$P_{ener,t} = (1 - \Gamma_{re,t}) \left(P_{ce,t} + \frac{CT_t}{CE_t} \right) + \Gamma_{re,t} P_{re,t}. \tag{2.75}$$

Production:

Final goods or services are produced by domestic sectors given a fixed proportion,

$$Y_{j,t} = \gamma_j Y_t, \; \sum_j \gamma_j = 1, \tag{2.76}$$

where $j = f, b, g, h$ denote firms, banks, governments and households.

Households:

The gross operating surplus of households is defined as,

$$\Pi_{h,t} = Y_{h,t} + W_{h,t} - TL_{h,t} - CT_{h,t}, \tag{2.77}$$

where $W_{h,t} = \gamma_{W_h} W_t$ is the wage paid by households with γ_{W_h}, the share of wage paid by households, and $TL_{h,t} = \tau_{L_h} Y_{h,t}$, the net production tax paid by households with τ_{L_h} is the net production tax rate paid by households.

The gross disposable income of households is,

$$YD_{g,t} = \Pi_{h,t} + W_t + INT_{rh,t} - INT_{lh,t} + DIV_{h,t} + OIP_{h,t}, \tag{2.78}$$

where $INT_{rh,t} = INT_{dh,t} + INT_{bh,t}$ is the total interest received by households, which is the sum of households' deposit interest, $INT_{dh,t} = r_{rh,t} D_{h,t-1}$, and households' bond interest, $INT_{bh,t} = r_{rh,t} B_{h,t-1}$, $INT_{lh,t} = r_{ph,t} L_{h,t-1}$ is households' loans interest paid, $DIV_{h,t} = \gamma_{DIV_h}(E_{h,t-1} + IFS_{h,t-1})$ is the dividend received by households with γ_{DIV_h} the dividend rate received by households, and $OIP_{h,t} = \gamma_{OIP_h} YD_{g,t-1}$ is households other income form properties received, which is a fixed proportion of households' gross disposable income for simplicity, γ_{OIP}.

The net disposable income of households is,

$$YD_t = YD_{g,t} - T_{h,t} - SC_t + SB_t - O_{h,t}, \tag{2.79}$$

where $T_{h,t}$ is the income tax paid by households, $T_{h,t} = \tau_{h,t} YD_{g,t}$, SC_t is the social contribution paid by households to the governments, proportional to total wages, $SC_t = \tau_{sc} W_t$, SB_t is the social benefits received from the governments, and $O_{h,t} = \gamma_{O_h} YD_{g,t}$ is households other current transfers paid, proportional to gross disposable income for simplicity.

Household savings is disposable income minus consumption,

$$S_{h,t} = YD_t - C_{h,t}. \tag{2.80}$$

Households' fixed capital depreciates at a fixed rate, δ_h. Assuming no other changes in value (OCV), the current fixed capital in value is the sum of fixed capital in the previous period after depreciation, fixed capital formation and revaluation effect,

$$K_{h,t} = K_{h,t-1}(1-\delta_h) + I_{h,t} + REV_{k_h,t}, \tag{2.81}$$

where $REV_{k_h,t}$ is the revaluation effect of households fixed capital.

Households' fixed capital in volume is the stock in value divided by housing prices,

$$k_{h,t} = \frac{K_{h,t}}{P_{k_h,t}}. \tag{2.82}$$

Households fixed capital revaluation equals the price change times the stock in volume in the previous period,

$$REV_{k_h,t} = \Delta P_{k_h,t} k_{h,t-1}. \tag{2.83}$$

Households' net financial investment equals households' savings minus fixed capital formation,

$$NFI_{h,t} = S_{h,t} - I_{h,t}. \tag{2.84}$$

Households' currencies savings equal to the change in stock,

$$\Delta H_t = H_t - H_{t-1}. \tag{2.85}$$

Households' deposit savings equal the change in stock,

$$\Delta D_{h,t} = D_{h,t-1} + \Delta D_{h,t}. \tag{2.86}$$

Household bonds held in volume equal to bonds held in value over the bond price,

$$b_{h,t} = \frac{B_{h,t}}{P_{b_h,t}}. \tag{2.87}$$

Household bond savings equal the change in stock value minus the revaluation effect of bonds,

$$\Delta B_{h,t} = B_{h,t} - B_{h,t-1} - REV_{b_h,t}, \tag{2.88}$$

where $REV_{b_h,t}$ is the revaluation effect of households' bonds held.

Households' bonds held revaluation equal to the price change times the stock in volume in the previous period,

$$REV_{b_h,t} = \Delta P_{b_h,t} b_{h,t}. \tag{2.89}$$

The price of households' bonds held is approximated as the inverse of their interest rate, as in Godley and Lavoie, 2006,

$$P_{b_h,t} = \frac{1}{r_{rh,t}}. \tag{2.90}$$

Households' equity held in value equals the stock in value in the previous period plus the revaluation effect,

$$E_{h,t} = E_{h,t-1} + REV_{e_h,t}, \tag{2.91}$$

where $REV_{e_h,t}$ is the revaluation effect of households equity held.

Households' equity held revaluation is the residual revaluation effect of equities held and issued by the other sector,

$$REV_{e_h,t} = REV_{e_{lf},t} + REV_{e_{lb},t} - REV_{e_{af},t} - REV_{e_{ab},t} - REV_{e_g,t} - REV_{e_r,t}. \tag{2.92}$$

Households' investment fund shares savings equal the change in stock value,[17]

$$\Delta IFS_{h,t} = IFS_{h,t} - IFS_{h,t-1}. \tag{2.93}$$

Households' insurance savings equal the change in stock value,

$$\Delta A_t = A_t - A_{t-1}. \tag{2.94}$$

We assume other accounts payable/receivables are proportional to households' net worth for simplicity,

$$Z_{h,t} = z_{h0} V_{h,t-1}. \tag{2.95}$$

Households' change in other accounts payable/receivables is

$$\Delta Z_{h,t} = Z_{h,t} - Z_{h,t-1}. \tag{2.96}$$

[17] We assume the price of investment fund shares is exogenous and constant for simplicity. As we have not found its determinant.

Households' loan borrowing closes the households' budget constraint,

$$\Delta L_{h,t} = \Delta H_t + \Delta D_{h,t} + \Delta B_{h,t} + \Delta IFS_{h,t} + \Delta A_{h,t} + \Delta Z_{h,t} - NFI_{h,t}. \tag{2.97}$$

The accumulation of households' loans is

$$L_{h,t} = L_{h,t-1} + \Delta L_{h,t}. \tag{2.98}$$

Households' net worth is

$$V_{h,t} = K_{h,t} + H_t + D_{h,t} + B_{h,t} - L_{h,t} + E_{h,t} + A_{h,t} + Z_{h,t}. \tag{2.99}$$

Firms:

The gross operating surplus of firms is

$$\Pi_{f,t} = Y_{f,t} - TL_{f,t} - W_{f,t} - CT_{f,t}, \tag{2.100}$$

where $TL_{f,t} = \tau_{L,f} Y_{f,t}$ is the net production tax paid by firms. $W_{f,t}$ denotes wages paid by firms, assumed to be a proportion of the total wage bill, $W_{f,t} = \gamma_{W_f} W_t$.

The gross disposable income of firms is

$$FP_{g,t} = \Pi_{f,t} + INT_{df,t} - INT_{pf,t} + DIV_{rf,t} - DIV_{pf,t} - OIP_{f,t}, \tag{2.101}$$

where $INT_{df,t} = r_{rf,t} D_{f,t-1}$ is the deposit interest received by firms, $INT_{pf,t} = INT_{bf,t} + INT_{lf,t}$ is the total interest paid by firms, which is the sum of bonds interest paid, $INT_{bf,t} = r_{pf,t} B_{f,t-1}$ and loans interest paid, $INT_{lf,t} = r_{pf,t} L_{f,t-1}$, $DIV_{rf,t} = \gamma_{DIV_{rf}} (E_{af,t-1} + FDI_{out,t-1})$ is the dividend received by firms with $\gamma_{DIV_{rf}}$ the dividend rate received by firms, $DIV_{pf,t}$ is dividend paid by firms, and $OIP_{f,t} = \gamma_{OIP_f} FP_{g,t}$ is firms other income from properties paid, which is a fixed proportion of firms' gross disposable income for simplicity.

Firms' dividend paid is the sum of dividends received by all sectors minus dividends paid by banks,

$$DIV_{pf,t} = DIV_{rf,t} + DIV_{rb,t} + DIV_{g,t} + DIV_{h,t} + DIV_{rr,t} - DIV_{pb,t}. \tag{2.102}$$

Firms' net disposable income is

$$FP_t = FP_{g,t} - T_{f,t} - O_{f,t}, \tag{2.103}$$

where $T_{f,t} = \tau_{f,t}$ is the income tax paid by firms and $O_{f,t} = \gamma_{O_f} FP_{g,t}$ is firms' other current transfers paid, assumed as fixed a proportion of firms' gross disposable income.

Firms' fixed capital held in value is

$$K_{1f,t} = K_{1f,t-1}(1 - \delta_{f,t}) + I_{1f,t} + REV_{k_{1f},t}, \tag{2.104}$$

where δ_f denotes the depreciation rate of firms' fixed capital and $REV_{k_{1f},t}$ is the revaluation effect.

Firms' fixed capital in volume is

$$k_{1f,t} = \frac{K_{1f,t}}{P_{k_1,t}}. \tag{2.105}$$

Firms' fixed capital formation in volume,

$$i_{1f,t} = \Delta k_{1f,t} + \frac{\delta_f K_{1f,t-1}}{P_{k_1,t}}. \tag{2.106}$$

Firms' fixed capital revaluation,

$$REV_{k_{1f},t} = \Delta P_{k_1,t} k_{1f,t-1}. \tag{2.107}$$

Firms' inventories in value,

$$K_{2f,t} = K_{2f,t-1} + I_{2f,t} + REV_{k_{2f},t}, \tag{2.108}$$

where $REV_{k_{2f},t}$ is the revaluation effect.

Firms' inventories in volume,

$$k_{2f,t} = \frac{K_{2f,t}}{P_{k_{2f},t}}. \tag{2.109}$$

We assume firms' changes in inventories as a fixed share of real GDP for simplicity,

$$i_{2f,t} = i_{2f0} y_{t-1}. \tag{2.110}$$

Firms' inventories revaluation,

$$REV_{k_{2f},t} = \Delta P_{k_{2f},t} k_{2f,t-1}. \tag{2.111}$$

Firms' other non-financial assets in value,

$$K_{3f,t} = K_{3f,t-1} + I_{3f,t} + REV_{k_{3f},t}. \tag{2.112}$$

Firms' other non-financial assets in volume,

$$k_{3f,t} = \frac{K_{3f,t}}{P_{k_3,t}}. \tag{2.113}$$

Firms' acquisition less disposal of other non-financial assets in value,

$$I_{3f,t} = P_{k_3,t} i_{3f,t}. \tag{2.114}$$

Firms' acquisition less disposal of other non-financial assets in volume is assumed to be a fixed share of real GDP for simplicity,

$$i_{3f,t} = i_{3f0} y_{t-1}. \tag{2.115}$$

Firms' other non-financial assets revaluation,

$$REV_{k_{3f},t} = \Delta P_{k_3,t} k_{3f,t-1}. \tag{2.116}$$

Firms' net financial investment,

$$NFI_{f,t} = FP_t + TRK_t + GS_t - I_{1f,t} - I_{2f,t} - I_{3f,t}, \tag{2.117}$$

where TRK_t is the capital transfers received by firms.

The firms' deposit savings are the change in deposit stock value,

$$\Delta D_{f,t} = D_{f,t} - D_{f,t-1}. \tag{2.118}$$

Firms' bond borrowing,

$$\Delta B_{f,t} = B_{f,t} - B_{f,t-1} - REV_{b_f,t}, \tag{2.119}$$

where $REV_{b_f,t}$ is firms' bond issued revaluation.

Firms' bonds issued in volume,

$$b_{f,t} = \frac{B_{f,t}}{P_{b_f,t}}, \tag{2.120}$$

where $P_{b_f,t} = \frac{1}{r_{pf,t}}$ is the price of firms' bond.

Firms' bond revaluation,

$$REV_{b_f,t} = \Delta P_{b_f,t} b_{f,t-1}. \tag{2.121}$$

Firms' equity held in value is the stock value in the previous period plus the revaluation effect,

$$E_{af,t} = E_{af,t-1} + REV_{e_af,t}. \tag{2.122}$$

Firms' equity held in volume,

$$e_{af,t} = \frac{E_{af,t}}{P_{e_{af},t}}, \tag{2.123}$$

where $P_{e_{af},t}$ is the price of firms' equity held.

Firms' equity held revaluation,

$$REV_{e_{af},t} = \Delta P_{e_{af},t} e_{af,t-1}. \tag{2.124}$$

We assume the price of FDIs is constant for simplicity. Outward FDI flow equals the change in stock value,

$$\Delta FDI_{out,t} = FDI_{out,t} - FDI_{out,t-1}. \tag{2.125}$$

Firms' insurance savings,

$$\Delta A_{f,t} = A_{f,t} - A_{f,t-1}. \tag{2.126}$$

We assume other accounts payable/receivables are proportional to the firm's net worth for simplicity,

$$Z_{f,t} = z_{f0} E_{lf,t-1}. \tag{2.127}$$

Firms' change in other accounts payable/receivables is

$$\Delta Z_{f,t} = Z_{f,t} - Z_{f,t-1}. \tag{2.128}$$

Firm loans issued,

$$L_{f,t} = L_{f,t-1} + \Delta L_{f,t}. \tag{2.129}$$

Firms' loan borrowing closes the financial constraint,

$$\Delta L_{f,t} = \Delta D_{f,t} - \Delta B_{f,t} + \Delta FDI_{out,t} - \Delta FDI_{in,t} + \Delta A_{f,t} + \Delta Z_{f,t} - NFI_{f,t}. \tag{2.130}$$

Banks:

Domestic interest rates, except banks' rate of interest received and firms' rate of interest paid, are correlated to 10-year government bonds yield,

$$r_{j,t} = r_{j0} + (1 - r_{j1}) r_{j,t-1} + r_{j1} r_{10,t}, \tag{2.131}$$

where $j = \{pb, pg, ph, rf, rg, rh\}$ denotes paid by banks, paid by governments, paid by households, received by firms, received by governments and received by households, respectively, $r_{j0} > 0$ is the interest rate premium, and $r_{j1} > 0$ is the sensitivity to 10-year government bonds yield.

Banks' gross operating surplus is

$$\Pi_{b,t} = Y_{b,t} - W_{b,t} - TL_{b,t} - CT_{b,t}, \tag{2.132}$$

where $W_{b,t} = \gamma_{W_b} W_t$ is the wage paid by banks, proportional to the total wage bill, and $TL_{b,t} = \tau_{L_b} Y_{b,t}$ is the net production tax paid by banks.

Banks' gross disposable income is

$$BP_{g,t} = \Pi_{b,t} + INT_{rb,t} - INT_{pb,t} + DIV_{rb,t} - DIV_{pb,t} - OIP_{b,t}, \tag{2.133}$$

where $INT_{rb,t} = INT_{db,t} + INT_{brb,t} + INT_{lb,t}$ is banks' interest received, which is the sum of banks' deposit interest received, $INT_{db,t} = r_{rb,t} D_{b,t-1}$, banks' bond interest received, $INT_{brb,t}$, and banks' loans interest received, $INT_{lb,t}$, $INT_{pb,t} = INT_{d,t} + INT_{bpb,t}$ is banks' interest paid, which is the sum of banks' deposit interest paid, $INT_{d,t}$ and banks' bond interest paid, $INT_{bpb,t} = r_{pb,t} B_{lb,t-1}$, $DIV_{rb,t} = \gamma_{DIV_{rb}}(E_{ab,t-1} + IFS_{ab,t-1})$ is banks' dividend received, $DIV_{pb,t} = \gamma_{DIV_{pb}}(E_{lb,t-1} + IFS_{lb,t-1})$ is banks' dividend paid, and $OIP_{b,t} = \gamma_{OIP_b} BP_{g,t-1}$ is banks' other income from properties, assumed to be fixed proportion of banks' gross disposable income.

Banks' bond interest received is the sum of all sectors' bond interest paid minus households' bond interest received,

$$INT_{brb,t} = INT_{bf,t} + INT_{bg,t} + INT_{brb,t} - INT_{bh,t}. \tag{2.134}$$

Similarly, banks' loan interest received is the sum of all sectors' loan interest paid minus the RoW loan interest received,

$$INT_{lb,t} = INT_{lf,t} + INT_{lh,t} + INT_{pr,t} - INT_{rr,t}. \tag{2.135}$$

Banks' deposit interest paid is the sum of all sectors' deposit interest received,

$$INT_{d,t} = INT_{db,t} + INT_{df,t} + INT_{dg,t} + INT_{dh,t}. \tag{2.136}$$

Banks' net disposable income is

$$BP_t = BP_{g,t} - T_{b,t} + O_{b,t}, \tag{2.137}$$

where $T_{b,t} = \tau_{b,t} BP_{g,t}$ denotes banks' income tax paid and $O_{b,t} = \gamma_{O_b} BP_{g,t}$ is banks' other current transfer received, assumed to be a fixed proportion of banks' gross disposable income.

Banks' fixed capital held in value,

$$K_{1b,t} = K_{1b,t-1}(1 - \delta_b) + I_{1b,t} + REV_{k_{1b},t}, \tag{2.138}$$

where δ_b is the depreciation rate of banks' fixed capital and $REV_{k_{1b},t}$ is the revaluation effect of banks' fixed capital.

Banks' fixed capital held in volume,

$$k_{1b,t} = \frac{K_{1b,t}}{P_{k_1,t}}. \tag{2.139}$$

Banks' fixed capital formation in volume,

$$i_{1b,t} = \Delta k_{1b,t} + \frac{\delta_b K_{1b,t-1}}{P_{k_1,t}}. \tag{2.140}$$

Banks' fixed capital revaluation,

$$REV_{k_{1b},t} = \Delta P_{k_1,t} k_{1b,t-1}. \tag{2.141}$$

Banks' other non-financial assets is positively correlated to GDP (capital acceleration),

$$K_{3b,t} = k_{3b0} Y_{t-1}, \tag{2.142}$$

where $k_{3b0} > 0$ is the acceleration effect parameter.

Since there is no banks' acquisition less disposal of other non-financial assets, we assume the change in stock value is caused by the revaluation effect,

$$REV_{k_{3b},t} = K_{3b,t} - K_{3b,t-1}. \tag{2.143}$$

Banks' net financial investment,

$$NFI_{b,t} = BP_t - I_{1b,t}. \tag{2.144}$$

Banks' deposit savings,

$$\Delta D_{b,t} = D_{b,t} - D_{b,t-1}. \tag{2.145}$$

Banks' deposit issued

$$D_t = D_{t-1} + \Delta D_t. \tag{2.146}$$

Banks receive deposit savings from all sectors,

$$\Delta D_t = \Delta D_{b,t} + \Delta D_{f,t} + \Delta D_{g,t} + \Delta D_{h,t}. \tag{2.147}$$

Banks' bonds held in value,

$$B_{ab,t} = B_{ab,t} + \Delta B_{ab,t} + REV_{b_{ab},t}, \tag{2.148}$$

where $REV_{b_{ab},t}$ is the revaluation effect of banks' bonds held.

Banks' bonds savings equal the sum of bonds issued by all sectors minus households' bonds savings,

$$\Delta B_{ab,t} = \Delta B_{f,t} + \Delta B_{g,t} + \Delta B_{lb,t} - \Delta B_{h,t}. \tag{2.149}$$

Similarly, banks' bonds held revaluation equals the sum of the revaluation of bonds issued by all sectors minus the revaluation of households' bonds held,

$$REV_{b_{ab},t} = REV_{b_f,t} + REV_{b_g,t} + REV_{b_{lb},t} - REV_{b_h,t}. \tag{2.150}$$

Banks' bonds issued in volume,

$$b_{lb,t} = \frac{B_{lb,t}}{P_{b_{lb},t}}, \tag{2.151}$$

where $P_{b_{lb},t} = \frac{1}{r_{pb,t}}$ is the price of banks' bonds issued.

Banks' bonds borrowing,

$$\Delta B_{lb,t} = B_{lb,t} - B_{lb,t-1} - REV_{b_{lb},t}, \tag{2.152}$$

where $REV_{b_{lb},t}$ is the revaluation effect of banks' bonds issued.

Banks' bonds issued revaluation,

$$REV_{b_{lb},t} = \Delta P_{b_{lb},t} b_{lb,t-1}. \tag{2.153}$$

Banks' loans issued,

$$L_{b,t} = L_{b,t-1} + \Delta L_{b,t}. \tag{2.154}$$

Banks fulfill the demand for domestic loan borrowing, that is, total loan demand minus foreign loan supply,

$$\Delta L_{b,t} = \Delta L_{f,t} + \Delta L_{h,t} + \Delta L_{lr,t} - \Delta L_{ar,t}. \tag{2.155}$$

Banks' equity held in value,

$$E_{ab,t} = E_{ab,t-1} + REV_{e_{ab},t}, \tag{2.156}$$

where $REV_{e_{ab},t}$ is the revaluation effect of banks' equity held.

Banks' equity held in volume,

$$e_{ab,t} = \frac{E_{ab,t}}{P_{e_{ab},t}}, \tag{2.157}$$

where $P_{e_{ab},t}$ is the price of banks' equity held.

Banks' equity held revaluation,

$$REV_{e_{ab},t} = \Delta P_{e_{ab},t} e_{ab,t-1}. \tag{2.158}$$

We assume banks held equities issued by firms, the price of banks' equities held depends on the price price of firms' equities on the liability side,

$$P_{e_{ab},t} = P_{e_{lf},t}. \tag{2.159}$$

Banks' investment fund shares investing,

$$\Delta IFS_{ab,t} = IFS_{ab,t} - IFS_{ab,t-1}. \tag{2.160}$$

Banks' investment fund shares issued,

$$IFS_{lb,t} = IFS_{lb,t-1} + \Delta IFS_{lb,t}. \tag{2.161}$$

Banks supply investment fund shares to the investment demand,

$$\Delta IFS_{lb,t} = \Delta IFS_{ab,t} + \Delta IFS_{g,t} + \Delta IFS_{h,t}. \tag{2.162}$$

Banks' insurance issued,

$$A_t = A_{t-1} + \Delta A_t. \tag{2.163}$$

Banks fulfill insurance demand,

$$\Delta A_t = \Delta A_{f,t} + \Delta A_{h,t}. \tag{2.164}$$

Banks' other payable/receivables close the instrument line (horizontal consistency),

$$\Delta Z_{b,t} = -(\Delta Z_{f,t} + \Delta Z_{g,t} + \Delta Z_{h,t} + \Delta Z_{r,t}). \tag{2.165}$$

The accumulation of banks' other payable/receivables is

$$Z_{b,t} = Z_{b,t-1} - \Delta Z_{b,t}. \tag{2.166}$$

Governments:

Governments' gross operating surplus is

$$\Pi_{g,t} = Y_{g,t} - W_{g,t}, \tag{2.167}$$

where $W_{g,t} = \gamma_{W_g} W_t$ is the wage paid by governments, proportional to the total wage bill.

Governments' gross disposable income is

$$GP_{g,t} = \Pi g, t + TL_t + CT_{g,t} + INT_{dg,t} - INT_{bg,t} + DIV_{g,t} + OIP_{g,t}, \tag{2.168}$$

where $TL_t = TL_{f,t} + TL_{h,t} + TL_{b,t}$ is the net production tax received by governments, $INT_{dg,t} = r_{rg,t} D_{g,t-1}$ is government deposit interest received, $INT_{bg,t} = r_{pg,t} B_{g,t-1}$ is government bond interest paid, $DIV_{g,t} = \gamma_{DIV_g}(E_{g,t-1} + IFS_{g,t-1})$ is government dividend received with a fixed dividend rate γ_{DIV_g}, and $OIP_{g,t}$ is government other income from properties received.

Governments receive other income from properties from other sectors minus households' other income from properties,

$$OIP_{g,t} = OIP_{f,t} + OIP_{b,t} + OIP_{r,t} - OIP_{h,t}. \tag{2.169}$$

Governments' net disposable income is

$$GP_t = GP_{g,t} + T_t + SC_t - SB_t + O_{g,t}, \tag{2.170}$$

where $T_t = T_{f,t} + T_{b,t} + T_{h,t}$ is the total income tax received by governments, $SB_t = \gamma_{SB} Y_t$ is the social benefits paid to households, proportional to nominal GDP, and $O_{g,t}$ is other current transfers.

Government receive other current transfers from other sectors minus banks' other current transfers received,

$$O_{g,t} = O_{f,t} + O_{h,t} + O_{r,t} - O_{b,t}. \tag{2.171}$$

Government savings equal net disposable income minus government consumption,

$$S_{g,t} = GP_t - C_{g,t}. \tag{2.172}$$

Governments' fixed capital depreciates at a fixed rate, δ_g. Government fixed capital in value,

$$K_{1g,t} = K_{1g,t-1}(1 - \delta_g) + I_{1g,t} + REV_{k_{1g},t}, \tag{2.173}$$

where $REV_{k_{1g},t}$ is the revaluation effect of government fixed capital.

Governments' fixed capital in volume,

$$k_{1g,t} = \frac{K_{1g,t}}{P_{k_1,t}}. \tag{2.174}$$

Governments' fixed capital revaluation,

$$REV_{k_{1g},t} = \Delta P_{k_1,t} k_{1g,t-1}. \tag{2.175}$$

Governments' inventories in value,

$$K_{2g,t} = P_{k_{2g},t} k_{2g,t}. \tag{2.176}$$

Governments target their inventories to production (Godley & Lavoie, 2006),

$$k_{2g,t} = k_{2g0} y_{t-1}, \tag{2.177}$$

where $k_{2g0} > 0$ is the accelerator effect parameter.

Government changes in inventories in volume, by definition,

$$i_{2g,t} = \Delta k_{2g,t}. \tag{2.178}$$

Government other non-financial assets in value,

$$K_{3g,t} = P_{k_3,t} k_{3g,t}. \tag{2.179}$$

Government other non-financial assets in volume is proportional to real GDP,

$$k_{3g,t} = k_{3g0} y_{t-1},\ k_{3g0} > 0. \tag{2.180}$$

Governments sell other non-financial assets to firms,[18]

$$I_{3g,t} = -I_{3f,t}. \tag{2.181}$$

Governments' net financial investment,

$$NFI_{g,t} = S_{g,t} - TRK_t - GS_t - I_{1g,t} - I_{2g,t} - I_{3g,t}, \tag{2.182}$$

where $TRK_t = \gamma_{TRK} Y_t$ is capital transfers to firms, which is a fixed proportion of nominal GDP.

Governments save part of their net worth as deposits,

$$D_{g,t} = d_{g0} V_{g,t}. \tag{2.183}$$

Governments' deposit savings,

$$\Delta D_{g,t} = D_{g,t} - D_{g,t-1}. \tag{2.184}$$

Governments' equities held in value,

$$E_{g,t} = E_{g,t-1} + REV_{e_g,t}, \tag{2.185}$$

where $REV_{e_g,t}$ is the revaluation effect of government equities held.

Governments' equities held in volume,

$$e_{g,t} = \frac{E_{g,t}}{P_{e_g,t}}. \tag{2.186}$$

[18]This accounting equation is based on the transaction flow matrix. There is a mismatch between the national balance sheet and the transaction flow matrix from the data, government other non-financial assets is increasing over year with negative funds paid (positive funds received). The classification of government other non-financial assets includes state-owned construction land (*China's National Balance Sheet 2018*), which mainly comes from legislation.

Governments' equities held revaluation,

$$REV_{e_g,t} = \Delta P_{e_g,t} e_{g,t-1}. \tag{2.187}$$

Governments invest a proportion of net worth in investment fund shares,

$$IFS_{g,t} = ifs_{g0} V_{g,t-1}. \tag{2.188}$$

Governments' investment fund shares savings,

$$\Delta IFS_{g,t} = IFS_{g,t} - IFS_{g,t-1}. \tag{2.189}$$

Governments' other accounts payable/receivables are proportional to net worth,

$$Z_{g,t} = z_{g0} V_{g,t-1}. \tag{2.190}$$

Governments' changes in other accounts payable/receivables,

$$\Delta Z_{g,t} = Z_{g,t} - Z_{g,t-1}. \tag{2.191}$$

Governments' bonds close the fiscal constraint,

$$\Delta B_{g,t} = \Delta D_{g,t} + \Delta IFS_{g,t} + \Delta Z_{g,t} - NFI_{g,t}. \tag{2.192}$$

Governments' bonds issued in value,

$$B_{g,t} = B_{g,t-1} + \Delta B_{g,t} + REV_{b_g,t}, \tag{2.193}$$

where $REV_{b_g,t}$ is the revaluation of government bonds.

Governments' bonds issued in volume,

$$b_{g,t} = \frac{B_{g,t}}{P_{b_g,t}}, \tag{2.194}$$

where $P_{b_g,t}$ is the price of government bonds.

Governments' bonds revaluation,

$$REV_{b_g,t} = \Delta P_{b_g,t} b_{g,t-1} \tag{2.195}$$

Assuming each unit of government bonds pays 1 rmb after one year, then the price of government bonds can be derived by the inverse of its interest rate (Godley and Lavoie, 2006),

$$P_{B_g,t} = \frac{1}{r_{pg,t}}. \tag{2.196}$$

Government net worth,

$$V_{g,t} = K_{1g,t} + K_{2g,t} + K_{3g,t} + D_{g,t} - B_{g,t} + E_{g,t} + IFS_{g,t} + Z_{g,t}. \tag{2.197}$$

The rest of the world:

Net exports, by definition, equal exports minus imports,

$$NX_t = X_t - M_t. \tag{2.198}$$

Foreign savings is the net current transfers received by the rest of the world,

$$S_{r,t} = -NX_t - W_{r,t} + INT_{rr,t} - INT_{pr,t} + DIV_{rr,t} - OIP_{r,t} - O_{r,t}, \tag{2.199}$$

where $W_{r,t}$ is the foreign wage paid, $INT_{rr,t} = r_{rr,t}L_{ar,t-1}$ is the rest of the world interest received, $INT_{pr,t} = r_{pr,t}L_{lr,t-1}$ is the rest of the world interest paid, $DIV_{rr,t} = \gamma_{DIV_{rr}}(E_{r,t-1} + FDI_{in,t-1})$ is the dividend received by the rest of the world, $OIP_{r,t} = \gamma_{OIP_r}S_{r,t-1}$ is the other income from properties paid by the rest of the world, assumed to be proportional to foreign savings, and $O_{r,t} = \gamma_{O_r}S_{r,t-1}$ are the other current transfers paid by the rest of the world, also assumed to by proportional to foreign savings for simplicity.

Foreign wages paid close row of wage payments,

$$W_{r,t} = W_t - W_{b,t} - W_{f,t} - W_{g,t} - W_{h,t}. \tag{2.200}$$

The current account,

$$CA_t = -S_{r,t}. \tag{2.201}$$

Foreign net financial investment,

$$NFI_{r,t} = S_{r,t}. \tag{2.202}$$

The rest of the world loans lending,

$$\Delta L_{ar,t} = L_{ar,t} - L_{ar,t-1}. \tag{2.203}$$

We assume the rest of the world loans issued are proportional to the foreign net worth, $V_{r,t}$,

$$L_{lr,t} = l_{lr0} V_{r,t-1}. \tag{2.204}$$

The rest of the world loans borrowing,

$$\Delta L_{lr,t} = L_{lr,t} - L_{lr,t-1}. \tag{2.205}$$

The rest of the world's equities held in value,

$$E_{r,t} = E_{r,t-1} + REV_{e_r,t}, \tag{2.206}$$

where $REV_{e_r,t}$ is the rest of the world equities' revaluation effect.

The rest of the world's equities held in volume,

$$e_{r,t} = \frac{E_{r,t}}{P_{e_r,t}}. \tag{2.207}$$

The rest of the world's equities held revaluation,

$$REV_{e_r,t} = \Delta P_{e_r,t} e_{r,t-1}. \tag{2.208}$$

Inward FDI stock,

$$FDI_{in,t} = FDI_{in,t-1} + \Delta FDI_{in,t}. \tag{2.209}$$

We assume the rest of the world's other accounts payable/receivables are proportional to the net worth,

$$Z_{r,t} = z_{r0} V_{r,t-1}. \tag{2.210}$$

The rest of the world's changes in other accounts payable/receivables,

$$\Delta Z_{r,t} = Z_{r,t} - Z_{r,t-1}. \tag{2.211}$$

International reserves close the balance of payment,

$$\Delta G_t = \Delta L_{ar,t} - \Delta L_{lr,t} + \Delta FDI_{in,t} - \Delta FDI_{out,t} + \Delta Z_{r,t} - NFI_{r,t}. \tag{2.212}$$

The accumulation of international reserves is

$$G_t = G_{t-1} + \Delta G_t. \tag{2.213}$$

The rest of the world's net worth,

$$V_{r,t} = -G_t + L_{ar,t} - L_{lr,t} + E_{r,t} + FDI_{in,t} - FDI_{out,t} + Z_{r,t}. \tag{2.214}$$

Table 2.4: Initial values for variables

Symbol	Description	Value	Remark/sources
A	Banks' insurance issued (100 million rmb)	185272	Based on China's National Balance Sheet
A_f	Firms' insurance held (100 million rmb)	55582	Based on China's National Balance Sheet
A_h	Households' insurance held (100 million rmb)	129690	Based on China's National Balance Sheet
B_{ab}	Banks' bonds held in value (100 million rmb)	827160	Based on China's National Balance Sheet
B_f	Firms' bonds in value (100 million rmb)	220142	Based on China's National Balance Sheet
B_g	Government bonds in value (100 million rmb)	352935	Based on China's National Balance Sheet
B_{lb}	Banks' bonds issued in value (100 million rmb)	281419	Based on China's National Balance Sheet
B_h	Households' bonds in value (100 million rmb)	27336	Based on China's National Balance Sheet
BP	Banks' net disposable income (100 million rmb)	-3196	Calculated from equation (2.144)
BPg	Banks' gross disposable income (100 million rmb)	34833	Based on National Bureau of Statistics of China
b_f	Firms' bonds in volume (100 million rmb)	5339	Calculated from equation (2.120)
b_g	Governments' bonds in volume (100 million rmb)	9141	Calculated from equation (2.194)
b_h	Households' bonds in volume (100 million rmb)	920	Calculated from equation (2.87)
b_{lb}	Banks' bonds issued in volume (100 million rmb)	7077	Calculated from equation (2.151)
C_g	Governments consumption (100 million rmb)	149600	Calculated from equation (2.26)
C_h	Households consumption (100 million rmb)	387188	Calculated from equation (2.26)
CA	Current account surplus/deficit (100 million rmb)	9501	Calculated from equation (2.201)
CI	Carbon intensity (Mt/100 million rmb)	0.0109	Calculated from equation (2.19)
c_h	Households consumption in volume (100 million rmb)	387188	Based on the assumption that initial prices are 1

c_g	Governments consumption in volume (100 million rmb)	149600	Based on the assumption that initial prices are 1
D	Total deposits (100 million rmb)	2279930	Calculated from equation (2.146)
D_b	Banks' deposits held (100 million rmb)	198935	Based on China's National Balance Sheet
D_f	Firms' deposits (100 million rmb)	621147	Based on China's National Balance Sheet
D_g	Governments' deposits (100 million rmb)	339179	Based on China's National Balance Sheet
D_h	Households' deposits (100 million rmb)	1120669	Based on China's National Balance Sheet
DIV_g	Governments' dividend received (100 million rmb)	11257	Based on National Bureau of Statistics of China
DIV_h	Households' dividend received (100 million rmb)	3467	Based on National Bureau of Statistics of China
DIV_{pb}	Banks' dividend paid (100 million rmb)	7175	Based on National Bureau of Statistics of China
DIV_{pf}	Firms' dividend paid (100 million rmb)	43895	Based on National Bureau of Statistics of China
DIV_{rb}	Banks' dividend received (100 million rmb)	1229	Based on National Bureau of Statistics of China
DIV_{rf}	Firms' dividend received (100 million rmb)	26165	Based on National Bureau of Statistics of China
DIV_{rr}	The rest of the world's dividend received (100 million rmb)	8951	Based on National Bureau of Statistics of China
ΔA	Banks' insurance borrowing (100 million rmb)	10405	Calculated from equation (2.164)
ΔA_f	Firms' insurance savings (100 million rmb)	3122	Calibrated from equation (2.126) for initial steady state
ΔA_h	Households' insurance savings (100 million rmb)	7284	Calibrated from equation (2.94) for initial steady state
ΔB_{ab}	Banks' bonds savings (100 million rmb)	46456	Calculated from equation (2.149)
ΔB_f	Firms' bonds borrowing (100 million rmb)	12364	Calibrated from equation (2.119) for initial steady state
ΔB_g	Governments' bonds borrowing (100 million rmb)	19822	Calibrated from equation (2.193) for initial steady state
ΔB_h	Households' bonds savings (100 million rmb)	1535	Calibrated from equation (2.88) for initial steady state
ΔB_{lb}	Banks' bonds borrowing (100 million rmb)	15805	Calibrated from equation (2.152) for initial steady state
ΔD	Total deposits saving (100 million rmb)	128048	Calculated from equation (2.147)
ΔD_b	Banks' deposits saving (100 million rmb)	11173	Calibrated from equation (2.145) for initial steady state
ΔD_f	Firms' deposits saving (100 million rmb)	34886	Calibrated from equation (2.118) for initial steady state
ΔD_g	Governments' deposits saving (100 million rmb)	19049	Calibrated from equation (2.184) for initial steady state
ΔD_h	Households deposits saving (100 million rmb)	62940	Calibrated from equation (2.86) for initial steady state
ΔFDI_{out}	FDI outward flow (100 million rmb)	8250	Calibrated from equation (2.125) for

			initial steady state
ΔFDI_{in}	FDI inward flow (100 million rmb)	11533	Calibrated from equation (2.72) for initial steady state
ΔG	Change in international reserves (100 million rmb)	12232	Calibrated from equation (2.213) for initial steady state
ΔH	Currencies savings (100 million rmb)	3585	Calibrated from equation (2.85) for initial steady state
ΔIFS_{ab}	Banks' investment fund shares savings (100 million rmb)	27428	Calibrated from equation (2.160) for initial steady state
ΔIFS_{g}	Governments' investment fund shares savings (100 million rmb)	5422	Calibrated from equation (2.189) for initial steady state
ΔIFS_{h}	Households' investment fund shares savings (100 million rmb)	10807	Calibrated from equation (2.93) for initial steady state
ΔIFS_{lb}	Banks' investment fund shares borrowing	27428	Calculated from equation (2.162)
ΔL_{ar}	The rest of the world's loans savings (100 million rmb)	3249	Calculated from equation (2.203)
ΔL_{b}	Banks' loans savings (100 million rmb)	102220	Calculated from equation (2.155)
ΔL_{f}	Firms' loans borrowing (100 million rmb)	66306	Calculated from equation (2.130)
ΔL_{h}	Households loans borrowing (100 million rmb)	34213	Calculated from equation (2.97)
ΔL_{lr}	The rest of the world's loans borrowing (100 million rmb)	4950	Calculated from equation (2.205)
ΔZ_{b}	Banks other payable/receivables flows (100 million rmb)	8637	Calibrated from equation (2.165)
ΔZ_{f}	Firms' change in other accounts payable/receivables (100 million rmb)	-336	Calibrated from equation (2.128) for initial steady state
ΔZ_{g}	Governments change in other accounts payable/receivables (100 million rmb)	1661	Calibrated from equation (2.191) for initial steady state
ΔZ_{h}	Households' change in other accounts payable/receivables (100 million rmb)	0.1685	Calibrated from equation (2.96) for initial steady state
ΔZ_{r}	The rest of the world's change in other accounts payable/receivables (100 million rmb)	1149	Calibrated from equation (2.211) for initial steady state
E_{ab}	Banks' equities held in value (100 million rmb)	333067	Based on China's National Balance Sheet
E_{af}	Firms' equities held in value (100 million rmb)	61154	Based on China's National Balance Sheet
E_{g}	Governments' equities held in value (100 million rmb)	850000	Based on China's National Balance Sheet
E_{h}	Households' equities held in value (100 million rmb)	1702111	Based on China's National Balance Sheet
E_{lb}	Banks' equities issued in value (100 million rmb)	287758	Based on China's National Balance Sheet
E_{lf}	Firms' equities issued in value (100 million rmb)	2692202	Based on China's National Balance Sheet
E_{r}	The rest of the world's equities held in value (100 million rmb)	33628	Based on China's National Balance Sheet
$EMIS$	Carbon emissions (Mt)	10741	Calculated from equation (2.17)
$ENER$	Total primary energy production (TWh)	39978491	Our World in Data
EI	Energy intensity (TWh/100 million rmb)	40.52	Based on World Bank and Our World in Data

e_{ab}	Banks' equities held in volume (100 million rmb)	333067	Based on the assumption that initial prices are 1
e_{af}	Firms' equities held in volume (100 million rmb)	61154	Based on the assumption that initial prices are 1
e_g	Governments' equities held in volume (100 million rmb)	850000	Based on the assumption that initial prices are 1
e_r	The rest of the world's equities held in volume (100 million rmb)	33628	Based on the assumption that initial prices are 1
FDI_{out}	FDI outward stock (100 million rmb)	146886	Based on China's National Balance Sheet
FDI_{in}	FDI inward stock (100 million rmb)	205340	Based on China's National Balance Sheet
FFR	Federal funds rate	0.005	Based on Federal Reserves Economic Data
FP	Firms' net disposable income (100 million rmb)	205563	Calculated from equation (2.117)
FP_g	Firms' gross disposable income (100 million rmb)	219249	Calculated from equation (2.101)
G	International reserves (100 million rmb)	217797	Based on China's National Balance Sheet
GP	Governments' net disposable income (100 million rmb)	159352	Calculated from equation (2.170)
GP_g	Governments' gross disposable income (100 million rmb)	124985	Calculated from equation (2.168)
GS	Green subsidies (100 million rmb)	0	Assumed
$\Gamma_{k_{re}}$	Share of green capital for renewable energy production	0.0061	Calculated from $\Gamma_{k_{re}} = \frac{k_{re}}{k_e}$
Γ_{re}	Share of renewable energy	0.1582	Calculated from equation (2.8)
g_{ei}	Energy intensity growth	-0.0562	Calculated from equation (2.1) for initial steady state
g_y	Real GDP growth	0.0595	Calculated from the series of y
H	Currencies (100 million rmb)	63840	Based on China's National Balance Sheet
I_{1b}	Banks' fixed capital formation in value (100 million rmb)	1270	Calibrated from equation (2.138) for initial steady state
I_{1f}	Firms' fixed capital formation in value (100 million rmb)	169038	Calibrated from equation (2.104) for initial steady state
I_{1g}	Governments' fixed capital formation in value (100 million rmb)	16697	Calibrated from equation (2.173) for initial steady state
I_h	Households' fixed capital formation in value(100 million rmb)	185997	Calibrated from equation (2.81) for initial steady state
I_{2f}	Firms' changes in inventories in value (100 million rmb)	67027	Calibrated from equation (2.108) for initial steady state
I_{2g}	Governments' changes in inventories in value (100 million rmb)	524.28	Calibrated from equation (2.178) for initial steady state
I_{3f}	Firms' acquisition less disposal of other non-financial assets in value (100 million rmb)	26669	Calculated from equation (2.181)
I_{3g}	Governments' acquisition less disposal of other non-financial assets in value (100 million rmb)	-26669	Calibrated from equation (2.112) for initial steady state
IFS_{ab}	Banks investment fund shares held (100 million rmb)	488365	Based on China's National Balance Sheet

IFS_g	Governments' investment fund shares held (100 million rmb)	96545	Based on China's National Balance Sheet
IFS_h	Households' investment fund shares held (100 million rmb)	192424	Based on China's National Balance Sheet
IFS_{lb}	Banks' investment fund shares issued (100 million rmb)	777334	Based on China's National Balance Sheet
INT_{bf}	Firms' bonds interest paid (100 million rmb)	5040	Calculated from $INT_{bf} = \frac{r_{pf}B_f}{1+g_y}$
INT_{bg}	Governments' bonds interest paid (100 million rmb)	8631	Calculated from $INT_{bg} = \frac{r_{pg}B_g}{1+g_y}$
INT_{bh}	Households' bonds interest received (100 million rmb)	868.41	Calculated from $INT_{bh} = \frac{r_{rh}B_h}{1+g_y}$
INT_{brb}	Banks' bonds interest received (100 million rmb)	19483	Calculated from equation (2.134)
INT_{bpb}	Banks' bonds interest paid (100 million rmb)	6680	Calculated from $INT_{bpb} = \frac{r_{pb}B_{lb}}{1+g_y}$
INT_d	Banks' deposits interest paid (100 million rmb)	66995	Calculated from equation (2.136)
INT_{db}	Banks' deposits interest received (100 million rmb)	4177	Calculated from $INT_{db} = \frac{r_{rb}D_b}{1+g_y}$
INT_{df}	Firms' deposits interest received (100 million rmb)	19921	Calculated from $INT_{df} = \frac{r_{rf}D_f}{1+g_y}$
INT_{dg}	Governments' deposits interest received (100 million rmb)	7296	Calculated from $INT_{dg} = \frac{r_{rg}D_g}{1+g_y}$
INT_{dh}	Households' deposits interest received (100 million rmb)	35601	Calculated from $INT_{dh} = \frac{r_{rh}D_h}{1+g_y}$
INT_{lb}	Banks' loans interest received (100 million rmb)	44892	Calculated from equation (2.135)
INT_{lf}	Firms' loans interest paid (100 million rmb)	27027	Calculated from $INT_{lf} = \frac{r_{pf}L_f}{1+g_y}$
INT_{lh}	Households' loans interest paid (100 million rmb)	13610	Calculated from $INT_{lh} = \frac{r_{ph}L_h}{1+g_y}$
INT_{pb}	Banks' interest paid (100 million rmb)	73674	Calculated from $INT_{pb} = INT_d + INT_{bpb}$
INT_{pf}	Firms' interest paid (100 million rmb)	32066	Calculated from $INT_{pf} = INT_{bf} + INT_{lf}$
INT_{pr}	The rest of the world's interest paid (100 million rmb)	5830	Calculated from $INT_{pr} = \frac{r_{pr}L_{lr}}{1+g_y}$
INT_{rb}	Banks' interest received (100 million rmb)	68552	Calculated from $INT_{rb} = INT_{db} + INT_{brb} + INT_{lb}$
INT_{rh}	Households' interest received (100 million rmb)	36470	Calculated from $INT_{rh} = INT_{dh} + INT_{bh}$
INT_{rr}	The rest of the world's interest received (100 million rmb)	1574	Calculated from $INT_{rr} = \frac{r_{rr}L_{ar}}{1+g_y}$
i_{1b}	Banks' fixed capital formation in volume (100 million rmb)	1270	Based on the assumption that initial prices are 1
i_{1f}	Firms' fixed capital formation in volume (100 million rmb)	169038	Based on the assumption that initial prices are 1
i_{1g}	Governments' fixed capital formation in volume (100 million rmb)	16697	Based on the assumption that initial prices are 1
i_h	Households' fixed capital formation in volume	185898	Based on the assumption that initial

	(100 million rmb)		prices are 1
i_{2f}	Firms' changes in inventories in volume (100 million rmb)	67027	Based on the assumption that initial prices are 1
i_{2g}	Governments' changes in inventories in volume (100 million rmb)	524.28	Based on the assumption that initial prices are 1
i_{3f}	Firms' acquisition less disposal of other non-financial assets in volume (100 million rmb)	26669	Based on the assumption that initial prices are 1
K_{1b}	Banks' fixed capital in value (100 million rmb)	15928	Based on China's National Balance Sheet
K_{1f}	Firms' fixed capital in value (100 million rmb)	1751211	Based on China's National Balance Sheet
K_{1g}	Governments' fixed capital in value (100 million rmb)	209337	Based on China's National Balance Sheet
K_{2g}	Governments' fixed capital in value (100 million rmb)	9335	Based on China's National Balance Sheet
K_h	Households' fixed capital in value (100 million rmb)	2499331	Based on China's National Balance Sheet
K_{2f}	Firms' inventories in value (100 million rmb)	1193439	Based on China's National Balance Sheet
K_{3b}	Banks' other non-financial assets in value (100 million rmb)	18282	Based on China's National Balance Sheet
K_{3f}	Firms' other non-financial assets in value (100 million rmb)	474852	Based on China's National Balance Sheet
K_{3g}	Governments' other non-financial assets in value (100 million rmb)	447314	Based on China's National Balance Sheet
k_{1b}	Banks' fixed capital in volume (100 million rmb)	15928	Based on the assumption that initial prices are 1
k_{1f}	Firms' fixed capital in volume (100 million rmb)	1751211	Based on the assumption that initial prices are 1
k_{1g}	Governments' fixed capital in volume (100 million rmb)	209337	Based on the assumption that initial prices are 1
k_h	Households' fixed capital in volume (100 million rmb)	2499331	Based on the assumption that initial prices are 1
k_{2f}	Firms' inventories in volume (100 million rmb)	1193439	Based on the assumption that initial prices are 1
k_{2g}	Governments' inventories in volume (100 million rmb)	9335	Based on the assumption that initial prices are 1
k_{3f}	Firms' other non-financial assets in volume (100 million rmb)	474852	Based on the assumption that initial prices are 1
k_{3g}	Governments' other non-financial assets in volume (100 million rmb)	447314	Based on the assumption that initial prices are 1
k_{ce}	Capital for convention energy production in volume (100 million rmb)	348122	Calculated from $k_{ce} = k_e - k_{re}$
k_e	Capital for energy production in volume, calculated by accumulating fixed capital formation of the energy sector (100 million rmb)	350247	Based on National Bureau of Statistics of China and China's National Balance Sheet
k_{re}	Capital for renewable energy production in volume (100 million rmb)	2125	Calculated from equation (2.3) under the assumption that renewable energy are produced with the same technology

L_{ar}	The rest of the world's loans held (100 million rmb)	57843	Based on China's National Balance Sheet
L_b	Banks loans held (100 million rmb)	1820063	Based on China's National Balance Sheet
L_f	Firms' loans (100 million rmb)	1180596	Based on China's National Balance Sheet
L_h	Households loans (100 million rmb)	609179	Based on China's National Balance Sheet
L_{lr}	The rest of the world's loans issued (100 million rmb)	88131	Based on China's National Balance Sheet
LF	Labour force (100 million)	7.7532	Based on World Bank
M	Imports (100 million rmb)	172444	Based on World Bank
m	Real import (100 million rmb)	172444	Based on the assumption that initial prices are 1
N	Employment (100 million)	7.3997	Based on World Bank
NFI_b	Banks' net financial investment (100 million rmb)	-4466	Calibrated from $NFI_b = \Delta G - \Delta H$ $+\Delta D_b - \Delta D + \Delta B_{ab} - \Delta B_{lb} + \Delta L_b$ $+\Delta IFS_{ab} - \Delta IFS_{lb} - \Delta A + \Delta Z_b$ for initial steady state
NFI_f	Firms' net financial investment (100 million rmb)	51939	Calculated from equation (2.130)
NFI_g	Governments' net financial investment (100 million rmb)	6311	Calculated from equation (2.182)
NFI_h	Households' net financial investment (100 million rmb)	-44281.96	Calculated from equation (2.84)
NFI_r	The rest of the world's net financial investment (100 million rmb)	-9501	Calculated from equation (2.202)
NX	Net exports (100 million rmb)	9174	Based on National Bureau of Statistics of China
O_b	Banks' other current transfers paid (100 million rmb)	-29153	Calculated from equation (2.137)
O_f	Firms' other current transfers paid (100 million rmb)	-14742	Calculated from equation (2.103)
O_g	Governments' other current transfers received (100 million rmb)	-7145	Calculated from equation (2.171)
O_h	Households' other current transfers paid (100 million rmb)	-25092	Calculated from $O_h = \gamma_{O_h} YD_g$
O_r	The rest of the world's other current transfers paid (100 million rmb)	3535	Calculated from equation (2.199)
OIP_b	Banks' other income from properties paid (100 million rmb)	1931	Calculated from equation (2.133)
OIP_f	Firms' other income from properties paid (100 million rmb)	7847	Based on National Bureau of Statistics of China
OIP_g	Governments' other income from properties received (100 million rmb)	5896	Calculated from equation (2.169)
OIP_h	Households other income from properties received (100 million rmb)	5159	Based on National Bureau of Statistics of China
OIP_r	The rest of the world's other income from properties paid (100 million rmb)	1276	Based on National Bureau of Statistics of China

P_{b_f}	Price of firms' bonds	41.23	Calculated from $P_{b_f} = \frac{1}{r_{pf}}$
P_{b_g}	Price of government bonds	38.59	Calculated from equation (2.196)
P_{b_h}	Price of households bonds	29.71	Calculated from equation (2.90)
$P_{b_{lb}}$	Price of banks bonds issued	39.76	Calculated from $P_{b_{lb}} = \frac{1}{r_{pb}}$
P_c	CPI (2019 = 1)	1	Assumed
P_{ce}	Price of conventional energy (100 million rmb/TWh)	3.8e-4	Based on China Energy Portal
$P_{e_{ab}}$	Price of banks equity held	1	Assumed
$P_{e_{af}}$	Price of firms equity held	1	Assumed
P_{e_g}	Price of governments equity held	1	Assumed
$P_{e_{lb}}$	Price of banks equity issued	1	Assumed
$P_{e_{lf}}$	Price of firms equity issued	1	Assumed
P_{e_r}	Price of the rest of the world equity held	1	Assumed
P_{ener}	Price of aggregate energy (100 million rmb/TWh)	0.0005	Calculated from equation (2.75)
P_{k_1}	Fixed capital price index (2019 = 1)	1	Assumed
P_{k_h}	Housing price index (2019 = 1)	1	Assumed
$P_{k_{2f}}$	Price of firms inventories (2019 = 1)	1	Assumed
$P_{k_{2g}}$	Price of government inventories (2019 = 1)	1	Assumed
P_{k_3}	Price of other non-financial assets (2019 = 1)	1	Assumed
P_m	Import price index (2019 = 1)	1	Assumed
P_{re}	Price of renewable energy, solar (100 million rmb/TWh)	8.5e-4	Based on China Energy Portal
P_x	Export price index (2019 = 1)	1	Assumed
P_y	GDP deflator (2019 = 1)	1	Assumed
Π_b	Banks' gross operating surplus (100 million rmb)	47833	Calculated from equation (2.132)
Π_f	Firms' gross operating surplus (100 million rmb)	256972	Calculated from equation (2.100)
Π_g	Governments' gross operating surplus (100 million rmb)	11535	Calculated from equation (2.167)
Π_h	Households' gross operating surplus (100 million rmb)	59284	Calculated from equation (2.77)
π	CPI inflation	0	Assumed for initial steady state
$REV_{b_{ab}}$	Banks' bonds held revaluation (100 million rmb)	0	Assumed for initial steady state
REV_{b_f}	Firms' bonds revaluation (100 million rmb)	0	Assumed for initial steady state
REV_{b_g}	Governments' bonds revaluation (100 million rmb)	0	Assumed for initial steady state
REV_{b_h}	Households' bonds revaluation (100 million rmb)	0	Assumed for initial steady state
$REV_{b_{lb}}$	Banks' bonds issued revaluation (100 million rmb)	0	Assumed for initial steady state
$REV_{e_{ab}}$	Banks' equity held revaluation (100 million rmb)	18706	Calibrated from equation (2.156) for initial steady state
$REV_{e_{af}}$	Firms' equity held revaluation (100 million rmb)	3435	Calibrated from equation (2.122) for initial steady state
REV_{e_g}	Governments' equity held revaluation (100 million rmb)	47739	Calibrated from equation (2.185) for initial steady state
REV_{e_h}	Households' equity held revaluation	95596	Calibrated from equation (2.91) for

	(100 million rmb)		initial steady state
$REV_{e_{lb}}$	Banks' equity issued revaluation (100 million rmb)	16161	Calibrated from equation (2.24) for initial steady state
$REV_{e_{lf}}$	Firms' equity issued revaluation (100 million rmb)	151202	Calibrated from equation (2.24) for initial steady state
REV_{e_r}	The rest of the world's equity held revaluation (100 million rmb)	1889	Calibrated from equation (2.206) for initial steady state
$REV_{k_{1b}}$	Banks' fixed capital revaluation (100 million rmb)	0	Assumed for initial steady state
$REV_{k_{1f}}$	Firms' fixed capital revaluation (100 million rmb)	0	Assumed for initial steady state
$REV_{k_{1g}}$	Governments' fixed capital revaluation (100 million rmb)	0	Assumed for initial steady state
REV_{k_h}	Households' fixed capital revaluation (100 million rmb)	0	Assumed for initial steady state
$REV_{k_{2f}}$	Firms' inventories revaluation (100 million rmb)	0	Assumed for initial steady state
$REV_{k_{3b}}$	Banks' other non-financial assets revaluation	1027	Calibrated from equation (2.143)
$REV_{k_{3f}}$	Firms' other non-financial assets revaluation (100 million rmb)	0	Assumed for initial steady state
r_{10}	10-year government bond yield	0.032	Based on Investing.com
r_{pb}	Banks rate of interest paid	0.0251	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{pf}	Firms rate of interest paid	0.0243	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{pg}	Governments rate of interest paid	0.0259	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{ph}	Households rate of interest paid	0.0237	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{pr}	The rest of the world rate of interest paid	0.0701	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{rb}	Banks rate of interest received	0.0222	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{rf}	Firms' rate of interest received	0.034	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{rg}	Governments' rate of interest received	0.0228	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{rh}	Households' rate of interest received	0.0337	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{rr}	The rest of the world's rate of interest	0.0288	Based on National Bureau of Statistics

	received		of China and China's National Balance Sheet
S_g	Governments' savings (100 million rmb)	9752	Calculated from equation (2.172)
S_h	Households' savings (100 million rmb)	237936	Calculated from equation (2.80)
S_r	The rest of the world's savings and (2.212) (100 million rmb)	-9501	Calibrated from equation (2.202) for initial steady state
SB	Social benefits (100 million rmb)	70238	Based on National Bureau of Statistics of China
SC	Social contributions (100 million rmb)	64049	Based on National Bureau of Statistics of China
T	Income tax received by governments (100 million rmb)	47702	Based on National Bureau of Statistics of China
T_b	Income tax paid by banks (100 million rmb)	8876	Based on National Bureau of Statistics of China
T_f	Income tax paid by firms (100 million rmb)	28428	Based on National Bureau of Statistics of China
T_h	Income tax paid by households (100 million rmb)	10399	Based on National Bureau of Statistics of China
TL	Net production tax received by governments (100 million rmb)	97632	Based on National Bureau of Statistics of China
TL_b	Net production tax paid by banks (100 million rmb)	7595	Based on National Bureau of Statistics of China
TL_f	Net production tax paid by firms (100 million rmb)	88546	Based on National Bureau of Statistics of China
TL_h	Net production tax paid by households (100 million rmb)	1493	Based on National Bureau of Statistics of China
θ	Carbon emission per energy consumption (Mt/TWh)	0.00027	Based on Our World in Data
U_k	Capacity utilization of firms' fixed capital	0.7511	Wang and Zeng (2022)[19]
ULC	Unit labour cost	0.5205	Calculated from equation (2.36)
u	Unemployment rate	0.0456	Based on World Bank
V_h	Households' net worth (100 million rmb)	5126225	Calculated from equation (2.99)
V_g	Governments' net worth (100 million rmb)	1628347	Calculated from equation (2.197)
V_r	The rest of the world's net worth (100 million rmb)	-135543	Calculated from equation (2.197)
W	Total wage bill (100 million rmb)	513472	Based on National Bureau of Statistics of China
W_b	Wage paid by banks (100 million rmb)	20824	Based on National Bureau of Statistics of China
W_f	Wage paid by firms (100 million rmb)	266647	Based on National Bureau of Statistics of China
W_g	Wage paid by governments (100 million rmb)	89253	Based on National Bureau of Statistics of China
W_h	Wage paid by households (100 million rmb)	136534	Based on National Bureau of Statistics of China
W_r	Wage paid by the rest of the world (100 million rmb)	213.73	Based on National Bureau of Statistics of China

[19] Chinese article. Wang and Zeng (2022). Research on the Macro Measurement Indicators and Methods of Capital Utilization Rate. *Statistical Research, 39*(7), 43-55.

w	Real wage (100 million rmb)	0.0005	Calculated from equation (2.35)
X	Export (100 million rmb)	181617	Based on World Bank
XR	Nominal effective exchange rate	1	Assumed
x	Real export (100 million rmb)	181617	Based on the assumption that initial prices are 1
Y	Nominal GDP (100 million rmb)	986515	Based on National Bureau of Statistics of China
Y_b	Banks' output (100 million rmb)	76251	Based on National Bureau of Statistics of China
Y_f	Firms' output (100 million rmb)	612165	Based on National Bureau of Statistics of China
Y_g	Governments' output (100 million rmb)	100788	Based on National Bureau of Statistics of China
Y_h	Households' output (100 million rmb) (100 million rmb)	197312	Based on National Bureau of Statistics of China
Y_r	Nominal GDP of the rest of the world (100 million US dollar)	5074080	Based on World Bank
YD	Households' net disposable income (100 million rmb)	625124	Calculated from equation (2.79)
YD_g	Households' gross disposable income (100 million rmb)	604242	Based on National Bureau of Statistics of China
y	Real GDP (100 million rmb)	986515.2	Based on the assumption that initial prices are 1
$y_{N,t}$	Labor productivity	133318	Real GDP per labour
Z_b	Banks' other accounts payable/receivables (100 million rmb)	-44044	Based on China's National Balance Sheet
Z_f	Firms' other accounts payable/receivables (100 million rmb)	-5991	Based on China's National Balance Sheet
Z_g	Governments' other accounts payable/receivables (100 million rmb)	29572	Based on China's National Balance Sheet
Z_h	Households other accounts payable/receivable (100 million rmb)	3	Based on China's National Balance Sheet
Z_r	The rest of the world other accounts payable/receivables (100 million rmb)	20460	Based on China's National Balance Sheet

Table 2.5: Values for parameters

Symbol	Description	Value	Remark/sources
a_{f0}	Firms insurance preference	0.0337	Calibrated from equation (2.54) for initial steady state
a_{f1}	Sensitivity of firms insurance to net disposable income	-0.1551	Estimated from OLS regression
a_{h0}	Housholds insurance preference	0.0563	Calibrated from equation (2.48) for initial steady state
a_{h1}	Sensitivity of households insurance to real equity and investment fund shares return	-0.009	Estimated from OLS regression
a_{h2}	Sensitivity of households insurance to	-0.2379	Estimated from OLS regression

	net disposable income		
α_0	Price mark-up of fixed assets (short-run)	-0.0135	Calibrated from equation (2.38) for initial steady state
α_1	Elasticity of price of fixed assets to CPI (short run)	1.1134	Estimated from OLS regression
α_2	Price of fixed assets long run correction	-0.3091	Estimated from OLS regression
α_2	Elasticity of price of fixed assets to unit labour cost (long run)	0.6729	Estimated from OLS regression
α_4	Elasticity of price of fixed assets to capacity utilization (long run)	0.6431	Estimated from OLS regression
α_{re}	Maximum elasticity of substitution of renewable energy with respect to conventional energy	18.74	Calibrated from equation (2.9) for initial steady state
b_{f0}	Firms bond issued preference	0.1919	Calibrated from equation (2.51) for initial steady state
b_{f1}	Sensitivity of firms bonds to net disposable income	-1.3786	Estimated from OLS regression
b_{h0}	Households bond held preference	0.004	Calibrated from equation (2.46) for initial steady state
b_{h1}	Sensitivity of households bonds to real interest received	0.2856	Estimated from OLS regression
b_{h2}	Sensitivity of households bonds to real interest paid	-0.3161	Estimated from OLS regression
b_{h3}	Sensitivity of households bonds to real equity and investment fund shares return	-0.0101	Estimated from OLS regression
β_0	Autonomous utilized fixed capital growth	1.5404	Calibrated from equation (2.28) for initial steady state
b_{lb0}	Banks liquidity demand for issuing bonds	1.252	Calibrated from equation (2.60) for initial steady state
b_{lb1}	Sensitivity of banks bonds issued to real rate of interest paid	-8.5838	Estimated from OLS regression
β_1	Elasticity of firms fixed capital utilized to real GDP (short run)	0.4926	Estimated from OLS regression
β_2	Firms fixed capital utilized long run correction	-0.1623	Estimated from OLS regression
β_3	Minimum firms fixed capital utilized, log	-11.3465	Estimated from OLS regression
β_4	Elasticity of firms fixed capital utilized to real GDP (long run)	2.4807	Estimated from OLS regression
β_5	Technology spillover effect of FDI inward (long run)	-1.4807	Calibrated from $\beta_5 = 1 - \beta_4$ for initial steady state
β_{re}	Sensitivity of elasticity of substitution of renewable energy with respect to conventional energy to the ratio of conventional energy over renewable energy	-3.07	Aleti and Hochman (2020)
c_0	Autonomous consumption growth	-0.102	Calibrated from equation (2.42) for initial steady state
c_1	Households consumption income effect (short run)	0.9299	Estimated from OLS regression
c_2	Households consumption long run correction income	-0.7253	Estimated from OLS regression
c_3	Households consumption habit formation	0.6199	Estimated from OLS regression
c_4	Households consumption income effect (short run)	0.3801	Calibrated from $c_4 = 1 - c_3$ for initial steady state
ce_0	Carbon emission per conventional energy	0.0003	Calibrated from equation (2.18) for

			initial steady state
ce_1	Sensitivity of carbon emission per energy to the share of renewable energy	-0.0003	Calibrated from equation (2.18) to have $\theta = 0$ when $\Gamma_{eg} = 1$
c_{g0}	Government consumption per real GDP	0.1607	Calibrated from equation (2.62) for initial steady state
d_{b0}	Banks deposit held preference	0.7325	Calibrated from equation (2.59) for initial steady state
d_{b1}	Sensitivity of banks deposits held to real rate of interest received	5.7436	Estimated from OLS regression
d_{f0}	Liquidity preference of firms	0.1226	Calibrated from equation (2.50) for initial steady state
d_{f1}	Sensitivity of firms deposits to real rate of interest received	0.5008	Estimated from OLS regression
d_{f2}	Sensitivity of firms deposits to net disposable income	1.5954	Estimated from OLS regression
d_{g0}	Governments' deposits per net worth	0.2207	Calibrated from equation (2.183) for initial steady state
d_{h0}	Households liquidity preference to deposits	0.215	Calibrated from equation (2.45) for initial steady state
d_{h1}	Sensitivity of households deposits to real interest received	1.2286	Estimated from OLS regression
d_{h2}	Sensitivity of households deposits to real interest paid	-1.0466	Estimated from OLS regression
δ_b	Banks' fixed capital depreciation rate	0.025	Based on China's National Balance Sheet
δ_f	Firms' fixed capital depreciation rate	0.0428	Based on China's National Balance Sheet
δ_g	Governments' fixed capital depreciation rate	0.025	Based on the China's National Balance Sheet
δ_h	Households' fixed capital depreciation rate	0.0193	Based on the China's National Balance Sheet
e_0	Minimum energy production (TWh)	397578	Calibrated from equation (2.3) for initial steady state
e_1	Sensitivity of energy production to capital for energy production	0.3612	Estimated from OLS regression
F_{re}	Fixed cost of renewable energy production	5295	Calibrated from equation (2.12) for initial steady state
fdi_{out0}	Firms outward FDI preference	0.0904	Calibrated from equation (2.53) for initial steady state
fdi_{out1}	Sensitivity of FDI outward to firms gross profit rate	-0.2539	Estimated from OLS regression
fdi_{in0}	Autonomous FDI inward accumulation rate	-0.0815	Calibrated from equation (2.72) for initial steady state
fdi_{in1}	Sensitivity of FDI inward to firms gross profit rate	0.9612	Estimated from OLS regression
γ_{DIV_g}	Governments rate of dividend received	0.0126	Calibrated from $\gamma_{DIV_g} = \frac{DIV_g(1+g_y)}{E_g+IFS_g}$ for initial steady state
γ_{DIV_h}	Households rate of dividend received	0.1333	Calibrated from $\gamma_{DIV_h} = \frac{DIV_h(1+g_y)}{E_h+IFS_h}$ for initial steady state
$\gamma_{DIV_{pb}}$	Banks rate of dividend paid	0.0071	Calibrated from $\gamma_{DIV_{pb}} = \frac{DIV_{pb}(1+g_y)}{E_{lb}+IFS_{lb}}$ for initial steady state

$\gamma_{DIV_{rb}}$	Banks rate of dividend received	0.0016	Calibrated from $\gamma_{DIV_{rb}} = \frac{DIV_{rb}(1+g_y)}{E_{ab}+IFS_{ab}}$ for initial steady state
$\gamma_{DIV_{rf}}$	Firms rate of dividend received	0.0019	Calibrated from $\gamma_{DIV_{rf}} = \frac{DIV_{rf}(1+g_y)}{E_{af}+FDI_{out}}$ for initial steady state
$\gamma_{DIV_{rr}}$	The rest of the world rate of dividend received	0.0397	Calibrated from $\gamma_{DIV_{rr}} = \frac{DIV_{rr}(1+g_y)}{E_r+FDI_{in}}$ for initial steady state
γ_{O_b}	Share of banks other current transfers received	-0.8369	Calculated from $\gamma_{O_b} = \frac{O_b}{BP_g}$
γ_{O_h}	Share of households other current transfers paid	-0.0415	Calibrated from equation (2.79), (2.80), (2.84) and (2.97) for initial steady state
γ_{O_f}	Share of firms other current transfers paid	-0.0672	Calculated from $\gamma_{O_f} = \frac{O_f}{FP_g}$
γ_{O_r}	Share of the rest of the world other current transfers paid	-0.3941	Calibrated from $\gamma_{O_r} = \frac{O_r(1+g_y)}{Sr}$ for initial steady state
γ_{OIP_b}	Share of banks other income from properties paid	0.0587	Calibrated from $\gamma_{OIP_b} = \frac{OIP_b(1+g_y)}{BP_g}$ for initial steady state
γ_{OIP_f}	Share of firms other income from properties received	0.0379	Calibrated from $\gamma_{OIP_f} = \frac{OIP_f(1+g_y)}{FP_g}$ for initial steady state
γ_{OIP_h}	Share of households other income from properties received	0.009	Calibrated from $\gamma_{OIP_h} = \frac{OIP_h(1+g_y)}{YD_g}$ for initial steady state
γ_{OIP_r}	Share of the rest of the world other income from properties paid	-0.1423	Calibrated from $\gamma_{OIP_r} = \frac{OIP_r(1+g_y)}{S_r}$ for initial steady state
γ_{SB}	Social benefit to GDP	0.0712	Calculated from $\gamma_{SB} = \frac{SB}{Y}$
γ_{TRK}	Capital transfers to GDP	0.0131	Calculated from $\gamma_{TRK} = \frac{TRK}{Y}$
γ_{W_b}	Share of banks' wage paid	0.0406	Calculated from $\gamma_{W_b} = \frac{W_b}{W}$
γ_{W_f}	Share of firms' wage paid	0.5193	Calculated from $\gamma_{W_f} = \frac{W_f}{W}$
γ_{W_g}	Share of governments wage paid	0.1738	Calculated from $\gamma_{W_g} = \frac{W_g}{W}$
γ_{W_h}	Share of households wage paid	0.2659	Calculated from $\gamma_{W_h} = \frac{W_h}{W}$
γ_{W_r}	Share of the rest of the world wage paid	0.0004	Calculated from $\gamma_{W_h} = \frac{W_r}{W}$
γ_{Y_b}	Share of banks' output	0.0773	Calculated from equation (2.76)
γ_{Y_f}	Share of firms' output	0.6205	Calculated from equation (2.76)
γ_{Y_g}	Share of governments' output	0.1022	Calculated from equation (2.76)
h_0	Households liquidity preference for currencies	-0.0231	Calibrated from equation (2.44) for initial steady state
h_1	Households' propensity to hold currencies	0.2981	Estimated from OLS regression
i_{b0}	Banks autonomous fixed capital accumulation rate	0.0207	Calibrated from equation (2.58) for initial steady state
i_{b1}	Sensitivity of banks fixed capital accumulation rate to profit rate	0.0147	Estimated from OLS regression
i_{f0}	Autonomous firms' capital accumulation rate	-0.7653	Calibrated from equation (2.49) for initial steady state
i_{f1}	Sensitivity of firms' capital accumulation rate to net profit rate	0.6249	Estimated from OLS regression
i_{f2}	Sensitivity of firms' capital accumulation rate to capacity utilization	0.9912	Estimated from OLS regression
i_{g0}	Government investment per real GDP	0.0179	Calibrated from equation (2.63) for initial steady state
i_{h0}	Households autonomous investment, growth	-0.0052	Calibrated from equation (2.43) for initial steady state
i_{h1}	Elasticity of households investment growth to	1.0902	Estimated from OLS regression

	net worth growth		
i_{1g0}	Government fixed capital formation to GDP	0.0179	Calibrated from equation (2.63) for initial steady state
i_{2f0}	Share of firms' changes in inventories	0.072	Calibrated from equation (2.110) for initial steady state
i_{3f0}	Share of firms' acquisition net disposal of other non-financial asset	0.0286	Calibrated from equation (2.115) for initial steady state
ifs_{ab0}	Banks investment fund shares held preference	1.5755	Calibrated from equation (2.61) for initial steady state
ifs_{ab1}	Sensitivity of banks investment fund shares held to banks rate of investment fund shares return	0.8398	Estimated from OLS regression
ifs_{ab2}	Sensitivity of banks investment fund shares held to net disposable income	-18.099	Estimated from OLS regression
ifs_{g0}	Share of governments investment fund share	0.0628	Calibrated from equation (2.188) for initial steady state
ifs_{h0}	Households preference for investment fund shares	0.0379	Calibrated from equation (2.47) for initial steady state
ifs_{h1}	Households investment fund shares auto-correlation of 1 lag	0.6631	Estimated from OLS regression
ifs_{h2}	Sensitivity of households investment fund shares to net disposable income lag	-0.1891	Estimated from OLS regression
k_{2g0}	Accelerator effect of governments inventories	0.01	Calibrated from equation (2.177) for initial steady state
k_{3b0}	Accelerator effect of banks other non-financial assets	0.0196	Calibrated from equation (2.142) for initial steady state
k_{3g0}	Accelerator effect of governments other non-financial assets	0.4804	Calibrated from equation (2.180) for initial steady state
l_{ar0}	The rest of world loans held autonomous accumulation	0.0388	Calibrated from equation (2.70) for initial steady state
l_{ar1}	Sensitivity of RoW loan held to rate of interest received by the RoW	0.7170	Estimated from OLS regression
l_{lr0}	Share of the rest of the world loans issued	-0.6888	Calibrated from equation (2.204) for initial steady state
m_0	Import level when $Y_t = 1$ (100 million rmb)	0.1852	Calibrated from equation (2.69) for initial steady state
p_{c0}	Mark-up of CPI, growth	0.6912	Calibrated from equation (2.37) for initial steady state
p_{c1}	Elasticity of CPI to unit labour cost (short run)	0.5753	Estimated from OLS regression
p_{c2}	CPI long run correction	-.3359	Estimated from OLS regression
p_{c3}	Elasticity of CPI to unit labour cost (long run)	0.6245	Estimated from OLS regression
p_{c4}	Elasticity of CPI to energy price (long run)	0.2144	Estimated from OLS regression
p_{eg0}	Return premium of government equity held	0.037	Calibrated from equation (2.64) for initial steady state
p_{eg1}	Price of government equity held long-run correction	-0.2749	Estimated from OLS regression
p_{eg2}	Price premium of government equity held	0.0757	Estimated from OLS regression
p_{eg3}	Elasticity of price of government equity held to price of banks equity issued	1	Calibrated for initial steady state
p_{er0}	Return premium of the rest of the world	-0.1272	Calibrated from equation (2.71)

	equities held		for initial steady state
p_{er1}	Elasticity of price of the rest of the world equity held to price of banks equity issued (short run)	3.2009	Estimated from OLS regression
p_{er2}	Price of the rest of the world equity held long-run correction	-0.5334	Estimated from OLS regression
p_{er3}	Elasticity of price of the rest of the world equity held to price of firms equity issued	1	Calibrated for initial steady state
p_{k0}	Mark-up of capital price	1.349	Calibrated from equation (2.38) for initial steady state
p_{kh1}	Elasticity of housing price growth to inflation	1.3932	Estimated from OLS regression
p_{x0}	Mark-up of export price	1.2502	Calibrated from equation (2.40) for initial steady state
p_{x1}	Elasticity of export price growth to unit labour cost growth	0.3297	Estimated from OLS regression
r_0	10-year government bond yield lower bound	0.0082	Calibrated from equation (2.55) for initial steady state
r_1	Sensitivity of 10-year government bond yield to housing price growth	0.0424	Estimated from OLS regression
r_2	Sensitivity of 10-year government bond yield to CPI inflation	0.2142	Estimated from OLS regression
$r_{k_{ce}}$	Marginal cost of conventional energy production	0.0158	Calibrated from equation (2.11) for initial steady state
r_{pb0}	Banks rate of interest paid premium	-0.0022	Calibrated from equation (2.131) for initial steady state
r_{pb1}	Sensitivity of banks rate of interest paid to 10-year government bond yield	0.3241	Estimated from OLS regression
r_{pf0}	Firms rate of interest paid premium	0.0015	Calibrated from equation (2.57) for initial steady state
r_{pf1}	Sensitivity of banks rate of interest paid to banks rate of interest received	0.762	Estimated from OLS regression
r_{pg0}	Governments rate of interest paid premium	-0.0015	Calibrated from equation (2.131) for initial steady state
r_{pg1}	Sensitivity of governments rate of interest paid to 10-year government bond yield	0.2432	Estimated from OLS regression
r_{ph0}	Households rate of interest paid premium	-0.0014	Calibrated from equation (2.131) for initial steady state
r_{ph1}	Sensitivity of Households rate of interest paid to 10-year government bond yield	0.1621	Estimated from OLS regression
r_{pr0}	The rest of the world rate of interest paid premium	-0.0014	Calibrated from equation (2.66) for initial steady state
r_{pr1}	Sensitivity of the rest of the world rate of interest paid to NEER growth	-0.2143	Estimated from OLS regression
r_{pr2}	Sensitivity of the rest of the world rate of interest paid to federal funds rate	0.2455	Estimated from OLS regression
r_{rb0}	Banks rate of interest received lower bound, log	-8.0814	Calibrated from equation (2.56) for initial steady state
r_{rb1}	Semi-elasticity of banks rate of interest received to capacity utilization	5.6927	Estimated from OLS regression
r_{rf0}	Firms rate of interest received premium	0.0005	Calibrated from equation (2.131)

			for initial steady state
r_{rf1}	Sensitivity of firms rate of interest received to 10-year government bond yield	0.2793	Estimated from OLS regression
r_{rg0}	Governments rate of interest received premium	-0.0015	Calibrated from equation (2.131) for initial steady state
r_{rg1}	Sensitivity of governments rate of interest received to 10-year government bond yield	0.1663	Estimated from OLS regression
r_{rh0}	Households rate of interest received premium	0.0006	Calibrated from equation (2.131) for initial steady state
r_{rh1}	Sensitivity of households rate of interest received to 10-year government bond yield	0.3832	Estimated from OLS regression
r_{rr0}	The rest of the world rate of interest received lower bound	0.0006	Calibrated from equation (2.67) for initial steady state
r_{rr1}	Sensitivity of the rest of the world rate of interest received to NEER growth	0.0226	Estimated from OLS regression
τ_b	Income tax rate paid by banks	0.2548	Calculated from $\tau_b = \frac{T_b}{BP_g}$
τ_f	Income tax rate paid by firms	0.1297	Calculated from $\tau_f = \frac{T_f}{FP_g}$
τ_h	Income tax rate paid by households	0.0172	Calculated from $\tau_h = \frac{T_h}{YD_g}$
τ_{L_b}	Net production tax rate paid by banks	0.0996	Calculated from $\tau_{L_b} = \frac{TL_b}{Y_b}$
τ_{L_f}	Net production tax rate paid by firms	0.1446	Calculated from $\tau_{L_f} = \frac{TL_f}{Y_f}$
τ_{L_h}	Net production tax rate paid by households	0.0076	Calculated from $\tau_{L_h} = \frac{TL_h}{Y_h}$
τ_{sc}	Social contribution ratio over wage bill	0.1247	Calculated from $\tau_{sc} = \frac{SC}{W}$
w_0	Exogenous real wage growth	0.0309	Calibrated from equation (2.34) for initial steady state
w_1	Sensitivity of real wage growth to labour productivity growth	-0.0009	Estimated from OLS regression
x_0	Autonomous export demand growth	0.2784	Calibrated from equation (2.68) for initial steady state
x_1	Elasticity of export to foreign demand (short run)	0.9844	Estimated from OLS regression
x_2	Exports long-run correction	-0.769	Estimated from OLS regression
x_3	Minimum exports demand, log	-8.2468	Estimated from OLS regression
x_4	Elasticity of exports to foreign demand (long run)	1.2962	Estimated from OLS regression
xr_0	Nominal effective exchange rate premium	-0.0152	Calibrated from equation (2.65) for initial steady state
xr_1	Elasticity of NEER to interest rate parity	0.5714	Estimated from OLS regression
z_{f0}	Share of firms other accounts payable/receivable	-0.0024	Calibrated from equation (2.127) for initial steady state
z_{g0}	Share of governments other accounts payable/receivable	0.0192	Calibrated from equation (2.190) for initial steady state
z_{h0}	Share of households other accounts payable/receivable	6.2e-7	Calibrated from equation (2.95) for initial steady state
z_{r0}	Share of the rest of the world other accounts payable/receivable	-0.1599	Calibrated from equation (2.210) for initial steady state
y_{n0}	Initial labour productivity, log	28.01	Calibrated from equation (2.30) for initial steady state
y_{n1}	Elasticity of labour productivity to FDI inward (short run)	0.1872	Estimated from OLS regression
y_{n2}	Labour productivity long run correction	-0.3688	Estimated from OLS regression
y_{n3}	Minimum labour productivity, log	-68.83	Estimated from OLS regression

y_{n4}	Elasticity of labour productivity to FDI inward (long run)	0.392	Estimated from OLS regression
y_{n5}	Labour productivity exogenous improvement	0.0375	Estimated from OLS regression

Chapter 3

An Empirical Ecological Stock Flow Consistent Model of China

Abstract

This paper develops an empirical ecological stock-flow consistent model for China. It embeds the Chinese balance sheet and transaction flow matrix and describes institutions' behaviours to mimic the Chinese economy. By including the material and energy balance, the model can link the economy to its effect on the environment. We also include the linkage that there is a negative relationship between inequality and environmental quality. We use the in-sample prediction to validate the model and find that the fitness of the data is fairly good. We run a baseline scenario under a promised green transition from 2019 to 2035, giving a reference to future predictions. It shows that green transition alone is insufficient to prevent emissions from increasing before 2030 in China (policy target). Then, we compare a working hour reduction shock to a wage increase policy and income redistribution policy. All three policies reduce real GDP, income inequality and emissions. A working hour reduction reduces income equality and unemployment more significantly but may trigger inflation in the short run. A wage increase only shows short-run effects in reducing income inequality and emissions and results in high inflation and more unemployment. A redistribution policy will have a long-lasting negative effect on economic growth, but it reduces income inequality and emissions to the air more significantly.

Keywords: *income inequality, stock-flow consistent modelling, working hour, energy balance, material emissions*

JEL codes: *D63, E12, J08, Q43, Q58*

3.1 Introduction

Stock-flow consistent (SFC) models, as a branch of macroeconomic models, are tools to answer macroeconomic research questions. Theoretical models are clean and tight to explain a specific economic phenomenon. When it comes to a national economy, an empirical model has the advantage of capturing some specific features of the economy Zezza and Zezza (2019). Theoretical models assume the economy starts with a balanced growth path or an initial steady state to avoid spikes in the beginning periods of the simulation and focus on the second moment fitness to the data, i.e. variance and covariance. It requires some parameters and initial value of variables to be chosen to calibrate to guarantee this assumption, losing some degree of freedom and introducing distortion. When the system is small, it is very likely that the calibrated parameters or initial variables have bizarre values because it ignores many channels of the real world. Empirical models, unlike theoretical models that are built from simple to more complex, start directly from the complete system and attempt to simplify without breaking the completeness of the system; for example, if we drop the deposits held by the rest of the world, then we need to assume the same amount of money appear somewhere in the assets side or cancelled out in the liability side so that the foreign net worth does not change; moreover, the interest generated by these deposits also has to be dropped and appear somewhere in the current account. Empirical models do not require an initial steady state assumption since they describe the full system, and the system never has a balanced growth path. It allows the model to directly validate the first moment of the data, e.g., the level and the long-term trend, and it does not require calibration to distort the value of the parameters and the initial value of the variables.

Recently, studies employing an empirical SFC framework for some economies have been emerging: the Argentina model (Valdecantos, 2022), the Denmark model (Byrialsen and Raza, 2021), the French model (Mazier and Reyes, 2022), the Italian model (F. Zezza and Zezza, 2022), the Netherlands model (Meijers and Muysken, 2022), the UK model (George and Dafermos, 2023), and a few to name. Most of the studies are on developed countries because of data availability. Very few of them have integrated the ecological side, which has become one of the biggest trends in the theoretical framework (Jacques et al., 2023). SFC models, as a type of demand-driven model of economic growth, have the advantage of studying social transformation to achieve sustainable growth, such as sustainable consumption, reduced working time, and the rebound effect (Rezai et al., 2013).

This paper presents an empirical ecological SFC model of China. It develops the first existing empirical SFC model of the Chinese economy and is one of the few that attempt to integrate the ecological side with the country's material and energy balance. Over the past decades, China has shown incredible economic growth. The tremendous economic performance of China, however, accompanies some costs. China has become the largest carbon emitter in the world. The income gap in China has risen and remains at a high level between the working class and the capitalists. In this paper, we attempt to give a near-future prediction of China and policy advice to solve these issues.

The National Bureau of Statistics has reported that the average working hour per week has reached 48.6 in the first half of 2024, which has peaked in the past two decades. The "996" work regime has become a hot word in China in recent years, which means working from 9 am to 9 pm daily and six working days weekly. While, according to the *Labor Law of the People's Republic of China* issued on 07/05/1994, the State shall practice a working hour system wherein labourers shall work for no more than eight hours a day and no more than 44 hours a week on the average.

Long working hours are considered one of the major risk factors for workplace accidents and workers' health (Lee and Lee, 2016, and Berniell and Bietenbeck, 2020). Reducing working hours, in traditional belief, is considered a policy for increasing employment since firms have to hire additional workers, i.e. work sharing. While it may also increase wage pressure, causing more unemployment (Skans, 2001). In this paper, we investigate the effect of a working hour reduction shock on unemployment, income inequality and material emissions. In comparison, we also test a wage increase policy and an income redistribution policy.

The following section describes the model. Section 3.3 discusses the data management and parameters estimations. Section 3.4 discusses the model validation. Section 3.5 shows the model prediction for the near future and policy scenarios. And, last, we conclude and remark.

3.2 The Model

The economy comprises five sectors: households, firms, banks, governments, and the rest of the world (RoW). Households and governments consume the final good according to their consumption functions. Investments are made by households (mainly real estate acquisition), firms and governments (final good production) through their investment decisions. Banks receive deposits and issue bonds and loans to fulfil money demand (endogenous money). The Central Bank, which is included in the banking sector, runs an inflation-biased Taylor rule by adjusting the policy rate. Accounting equations such as changes in loans and bonds and the accumulation of assets and liabilities are modelled to guarantee stock-flow consistency. Behaviour equations, e.g., consumption and investment decisions and financial instruments saving/borrowings, follow Post-Keynesian economic theory and adjust to the econometric regression results. Prices are endogenous and depend on production costs.

The ecological block includes the material balance and energy balance of China (see Table 3.1). They account for material and energy inflows and outflows, which are linked to economic activities.

Table 3.1: Physical flow matrix

	Material balance	Energy balance
Inflows		
Biomass extraction	$+DE_b$	
Fossil energy material extraction	$+DE_f$	$+EN$
Metal ores extraction	$+DE_m$	
Non-metallic material extraction	$+DE_{nm}$	
Renewable energy		$+ER$
Biomass import	$+MIM_b$	
Fossil energy material import	$+MIM_f$	$+EIM$
Metal ores import	$+MIM_m$	
Non-metallic material import	$+MIM_{nm}$	
Other products import	$+MIM_o$	
Balancing items	$+BI_{in}$	
Recovery of energy		$+RoE$
Outflows		
Biomass consumption	$-DMC_b$	
Fossil energy material consumption	$-DMC_f$	
Metal ores consumption	$-DMC_m$	
Non-metallic ores consumption	$-DMC_{nm}$	
Other products consumption	$-DMC_o$	
Energy consumption		$-EC$
Biomass export	$-MEX_b$	
Fossil energy material export	$-MEX_f$	$-EEX$
Metal ores export	$-MEX_m$	
Non-metallic material export	$-MEX_{nm}$	
Other products export	$-MEX_o$	
Emissions to air	$-DPO_a$	
Dissipative use of products	$-DPO_{dup}$	
Emissions to water	$-DPO_w$	
Balancing items	$-BI_{out}$	$-EB$
Change in stock	$-NAS$	$+ESC$
Total	0	0

Note: + denotes inflows, - denotes outflows. Other product consumption is a mismatched item. Energy stock change is recorded as an inflow.

3.2.1 Energy

According to the energy balance sheet from the National Bureau of Statistics of China (NBSC), energy consumption, EC_t, follows,

$$EC_t = EP_t - EEX_t + EIM_t + RoE_t + ESC_t - EB_t, \tag{3.1}$$

where EP_t denotes primary energy production, EEX_t denotes energy exports, EIM_t denotes energy imports, RoE_t denotes recovery of energy, ESC_t denotes energy stock change, and EB_t is a balancing item. The last three terms are assumed to be exogenous because their level is negligible from the data.

Primary energy production is driven by energy intensity and aggregate demand,

$$EP_t = \varepsilon_t y_t, \tag{3.2}$$

where y_t denotes real GDP and ε_t denotes energy intensity. Jun et al. (2011) show there is a negative relationship between income distribution and environmental quality in China, which supports the hypothesis in Boyce 1994. We assume that a larger income distribution gap would cause people to consume more energy-intensive goods to capture this relationship,

$$\Delta \ln \varepsilon_t = \varepsilon_1 \Delta \ln y_t + \varepsilon_2 \left[\ln \varepsilon_{t-1} - \varepsilon_3 - \varepsilon_4 \ln gini_{t-1} - \varepsilon_5 \ln y_{t-1}\right], \tag{3.3}$$

where $\varepsilon_1 < 0$ is the short-run elasticity of energy intensity to real GDP (Kaldor-Verdoon law), $-1 < \varepsilon_2 < 0$ is the long-run correction parameter of energy intensity, ε_3 is the level of energy intensity in logarithm when the Gini coefficent equals 1 and real GDP equals 100 million rmb, $\varepsilon_4 > 0$ is the elasticity of energy intensity to the Gini coefficient, and $\varepsilon_5 < 0$ is the long-run elasticity of energy intensity to real GDP (Kaldor-Verdoon law).

Primary energy production consists of fossil energy production and renewable energy production. Renewable energy production is determined by the green share,

$$ER_t = \theta_t EP_t, \tag{3.4}$$

where θ_t denotes the share of renewable energy production, which is exogenous.

Fossil energy production fulfils the remaining energy production needs,

$$EN_t = EP_t - ER_t. \tag{3.5}$$

Energy exports depend on exports in volume,

$$EEX_t = \varepsilon_{ex} x_t, \tag{3.6}$$

where ε_{ex} is the energy intensity of exports, which is exogenous, and x_t is exports in volume.

Similarly, energy imports depend on imports in volume,

$$EIM_t = \varepsilon_{im} m_t, \tag{3.7}$$

where ε_{im} is the energy intensity of imports, also exogenous, and m_t is imports in volume.

3.2.2 Materials

The accounting structure of material flows follows Chen et al. (2022). We separate materials into five categories: biomass, fossil energy materials, metal ores, non-metallic materials, and other products.

Aggregate domestic material input consists of aggregate domestic extraction and aggregate material import,

$$DMI_t = DE_t + MIM_t, \tag{3.8}$$

where DE_t denotes aggregate domestic extraction and MIM_t denotes aggregate material import.

Similarly, domestic biomass input, domestic fossil energy materials input, domestic metal ores input, and domestic non-metallic input are the sum of their domestic extraction and imports,

$$DMI_{i,t} = DE_{i,t} + MIM_{i,t},\ i = b, f, m, nm, \tag{3.9}$$

where the subscript $i = b, f, m, nm$ represents biomass, fossil energy materials, metal ores, and non-metallic materials, respectively.

Other product inputs, specifically, are only imported,

$$DMI_{o,t} = MIM_{o,t}, \tag{3.10}$$

where the subscript o represents other products.[1]

Aggregate domestic extraction equals the sum of biomass extraction, fossil energy materials

[1] Other products are balancing instruments for the physical trade balance, which are only recorded in material exports and imports.

extraction, metal ores extraction, and non-metallic extraction,

$$DE_t = DE_{b,t} + DE_{f,t} + DE_{m,t} + DE_{nm,t}. \tag{3.11}$$

Domestic extractions, except fossil energy materials, are demanded directly from economic activities,

$$DE_{i,t} = \mu_i y_t,\ \forall i \neq f, \tag{3.12}$$

where μ_i denotes the respective material intensity, which is exogenous.

Domestic fossil energy material extraction is driven by fossil energy production,

$$DE_{f,t} = \frac{EN_t}{car}, \tag{3.13}$$

where car is the coverage ratio of fossil energy production, which is exogenous.

Aggregate material imports contain all five types of material imports,

$$MIM_t = MIM_{b,t} + MIM_{f,t} + MIM_{m,t} + MIM_{nm,t} + MIM_{o,t}. \tag{3.14}$$

Material imports, except fossil energy materials, are driven by imports in volume,

$$MIM_{i,t} = \mu_{i,im} m_t,\ \forall i \neq f, \tag{3.15}$$

where $\mu_{i,im}$ denotes the respective import material intensity.

Fossil energy material import is determined by the imported energy,

$$MIM_{f,t} = \frac{EIM_t}{car_{im}}, \tag{3.16}$$

where car_{im} is the coverage ratio of energy imports.

Aggregate domestic material consumption equals aggregate domestic material input subtracts aggregate material export,

$$DMC_t = DMI_t - MEX_t, \tag{3.17}$$

where MEX_t denotes aggregate material export. The same for all types of materials,

$$DMC_{i,t} = DMI_{i,t} - MEX_{i,t},\ \forall i. \tag{3.18}$$

Aggregate material exports contain all five types of material exports,

$$MEX_t = MEX_{b,t} + MEX_{f,t} + MEX_{m,t} + MEX_{nm,t} + MEX_{o,t}. \tag{3.19}$$

Material exports, except fossil energy materials, are driven by exports in volume,

$$MEX_{i,t} = \mu_{i,ex} x_t, \ \forall i \neq f, \tag{3.20}$$

where $\mu_{i,ex}$ denotes the respective export material intensity.

Fossil energy material export is determined by the exported energy,

$$MEX_{f,t} = \frac{EEX_t}{car_{ex}}, \tag{3.21}$$

where car_{ex} is the coverage ratio of energy exports.

Aggregate material stock follows,

$$MS_t = MS_{t-1} + NAS_t + OCS_t, \tag{3.22}$$

where NAS_t denotes net additions to material stock, and OCS_t denotes other changes in material stock, which is a discrepancy item assumed to be exogenous.

Net additions to material stock follow,

$$NAS_t = DMC_t + BI_{in,t} - DPO_t - BI_{out,t}, \tag{3.23}$$

where $BI_{in,t}$ denotes material inflows balancing items, DPO_t denotes aggregate domestic processed output, and $BI_{out,t}$ denotes material outflows balancing items.

Material inflow balancing items are mainly oxygen required in the combustion process of fossil energy,

$$BI_{in,t} = comb_{in} DMC_{f,t}, \tag{3.24}$$

where $comb_{in}$ denotes the combustion inflow coefficient.

The aggregate domestic processed output follows,

$$DPO_t = DPO_{a,t} + DPO_{dup_t} + DPO_{w,t}, \tag{3.25}$$

where $DPO_{a,t}$ denotes emissions to air, $DPO_{dup,t}$ denotes dissipative use of products, and $DPO_{w,t}$ denotes emission to water.

Emissions to air are mainly CO_2, SO_2, etc released from the fossil energy combustion process,

$$DPO_{a,t} = \nu_a DMC_{f,t}, \tag{3.26}$$

where ν_a is the coefficient of emission to air, which is exogenous.

The dissipative use of products mainly consists of materials dissipated by fertilizer use. It is driven by biomass extraction,

$$DPO_{dup,t} = \nu_{dup,t} DE_{b,t}, \tag{3.27}$$

where $\nu_{dup,t}$ is the coefficient of dissipative use of products. We assume a larger income distribution gap would cause more dissipative use of products under the same level of biomass extraction to capture the negative relationship between income distribution and environmental quality (Boyce, 1994 and Jun et al., 2011),

$$\Delta \ln \nu_{dup,t} = dup_0 + dup_1 \Delta \ln gini_t + dup_2 \left[\ln \nu_{dup,t-1} - dup_3 - dup_4 \ln gini_{t-1} - dup_5 \ln y_{t-1} \right], \tag{3.28}$$

where $dup_0 < 0$ denotes the short-run exogenous reduction of dissipative use of products to biomass extraction, $dup_1 > 0$ is the short-run elasticity of the coefficient of dissipative use of products to the Gini coefficient, $-1 < dup_2 < 0$ is the long-run correction parameter of the coefficient of dissipative use of products, dup_3 is the level of the coefficient of dissipative use of products in logarithm when the Gini coefficient equals 1 and real GDP equals 100 million rmb, $dup_4 > 0$ is the long-run elasticity of the coefficient of dissipative use of products to the Gini coefficient, and $dup_5 < 0$ is the elasticity of the coefficient of dissipative use of products to real GDP (Kaldor-Verdoorn law).

Emissions to water are mainly materials released in industrial and municipal wastewater. They are driven by economic activities,

$$DPO_{w,t} = \nu_{w,t} y_t, \tag{3.29}$$

where $\nu_{w,t}$ is the emissions to water intensity. Similar to energy intensity and the coefficient of dissipative use of products, we assume a larger income distribution gap would cause more wastewater to real GDP,

$$\Delta \ln \nu_{w,t} = \nu_{w1} \Delta \ln y_t + \nu_{w2} \left[\ln \nu_{w,t-1} - \nu_{w3} - \nu_{w4} \ln gini_{t-1} - \nu_{w5} \ln y_{t-1} \right], \tag{3.30}$$

where $\nu_{w1} < 0$ denotes the short-run elasticity of emissions to water intensity to real GDP (Kaldor-Verdoorn law), $-1 < \nu_{w2} < 0$ is the long-run correction parameter of emissions to water intensity, ν_{w3} is the level of emissions to water intensity in logarithm when the Gini coefficient equals 1 and real GDP equals 100 million rmb, $\nu_{w4} > 0$ is the elasticity of emission to water intensity to the Gini coefficient, and $\nu_{w5} < 0$ is the long-run elasticity of emissions to water intensity to real GDP (Kaldor-Verdoorn law).

Material outflow balancing items are mainly water vapour from the combustion process of fossil energy,

$$BI_{out,t} = comb_{out} DMC_{f,t}, \tag{3.31}$$

where $comb_{out}$ denotes the combustion outflow coefficient, which is exogenous.

3.2.3 Macroeconomy

This section is an improved version of the macroeconomic model in An (2024b). The economy comprises five sectors: firms, banks, governments, households, and the rest of the world (RoW) (see Table 3.3). Firms, banks, governments, and households hold fixed capital, K_{1f}, K_{1b}, K_{1g} and K_{1h}, respectively. Firms and governments hold inventories, K_{2f} and K_{2g}, which include both output and input inventories. Firms, banks, and governments hold other non-financial assets (NFA), K_{3f}, K_{3b}, and K_{3g}, respectively, which include patents and nationally owned construction land, etc. Banks hold international reserves, G. Households hold currencies issued by the central bank, H. Banks issue deposits, D. Sectors borrow money from each other through bonds or loans, B and L. Firms' and banks' equity on the liability side account for both equity issued and net assets, so their net worth is 0 (*China's National Balance Sheet 2018*). In this case, the net worth of firms and banks is transferred to their owners (the other sectors) through equities holding, E. Investing banks issue investment fund shares to investors, IFS. Firms and households buy insurance from banks, A_f and A_h, respectively. Other accounts payable/receivables, Z, capture the statistic misallocation and net position of all the other instruments by sectors that are not included in the model.[2] Net worth represents the net asset position of the sectors, in other words, wealth. The economy's total wealth should equal total physical capital, aggregate fixed capitals, inventories, and other NFA, $V_g + V_h + V_r = K = K_1 + K_2 + K_3$.

[2]For simplicity, we drop net positions of the instruments held by sectors that are negligible in their size, for example, currencies held by sectors other than households and foreign bonds held and issued.

Table 3.3: The national balance sheet

	Firms	Banks	Governments	Households	RoW	Total
Fixed capitals	$+K_{1f}$	$+K_{1b}$	$+K_{1g}$	$+K_h$		$+K_1$
Inventories	$+K_{2f}$		$+K_{2g}$			$+K_2$
Other NFA	$+K_{3f}$	$+K_{3b}$	$+K_{3g}$			$+K_3$
International reserves		$+G$			$-G$	0
Currencies		$-H$		$+H$		0
Deposits	$+D_f$	$+D_b - D$	$+D_g$	$+D_h$		0
Bonds	$-B_f$	$+B_{ab} - B_{lb}$	$-B_g$	$+B_h$		0
Loans	$-L_f$	$+L_b$		$-L_h$	$+L_{ar} - L_{lr}$	0
Equities	$+E_{af} - E_{lf}$	$+E_{ab} - E_{lb}$	$+E_g$	$+E_h$	$+E_r$	0
Investment funds shares		$+IFS_{ab} - IFS_{lb}$	$+IFS_g$	$+IFS_h$		0
FDI	$+FDI_{out} - FDI_{in}$				$+FDI_{in} - FDI_{out}$	0
Insurance	$+A_f$	$-A$		$+A_h$		0
Other accounts payable/receivable (+/-)	$+Z_f$	$+Z_b$	$+Z_g$	$+Z_h$	$+Zr$	0
Networth	0	0	V_g	V_h	V_r	$+K$

Note: + denotes assets, - denotes liabilities.

The transaction flow matrix shows the transaction received and paid between sectors (see Table 3.4). Each column has to sum up to zero to satisfy the vertical consistency, meaning that transactions received and paid have to even out in every sector (see equation 3.53 for the example of households). Each row also has to sum up to zero for horizontal consistency. It guarantees that there is no black hole; any transaction received/paid by a sector has to be paid/received by another sector.

Table 3.4: Transaction flow matrix

	Production	Firms	Banks	Governments	Households	RoW	Total
GDP	$-Y$	$+Y_f$	$+Y_b$	$+Y_g$	$+Y_h$		0
	$+Y_{adj}$						
Consumption	$+C$			$-C_g$	$-C_h$		0
Fixed capital formation	$+I_1$	$-I_{1f}$	$-I_{1b}$	$-I_{1g}$	$-I_h$		0
Change in inventories	$+I_2$	$-I_{2f}$		$-I_{2g}$			0
Acquisition less disposals of		$-I_3$		$+I_3$			0
other NFA							
Export	$+X$					$-X$	0
Import	$-M$					$+M$	0
Net export adjustment	$+NX_{adj}$					$-NX_{adj}$	0
Wages		$-W_f$	$-W_b$	$-W_g$	$+W-W_h$	$-W_r$	0
Net taxes on production		$-TL_f$	$-TL_b$	$+TL$	$-TL_h$		0
Interest on deposits		$+INT_{df}$	$+INT_{db}$	$+INT_{dg}$	$+INT_{dh}$		0
			$-INT_d$				
Interest on bonds		$-INT_{bf}$	$+INT_{brb}$	$-INT_{bg}$	$+INT_{bh}$		0
			$-INT_{bpb}$				
Interest on loans		$-INT_{lf}$	$+INT_{lb}$		$-INT_{lh}$	$+INT_{rr}$	0
						$-INT_{pr}$	
Distributed income of		$+DIV_{rf}$	$+DIV_{rb}$	$+DIV_g$	$+DIV_h$	$+DIV_{rr}$	0
Corporations		$-DIV_{pf}$	$-DIV_{pb}$				
Other income from properties		$+OIP_f$	$-OIP_b$	$+OIP_g$	$+OIP_h$	$-OIP_r$	0
Taxes on income and wealth		$-T_f$	$-T_b$	$+T$	$-T_h$		0
Social contributions				$+SC$	$-SC$		0
Social benefits				$-SB$	$+SB$		0
Other current transfers		$-O_f$	$+O_b$	$+O_g$	$-O_h$	$-O_r$	0
Social transfers in kind				$-STR$	$+STR$		0
Capital transfers		$+TRK$		$-TRK$			0
Errors and omissions	$-EO$	$+EO_f$	$+EO_b$	$+EO_g$	$+EO_h$	$+EO_r$	0
International reserves			$-\Delta G$			$+\Delta G$	0
Currencies			$+\Delta H$		$-\Delta H$		0
Deposits		$-\Delta D_f$	$-\Delta D_b$	$-\Delta D_g$	$-\Delta D_h$		0
			$+\Delta D$				
Bonds		$+\Delta B_f$	$-\Delta B_{ab}$	$+\Delta B_g$	$-\Delta B_h$		0
			$+\Delta B_{lb}$				
Loans		$+\Delta L_f$	$-\Delta L_b$		$+\Delta L_h$	$-\Delta L_{ar}$	0
						$+\Delta L_{lr}$	
Investment fund shares			$-\Delta IFS_{ab}$	$-\Delta IFS_g$	$-\Delta IFS_h$		0
			$+\Delta IFS_{lb}$				
FDI inward		$+\Delta FDI_{in}$				$-\Delta FDI_{in}$	0
FDI outward		$-\Delta FDI_{out}$				$+\Delta FDI_{out}$	0
Insurance		$-\Delta A_f$	$+\Delta A$		$-\Delta A_h$		0
Other account payable		$-\Delta Z_f$	$-\Delta Z_b$	$-\Delta Z_g$	$-\Delta Z_h$	$-\Delta Z_r$	0
/receivables (+/-)							
Total	0	0	0	0	0	0	0

Note: + denotes transactions received, - denotes transactions paid. According to the National Bureau of Statistics of China, acquisition less disposals of other NFA are mainly transfers from firms to governments, and there are no data for banks, which are inconsistent with the balance sheet. Adjustment variables and errors and omissions are included to solve the data mismatch because of different sources and statistical methods.

Same with An (2024b), firms' and banks' equity on the liability side account for both equity issued and net assets, so their net worth is 0 (*China's National Balance Sheet 2018*, see Table 2.2). Equity flows reported by *National Bureau of Statistics* of China are 0 (see Table 2.3). Therefore, we have the following treatment for equity liabilities of firms and banks, i) the value of firms' and banks' equity on the liability side of the balance sheet satisfies the following conditions to guarantee their net worth is zero,

$$E_{lf,t} = K_{1f,t} + K_{2f,t} + K_{3f,t} + D_{f,t} - B_{f,t} - L_{f,t} + E_{af,t} + FDI_{out,t} - FDI_{in,t} + A_{f,t} + Z_{f,t} \quad (V_{f,t} = 0), \quad (3.32)$$

$$E_{lb,t} = K_{1b,t} + K_{3b,t} + G_t - H_t + D_{b,t} - D_t + B_{ab,t} - B_{lb,t} + L_{b,t} + E_{ab,t} + IFS_{ab,t} - IFS_{lb,t} - A_t + Z_{b,t} \quad (V_b = 0), \quad (3.33)$$

ii) since there are no equity flows, the revaluation effect accounts for all the changes in value,

$$REV_{e_{lj},t} = E_{lj,t} - E_{lj,t-1},\ j = b, f, \quad (3.34)$$

iii) we derive the implicit equity price indices,[3]

$$P_{e_{lj},t} = P_{e_{lj},t-1} \frac{REV_{e_{lj},t}}{E_{lj,t-1}},\ j = b, f. \quad (3.35)$$

The following subsections present the main equations of the sectors. Behaviour equations follow the Post-Keynesian macroeconomic theory (e.g. Godley and Lavoie, 2006) and are pragmatically verified by econometrics employing historical annual data from 2000 to 2019 (National Bureau of Statistics of China, China's National Balance Sheet and World Bank).[4] Other simplified behaviour equations and accounting equations are shown in detail in the Appendix.

Final good equilibrium

Final good production, Y_t, fulfills the aggregate demand, which consists of households consumption, $C_{h,t}$, government consumption, $C_{g,t}$, fixed capital formation by firms, banks, and governments, $I_{1f,t}$, $I_{1b,t}$ and $I_{1g,t}$, respectively, fixed capital formation by households (mainly dwelling acquisition), $I_{h,t}$, change in inventories by firms and governments, $I_{2f,t}$ and $I_{2g,t}$, net exports, $X_t - M_t$, net exports adjustment, $NX_{adj,t}$, errors and omissions, EO_t, and GDP adjustment, $Y_{adj,t}$,

$$Y_t = C_{h,t} + C_{g,t} + I_{1f,t} + I_{1b,t} + I_{1g,t} + I_{h,t} + I_{2f,t} + I_{2g,t} + X_t - M_t + NX_{adj,t} - EO_t + Y_{adj,t}. \quad (3.36)$$

[3] We have tried using the stock market price index to estimate equity flows, but it would increase the mismatch of net financial investment between the real account and financial account in the transaction-flow matrix.

[4] Our method is pragmatic in the sense that we try to follow economic theories as closely as possible but drop the determinants in the behaviour equations that are not statistically significant.

Aggregate demand in real term (in volume),

$$y_t = c_{h,t} + c_{g,t} + i_{1f,t} + i_{1b,t} + i_{1g,t} + i_{h,t} + i_{2f,t} + i_{2g,t} + x_t - m_t + nx_{adj,t} - eo_t + y_{adj,t}, \quad (3.37)$$

where $c_{h,t} = \frac{C_{h,t}}{P_{c,t}}$, $c_{g,t} = \frac{C_{g,t}}{P_{c,t}}$, $i_{f,t} = \frac{I_{1f,t}}{P_{k_1,t}}$, $i_{1b,t} = \frac{I_{1b,t}}{P_{k_1,t}}$, $i_{1g,t} = \frac{I_{1g,t}}{P_{k_1,t}}$, $i_{h,t} = \frac{I_{h,t}}{P_{k_h,t}}$, $i_{2f,t} = \frac{I_{2f,t}}{P_{k_{2f},t}}$, $i_{2g,t} = \frac{I_{2g,t}}{P_{k_{2g},t}}$, $x_t = \frac{X_t}{P_{x,t}}$, $m_t = \frac{M_t}{P_{m,t}}$, $nx_{adj,t} = \frac{NX_{adj,t}}{P_{x,t}}$, $eo_t = \frac{EO_t}{P_{eo,t}}$ and $y_{adj,t} = \frac{Y_{adj,t}}{P_{y,t}}$ are the aggregate demand components in volume.[5] $P_{c,t}$ is the consumer price index (CPI). $P_{k_1,t}$ is the general capital price index. $P_{k_h,t}$ is the capital price index of households. $P_{k_{2f},t}$ and $P_{k_{2g},t}$ are the price of inventories held by firms and governments, respectively. $P_{x,t}$ and $P_{m,t}$ are the export and import price index, respectively. We assume net export adjustment is deflated by export price. $P_{eo,t}$, price of errors and omissions is calculated to make sure equation (3.36) and (3.37) are consistent. By definition, then, GDP deflator is $P_{y,t} = \frac{Y_t}{y_t}$.

Labour market

Following Keynes (1937), the employment level is determined by aggregate demand. Then, employment in our model, N_t, is simply real GDP over labour productivity times working hours,

$$N_t = \eta \frac{y_t}{y_{N,t}}, \quad (3.38)$$

where η is working hours standardize to 1 in the in-sample prediction and baseline scenario, and $y_{N,t}$ is labour productivity, measured in real GDP per labour, referring to Reati (2001).[6] Labour productivity follows the Kaldor-Verdoorn Law,

$$\Delta \ln y_{N,t} = y_{n_1} \Delta \ln y_{N,t-1} + y_{n_2} \Delta \ln y_t + y_{n_3}[\ln y_{N,t-1} - y_{n_4} - y_{n_5} \ln y_{N,t-2} - y_{n_6} \ln y_{t-1}], \quad (3.39)$$

where $0 < y_{n1} < 1$ is the short-run persistence of labour productivity, $y_{n2} > 0$ captures the short-run Kaldor-Verdoorn effect, $-1 < y_{n3} < 0$ is the parameter of labour productivity long-run correction, y_{n4} is the intercept of the long-run equation of labour productivity in logarithm, $0 < y_{n5} < 1$ is the long-run persistence of on labour productivity and $y_{n6} > 0$ captures the long-run Kaldor-Verdoorn effect.[7]

[5] Capital letters denote variables in value (nominal term), and small letters denote variables in volume (real term).

[6] We standardize working hour to 1 because there is no sufficient data to model it. Labour productivity is measured as annual real GDP per worker, which results in a caveat that the model does not capture the positive effect of working hour reduction on labour productivity (Collewet & Sauermann, 2017).

[7] We introduce the Kaldor-Verdoorn Law in labour productivity to offset the fluctuation of real GDP to employment and, as a consequence, to stabilize the unemployment rate in the model.

The unemployment rate, by definition, is unemployment over the labour force,

$$u_t = \frac{LF_t - N_t}{LF_t}, \tag{3.40}$$

where $LF_t = \gamma_{LF,t} POP_t$ denotes labour force, with $\gamma_{LF,t}$ the share of labour force in population and POP_t total population. The share of the labour force depends on the labour market condition; the higher the unemployment rate, the less the opportunity for the unemployed to find a job, and the less they want to enter the labour market,

$$\Delta\gamma_{LF,t} = lf_0 + lf_1 \Delta\gamma_{LF,t-1} + lf_2 u_t, \tag{3.41}$$

where $lf_0 > 0$ denotes the exogenous change of the labour force share, $0 < lf_1 < 1$ is the persistence of the change of labour force share, and $lf_2 < 0$ is the sensitivity of the change of labour share to the unemployment rate.

The nominal wage, w_t^{nom}, adjusts to CPI and depends on labour productivity and unemployment,

$$\begin{aligned} \Delta \ln w_t^{nom} = {} & w_1 \Delta \ln P_{c,t} + w_2 \Delta \ln \frac{y_t}{N_t} \\ & + w_3 \left(\ln w_{t-1}^{nom} - w_4 - w_5 \ln P_{c,t-1} - w_6 u_{t-1} - w_7 \ln \frac{y_{t-1}}{N_{t-1}} \right), \end{aligned} \tag{3.42}$$

where $w_1 > 0$ denotes the short-run elasticity of nominal wage to CPI, $w_2 > 0$ is the short-run elasticity of nominal wage to labour productivity, $-1 < w_3 < 0$ is the long-run correction parameter of nominal wage, w_4 is the nominal wage level in logarithm with full employment, CPI equals 1 and labour productivity equals 1 rmb per labour, $w_5 > 0$ is the long-run elasticity of nominal wage to CPI, $w_6 < 0$ denotes the sensitivity of nominal wage to unemployment and $w_7 > 0$ denotes the long-run elasticity of nominal wage to labour productivity.[8] The unemployment rate has a negative effect on the nominal wages because it decreases the probability of finding new jobs for workers, and consequently, the value of their outside options is reduced. Conversely, firms have a higher probability of filling their vacancy under a higher unemployment labour market. In summary, workers are worse off, and firms are better off in the wage bargaining process as the unemployment rate increases (Pissarides, 2000).

The total wage bill, W_t, equals the nominal wage times labour,

$$W_t = w_t^{nom} N_t. \tag{3.43}$$

[8] In equation (3.42) we have $\frac{y_t}{N_t}$ rather than $y_{N,t}$ for the working hour reduction scenario shown in section 3.5.2 because our nominal wage, w_t^{nom}, is measured by annually per workers rather than hourly per workers.

Unit labour cost, by definition, is the total wage bill divided by real GDP,

$$ULC_t = \frac{W_t}{y_t}. \tag{3.44}$$

Inequality

Income inequality can be caused by three aspects, i. inequality driven by unemployment, ii. wage inequality, iii. distributional income inequality (Checchi & García-Peñalosa, 2008). This model does not study wage inequality between skilled and unskilled workers. We focus on the two other aspects.

We employ the Gini coefficient to measure income inequality. By definition, it consists of the product of the employment share, $\frac{N_t}{POP_t}$, and the wage share, $\frac{W_t}{Y_t}$ (Bowles & Halliday, 2022). In addition, we include the social benefit to nominal GDP to capture the income redistribution effect,

$$gini_t = gini_0 + gini_1 \frac{N_t}{POP_t}\frac{W_t}{Y_t} + gini_2 \frac{SB}{Y_t}, \tag{3.45}$$

where $gini_0 \approx 1$ is the area below the equality line times two, $gini_1 \approx -1$ by definition, and $gini_3 < 0$ is the sensitivity of the Gini coefficient to the ratio of social benefits to nominal GDP.

Prices

Producers fulfil aggregate demand but set their prices based on their cost of production. The consumer price index (CPI) is determined by import price and unit labour cost,

$$\Delta \ln P_{c,t} = p_{c1}\Delta \ln P_{c,t-1} + p_{c2}\Delta \ln ULC_t + p_{c3}(\ln P_{c,t-1} - p_{c4} - p_{c5} \ln P_{c,t-2} - p_{c6} \ln ULC_{t-1}), \tag{3.46}$$

where $0 < p_{c1} < 1$ is the short-run persistence of CPI, $p_{c2} > 0$ is the short-run elasticity of CPI to unit labour cost, $-1 < p_{c3} < 0$ is the parameter of long-run correction of CPI, $p_{c4} > 0$ denotes the mark-up of CPI, $0 < p_{c5} < 1$ is the long-run persistence of CPI, and $p_{c6} > 0$ is the long-run elasticity of CPI to unit labour cost.

Similarly, the price of productive fixed capital depends on the import price and unit labour cost,

$$\Delta \ln P_{k_1,t} = \alpha_1 \Delta \ln P_{m,t} + \alpha_2 \Delta \ln ULC_t + \alpha_3(\ln P_{k_1,t-1} - \alpha_4 - \alpha_5 \ln P_{m,t-1} - \alpha_6 \ln ULC_{t-1}), \tag{3.47}$$

where $\alpha_1 > 0$ is the short-run elasticity of the price of fixed capital to import price, $\alpha_2 > 0$ is the short-run elasticity of the price of fixed capital to unit labour cost, $-1 < \alpha_3 < 0$ is the long-run correction parameter, $\alpha_4 > 0$ is the mark-up of the price of fixed capital, $\alpha_5 > 0$ is the long-run elasticity of the price of fixed capital to import price, and $\alpha_6 > 0$ is the long-run elasticity of the price of fixed capital to unit labour cost.

The housing price, $P_{k_h,t}$, is driven by housing demand, $k_{h,t}$,

$$\Delta \ln P_{k_h,t} = p_{kh1}\Delta \ln k_{h,t} + p_{kh2}\left(\ln P_{kh,t-1} - p_{kh3} - p_{kh4}\ln P_{k_h,t-2} - p_{kh5}\ln k_{h,t-1}\right), \quad (3.48)$$

where $p_{kh1} > 0$ is the short-run inversed demand elasticity of housing, $-1 < p_{kh2} < 0$ is the long-run correction parameter of housing price, p_{kh3} denotes the nominal housing price level in logarithm when the lagged level equals 1 and housing stock equals 100 million rmb, $0 < p_{kh4} < 1$ is the persistence of housing price, and $p_{kh5} > 0$ is the long-run inversed demand elasticity of housing.

Export price is determined by unit labour cost and the nominal effective exchange rate (rise = appreciation), XR_t, (imperfect pass-through, Goldberg and Knetter, 1996),

$$\Delta \ln P_{x,t} = p_{x1}\Delta \ln ULC_t + p_{x2}\Delta \ln XR_t + p_{x3}(\ln P_{x,t-1} - p_{x4} - p_{x5}\ln ULC_{t-1} - p_{x6}\ln XR_{t-1}), \quad (3.49)$$

where $p_{x1} > 0$ denotes the short-run elasticity of export price to unit labour cost, $p_{x2} < 0$ denotes the elasticity of export price to the exchange rate, $-1 < p_{x3} < 0$ is the long-run correction parameter of export price, p_{x4} is the level of export price in logarithm when the unit labour cost and the exchange rate equal 1, $p_{x5} > 0$ is the long-run elasticity of export price to unit labour cost, and $p_{x6} < 0$ is the elasticity of export price to the exchange rate.

For simplicity, we assume the price of imports, firms' inventories, government inventories, and other non-financial assets are exogenous.

Households

Households earn revenues, wages, interest from deposits and bonds, dividends, other income from properties, social benefits, and social transfers in kind. They pay taxes, interest on loans and social contributions.

Households' consumption depends on their consumption level in the past (habit formation), their disposable income deflated by consumption good price, $\frac{YD_t}{P_{c,t}}$ (income effect), and their currencies and deposit deflated by consumption good price, $\frac{H_{t-1}+D_{h,t-1}}{P_{c,t}}$ (wealth effect),

$$\Delta \ln c_{h,t} = c_0 + c_1 \Delta \ln \frac{YD_t}{P_{c,t-1}} + c_2 \left(\ln c_{h,t-1} - c_3 - c_4 \ln c_{h,t-2} - c_5 \ln \frac{YD_{t-1}}{P_{c,t-1}} - c_6 \ln \frac{H_{t-2} + D_{h,t-2}}{P_{c,t-1}} \right), \quad (3.50)$$

where $c_0 > 0$ denotes the autonomous consumption growth, $c_1 > 0$ captures the short-run income effect, $-1 < c_2 < 0$ is the long-run correction parameter, $c_3 > 0$ denotes the autonomous consumption, $0 < c_4 < 1$ captures consumption habit formation, $c_5 > 0$ captures the long-run income effect, $c_6 > 0$ captures the wealth effect.

Housing demand depends on the population. We introduce a lag for housing demand to capture speculation behaviour in the housing market with equation (3.48),

$$\Delta \ln k_{h,t} = k_{h1} \Delta \ln k_{h,t-1} + k_{h2} \Delta \ln POP_t + k_{h3} (\ln k_{h,t-1} - k_{h4} - k_{h5} \ln k_{h,t-2} - k_{h6} \ln POP_{t-1}), \quad (3.51)$$

where $k_{h1} > 0$ captures the short-run speculation behaviour, $k_{h2} > 0$ denotes the short-run elasticity of housing demand to population, $-1 < k_{h3} < 0$ is the long-run correction parameter, k_{h4} is the intercept of the long-run correction equation, $k_{h5} > 0$ captures the long-run speculation behaviour, $k_{h6} > 0$ is the long-run elasticity of housing demand to population.

Financial assets and liabilities follow Tobin's portfolio theory (Tobin, 1982) as in Godley and Lavoie (2006). Households have liquidity preferences on currencies. They keep a proportion of their net worth as cash in hand and hold more when income increases,

$$\frac{H_t}{V_{h,t}} = h_0 + h_1 \frac{YD_t}{V_{h,t}}, \quad (3.52)$$

where $h_0 > 0$ is the preference for currencies and $h_1 > 0$ captures the income effect.

Households' deposit savings close their budget constraint,

$$\Delta D_{h,t} = NFI_{h,t} - \Delta H_t - \Delta B_{h,t} + \Delta L_{h,t} - \Delta A_{h,t} - Z_{h,t}. \quad (3.53)$$

Households invest in bonds to earn interest, $r_{rh,t} - \pi_{y,t}$, where $r_{rh,t}$ denotes the nominal rate of interest households receive and $\pi_{y,t} = \frac{\Delta P_{y,t}}{P_{y,t-1}}$ is the GDP deflator inflation rate. They would invest more with more disposable income.

$$\frac{B_{h,t}}{V_{h,t}} = b_{h0} + b_{h1} \frac{B_{h,t-1}}{V_{h,t-1}} + b_{h2}(r_{rh,t} - \pi_{y,t}) + b_{h3} \frac{YD_t}{V_{h,t}}, \quad (3.54)$$

where b_{h0} is the preference for bonds, $0 < b_{h1} < 1$ is the persistence of the share of households' bonds held, $b_{h2} > 0$ is the sensitivity of households' bonds held to real interest rate received, and $b_{h3} > 0$ captures the income effect.

Households borrow loans, mainly mortgages, to buy houses. They borrow more when the real rate of interest received from other savings increases or the real housing price increases and less when the borrowing cost increases,

$$\frac{\Delta L_{h,t}}{I_{h,t}} = l_{h0} + l_{h1}(r_{rh,t} - \pi_{y,t}) + l_{h_2}(r_{ph,t} - \pi_{y,t}) + l_{h3}(\Delta \ln P_{k_h,t} - \pi_{y,t}), \tag{3.55}$$

where l_{h0} denotes the preference for loan borrowing, $l_{h1} > 0$ denotes the sensitivity of household loans borrowing ratio to the real rate of interest received, $l_{h2} < 0$ denotes the sensitivity of household loans borrowing ratio to the real rate of interest paid, and $l_{h3} > 0$ is the sensitivity of households loan borrowing to real housing price growth.

Firms

Firms earn revenue from production, interest from deposits, and dividends from equity ownership. They also pay taxes, wages, and interest on debt and distribute profit through dividends.

Firms fixed capital formation rate, $\frac{\Delta k_{1f,t}}{k_{1f,t-1}}$, is driven by the net profit rate in one lag, $\frac{\Pi_{f,t-1} - INT_{pf,t-1}}{P_{k1,t-1}k_{1f,t-2}}$ (*Kaleckian*), and capacity utilization rate, $U_{k,t}$ (*Straffian*),

$$\frac{\Delta k_{1f,t}}{k_{1f,t-1}} = \beta_0 + \beta_1 \frac{\Pi_{f,t-1} - INT_{pf,t-1}}{P_{k_1,t-1}k_{1f,t-2}} + \beta_2 U_{k.t}, \tag{3.56}$$

where β_0 denotes the autonomous firms' fixed capital formation rate, $\beta_1 > 0$ is the sensitivity of firms' fixed capital formation rate to the net profit rate, and $\beta_2 > 0$ is the sensitivity of firms' fixed capital formation rate to capacity utilization rate. Capacity utilization rate by definition, is the ratio of firms' utilized fixed capital in volume to firms' total fixed capital in volume,

$$U_{k,t} = \frac{k_{1fu,t}}{k_{1f,t}}, \tag{3.57}$$

where $k_{1fu,t}$ denotes firms' utilized fixed capital in volume, driven by firms' production in volume, $y_{f,t} = \frac{Y_{f,t}}{P_{y,t}}$, and capital productivity, which depends on the scale of firms' fixed capital in volume (scale effect),

$$\Delta \ln k_{1fu,t} = v_1 \Delta \ln y_{f,t} + v_2 \Delta \ln k_{1f,t} + v_3(\Delta \ln k_{1fu,t-1} - v_4 - v_5 \ln y_{f,t-1} - v_6 \ln k_{1f,t-1}), \tag{3.58}$$

where $v_1 > 0$ denotes the short-run elasticity of firms' utilized fixed capital to firms' production in volume, $v_2 > 0$ captures the short-run decreasing return to scale of firms' fixed capital, $-1 < v_3 < 0$ is the long-run correction parameter of firms' utilized fixed capital, v_4 is the level of firms' utilized fixed capital in logarithm when firms' production and firms' fixed capital equal 100 million rmb, $v_5 > 0$ is the long-run elasticity of firms' utilized fixed capital to firms' production, and $v_6 > 0$ captures the long-run decreasing return to scale of firms' fixed capital.

Firms hold deposits as a proportion of their net worth, i.e. $E_{lf,t}$, in need of operation expenditure. They increase savings in deposits as their net cash flow increases, $\frac{FP_t}{E_{lf,t}}$.

$$\frac{D_{f,t}}{E_{lf,t}} = d_{f0} + d_{f1}\frac{FP_t}{E_{lf,t}}, \tag{3.59}$$

where $d_{f0} > 0$ denotes the liquidity preference of firms, and $d_{f1} > 0$ is the sensitivity of firms' deposits to net disposable income.

Firms issue bonds to finance and less when they have sufficient cash flow,

$$\frac{B_{f,t}}{E_{lf,t}} = b_{f0} + b_{f1}\frac{FP_t}{E_{lf,t}}, \tag{3.60}$$

where $b_{f0} > 0$ is the preference for issuing bonds and $b_{f1} < 0$ is the sensitivity of firms' bonds to net disposable income.

Firms would invest abroad in the form of outward foreign direct investment (FDI) when domestic investment is less profitable, and they would invest less if the borrowing cost increases, $r_{pf,t} - \pi_{y,t}$,

$$\frac{FDI_{out,t}}{E_{lf,t}} = fdi_{out0} + fdi_{out1}\frac{\Pi_{f,t} - INT_{pf,t}}{P_{k1,t}k_{1f,t-1}} + fdi_{out2}(r_{pf,t} - \pi_{y,t}), \tag{3.61}$$

where $fdi_{out0} > 0$ is the preference for outward FDI, $fdi_{out1} < 0$ is the sensitivity of outward FDI to the net profit rate of domestic investment, $fdi_{out2} < 0$ is the sensitivity of outward FDI to the real rate of interest paid by firms.

Banks

Banks earn revenues, interest from lending, and dividends. They pay wages, taxes, interest on deposits and inter-bank lending, dividends, and insurance indemnity. As the closing sector of the model, the vertical consistency of the banks' transaction flows, i.e., budget constraint, is inherently fulfilled.

The central bank is included in the banking sector and runs an inflation-biased Taylor rule by adjusting the policy rate,

$$r_{\delta,t} = r_{\delta 0} + r_{\delta 1} r_{\delta,t-1} + r_{\delta 2}\pi_t, \tag{3.62}$$

where $\pi_t = \frac{\Delta P_{c,t}}{P_{c,t-1}}$ denotes CPI inflation, $r_{\delta 0} > 0$ is the lower bound of the policy rate, $0 < r_{\delta 1} < 1$ denotes the persistence of the policy rate, and $r_{\delta 2} > 0$ is the sensitivity of the policy rate to CPI inflation.

Domestic interest rates, except governments' rate of interest paid and received, positively correlate to the policy rate (see Appendix).[9]

Banks' fixed capital formation rate, $\frac{\Delta k_{1b,t}}{k_{1b,t-1}}$, depends on banks' gross profit rate in one lag, $\frac{\Pi_{b,t-1}}{P_{k_1,t-1} k_{1b,t-2}}$,

$$\frac{\Delta k_{1b,t}}{k_{1b,t-1}} = i_{b0} + i_{b1} \frac{\Pi_{b,t-1}}{P_{k_1,t-1} k_{1b,t-2}}, \tag{3.63}$$

where i_{b0} is banks' autonomous fixed capital formation rate and $i_{b1} > 0$ is the sensitivity of banks' fixed capital formation rate to gross profit rate.

Banks have liquidity preference for holding deposits and increase their holding if the real rate of interest received increases, $r_{rb,t} - \pi_{y,t}$,

$$\frac{D_{b,t}}{E_{lb,t}} = d_{b0} + d_{b1}(r_{rb,t} - \pi_{y,t}), \tag{3.64}$$

where $d_{b0} > 0$ is banks' liquidity preference for holding deposits and $d_{b1} > 0$ is the sensitivity of banks' deposits to the real rate of interest received.

Banks issue bonds in case of shortage of funds because banks face liquidity risk by holding long-term assets, e.g. firm loans, and short-term debts, e.g. household deposits, and would issue less if the real rate of interest paid rises, $r_{pb,t} - \pi_{y,t}$,

$$\frac{B_{lb,t}}{E_{lb,t}} = b_{lb0} + b_{lb1}(r_{pb,t} - \pi_{y,t}), \tag{3.65}$$

where $b_{lb0} > 0$ is banks' liquidity demand for issuing bonds and $b_{lb1} < 0$ is the sensitivity of banks' bonds issued to the real rate of interest paid.

Governments

Governments receive taxes, interests from deposits, dividends, and social contributions. They pay wages, interest for bonds, social benefits and social transfers in kind to households and capital transfers to firms.

[9] We failed to find any correlation between the policy rate and the rate of interest received by the governments. Including the rate of interest paid by the governments endogenously worsens the model's performance in Section 3.4.

Governments' consumption consists of goods and services provided to society. It is procyclical because demand for public goods and services increases when economic activity increases. For simplicity, we assume it is proportional to real output,

$$c_{g,t} = \gamma_{c_g} y_t, \tag{3.66}$$

where γ_{c_g} denotes the share of governments' consumption.

Government fixed capital formation rate, $\frac{\Delta k_{1g,t}}{k_{1g,t-1}}$, targets the unemployment rate and depends on their net disposable income per fixed capital deflated by the price of fixed capital, $\frac{GP_t}{P_{k,t}k_{1g,t-1}}$,

$$\frac{\Delta k_{1g,t}}{k_{1g,t-1}} = i_{g1}\frac{GP_t}{P_{k,t}k_{1g,t-1}} + i_{g2}u_t, \tag{3.67}$$

where $i_{g1} > 0$ is the sensitivity of government investment to their net disposable income, and $i_{g2} > 0$ is the sensitivity of government investment to the unemployment rate.

The rest of the world

The rest of the world demands export goods, supplies import goods, and other current transfers and financial transfers between the domestic sectors.

The nominal effective exchange rate (rise = appreciation) follows the uncovered interest parity, which depends on the policy rate of the central bank, $r_{\delta,t}$ and federal funds rate, ffr_t,

$$\Delta \ln XR_t = xr_1 \ln\left(\frac{1 + r_{\delta,t}}{1 + ffr_t},\right) \tag{3.68}$$

where $0 < xr_1 < 1$ is the imperfection of interest parity caused by currency hierarchy and capital controls.

The federal funds rate, ffr_t and foreign GDP (nominated in US dollar), $Y_{r,t}$, are exogenous in the model.

Due to the conversion of currencies, the rate of interest paid by the foreign sector includes the change in exchange rate within the maturity,

$$r_{pr,t} = (1 - r_{pr1} - r_{pr2})r_{pr,t-1} + r_{pr1}\Delta \ln XR_t + r_{pr2}ffr_t, \tag{3.69}$$

where $r_{pr1} < 0$ is the sensitivity of the interest rate paid by the foreign sector to nominal effective exchange rate growth and $r_{pr2} > 0$ is the sensitivity to federal funds rate. Whereas, the rate of interest received by the foreign sector, $r_{rr,t}$ is assumed to be exogenous.[10]

[10]We did not find any statistical explanation for the rate of interest received by the foreign sector.

Exports depend on foreign demand converted into domestic currencies and deflated by export price, $\frac{Y_{r,t}}{P_{x,t}XR_t}$, and the economic complexity index (Hidalgo & Hausmann, 2009), ECI_t,

$$\Delta \ln x_t = x_1 \Delta \ln \frac{Y_{r,t}}{P_{x,t}XR_t} + x_2 \Delta \ln ECI_t + x_3 \left(\ln x_{t-1} - x_4 \ln \frac{Y_{r,t-1}}{P_{x,t-1}XR_{t-1}} - x_5 \ln ECI_{t-1} \right), \tag{3.70}$$

where $x_1 > 0$ is the short-run elasticity of export to foreign demand, $x_2 > 0$ is the short-run elasticity of export to the economic complexity, $-1 < x_3 < 0$ is the export long-run correction parameter, $x_4 > 0$ is the long-run elasticity of export to foreign demand, and $x_5 > 0$ is the long-run elasticity of export to the economic complexity.

For simplicity, imports are proportional to real GDP,

$$m_t = \gamma_m y_t, \tag{3.71}$$

where $\gamma_m > 0$ is the share of import in volume.

The foreign sectors lend loans to the domestic sectors depending on the rate of interest received, the higher the return, the more they supply,

$$\frac{\Delta L_{ar,t}}{L_{ar,t-1}} = l_{ar1} r_{rr,t}, \tag{3.72}$$

where $l_{ar1} > 0$ is the sensitivity of foreign loan lending to the rate of interest received by the foreign sector.

Inward FDI depends on the domestic firms' gross profit, $\frac{\Pi_{f,t}}{P_{k_1,t}k_{1f,t-1}}$, with higher domestic economic growth, cheaper labour, lower taxes, and lower fixed asset prices, the domestic sector will attract more inward FDI,

$$\frac{\Delta FDI_{in,t}}{FDI_{in,t}} = fdi_{in0} + fdi_{in1} \frac{\Pi_{f,t}}{P_{k_1,t}k_{1f,t-1}}, \tag{3.73}$$

where fdi_{in0} is the autonomous inward FDI accumulation rate and $fdi_{in1} > 0$ is the sensitivity of inward FDI to domestic firms' gross profit rate.

3.3 Data and parameters

Table 3.6 and 3.7 in the Appendix give an overall description of the variables and parameters.

Our data covers a maximum range of the years 1992 to 2023.[11] Material flows are obtained

[11] The specification of the behavioural equations is determined by the maximum range of the data period, but the parameters employed in the simulation are estimated based on data from the years 2002 to 2019, which is the period that all variables are available.

from Chen et al. (2022), and material stocks are obtained from Song et al. (2021). The energy balance is obtained from the National Bureau of Statistics of China (NBSC). The economy balance sheets, e.g., non-financial assets and financial assets and liabilities, are obtained from China's National Balance. Transaction data are obtained from NBSC.

The GDP deflator is obtained from World Development Indicators. Other price variables are obtained or estimated from NBSC. The nominal effective exchange rate is obtained from the European Central Bank. Fiscal tax rates and interest rates are estimated using the transaction data and stock data, dividing the flows by the stocks. The Central Bank policy rate is obtained from the International Financial Statistics (IFS) of the IMF. The federal funds rate is obtained from the Federal Reserve Economic Data (FRED). Employment, labour force and population data are obtained from the World Bank. The foreign nominal GDP is the world's nominal GDP subtracts China's nominal GDP, based on data from the World Bank. The nominal wage is calculated by the wage bill payment over employment. Equity price indices are calculated by the revaluation effect over the lagged stock in value. The revaluation effect of equities is calculated by the equity accumulation equation. Adjustment variables and errors and omissions are calculated based on the accounting equations to solve the mismatch in the data. Other changes in values are calculated based on the stock accumulation equations to ensure stock-flow consistency.

Parameters in the behaviour equations are estimated by running simple OLS regressions with the Durbin-Watson test to ensure they do not reject the homoskedasticity hypothesis. Moreover, we run Augmented Dickey-Fuller (ADF) tests on the residuals to ensure co-integrations between the variables. Other parameters, such as ratios and shares, are calculated based on the data.

3.4 Model validation

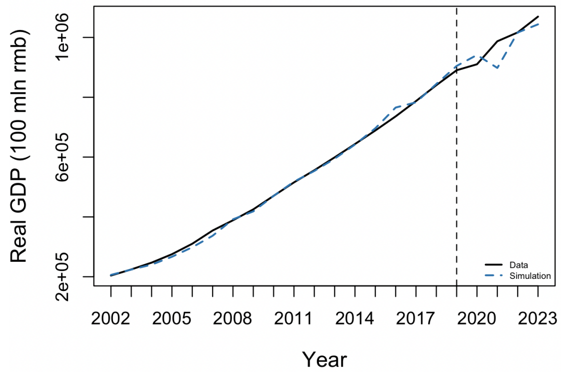
We run an in-sample prediction to check the model performance. Specifically, we run a dynamic simulation of the model from 2002 to 2023 and compare it with the data.[12] Endogenous variables only employ the 2002 values as the initial values. Exogenous variables employ the data. Ratios and shares become moving parameters and employ the data.

Figure 3.1 shows the in-sample prediction results. The black solid line represents the data, the blue dashed line represents the simulation results, and the vertical dashed line represents the year 2019, which is the last period of available data for the stock variables. Real GDP from

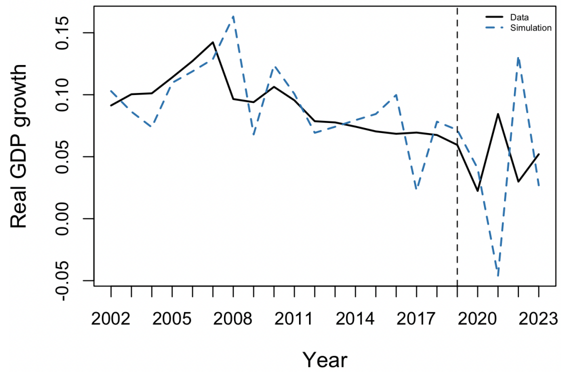
[12] A dynamic simulation accumulates model errors over time. we could also run a static simulation, which will have a better performance but only show model errors of each year because it employs the data for the lagged variables. This model is built for future scenario prediction. It would be reasonable to check the model validation dynamically.

the dynamic simulation performs more fluctuation than the data in certain periods but follows closely to the trend of the data. (Figure 3.1a, 3.1b). The unemployment rate and capacity utilization rate measure the disequilibrium between the demand and supply of the production inputs, labour and capital, respectively. The model simulation performs more fluctuation than the data. Still, it is stable within a range and follows the long-term trend (Figure 3.1c and 3.1d). The consumer price index in the model grows closely to the inflation rate of the data (Figure 3.1e). The Gini coefficient is more volatile than the data because of the volatility of the unemployment rate (Figure 3.1f). Firms' leverage ratio and public debt to GDP closely follow the data, showing that the model is capable of explaining the financial side of the Chinese economy. Regarding the ecological part, energy intensity follows the long-term with some misalignment (Figure 3.1i). Emissions to air, dissipative use of products and emissions water fit relatively well with the data (Figure 3.1j, 3.1k and 3.1l).

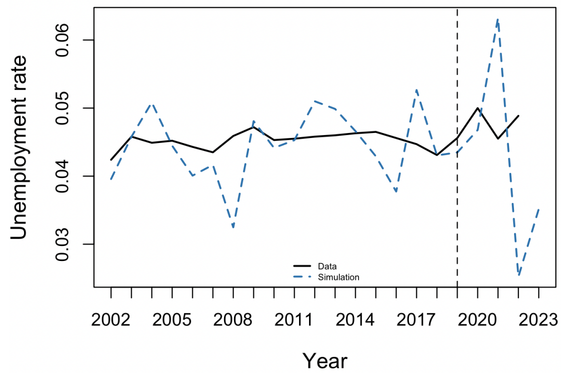
Overall, the model is capable of mimicking the Chinese economy and its connection to ecology fairly well. After many trials and errors, we are confident in the validation.



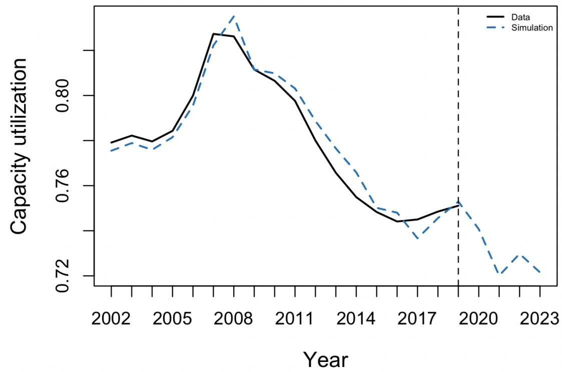
(a) Real GDP



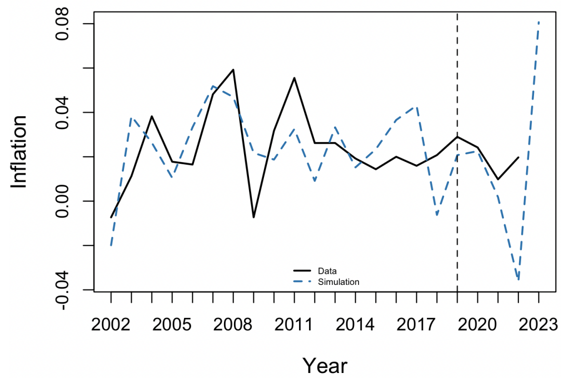
(b) Real GDP growth



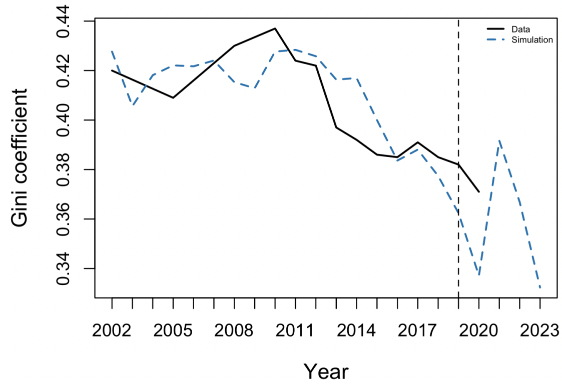
(c) Unemployment rate



(d) Capacity utilization rate



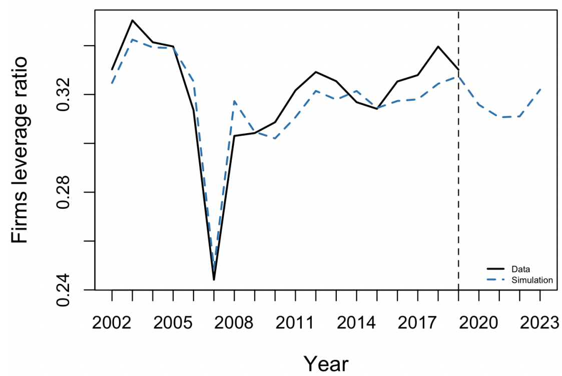
(e) Inflation



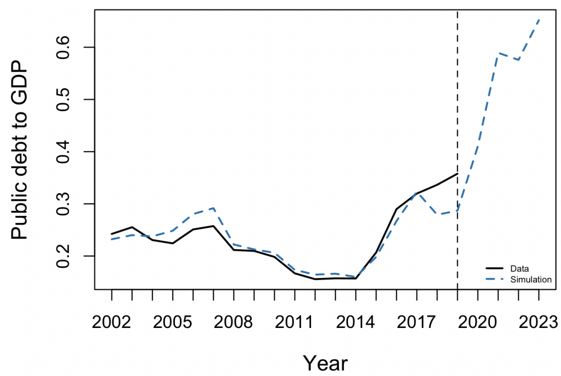
(f) Gini coefficient

Figure 3.1: In-sample prediction

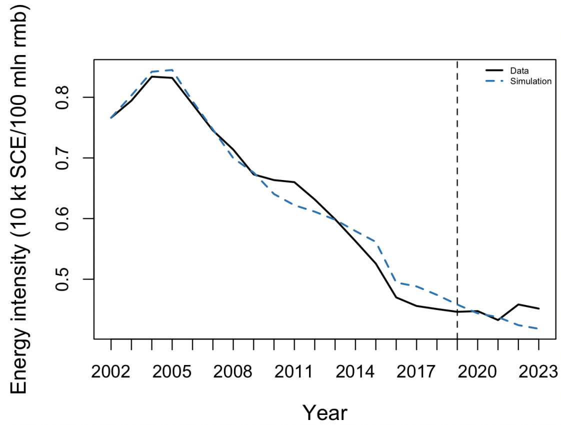
Note: The black solid line is the data. The blue dashed line is the dynamic simulation starting from 2002. The black vertical dashed is the year 2019, which is the last period of data availability for the stock variables.



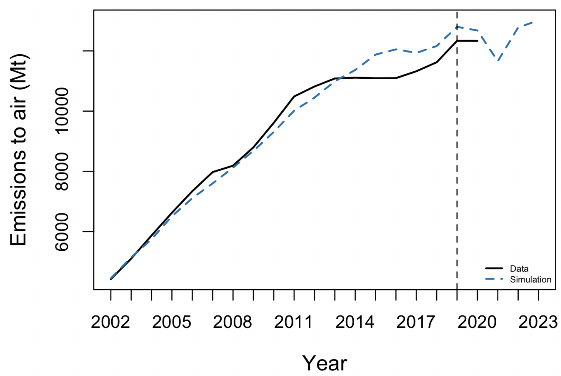
(g) Firms' leverage ratio



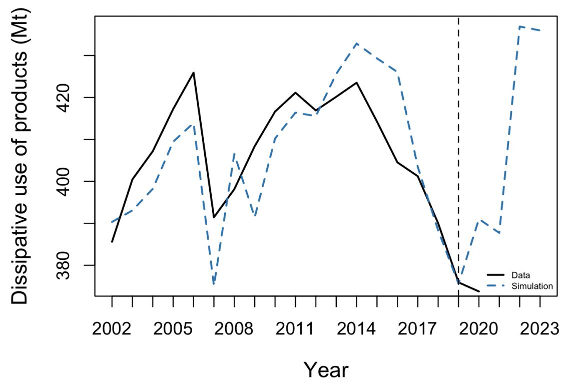
(h) Public debt to GDP



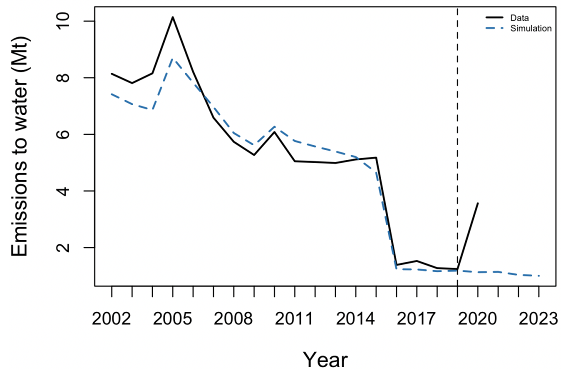
(i) Energy intensity



(j) Emissions to air



(k) Dissipative use of products



(l) Emissions to water

Figure 3.1: In-sample prediction

Note: The black solid line is the data. The blue dashed line is the dynamic simulation starting from 2002. The black vertical dashed is the year 2019, which is the last period of data availability for the stock variables.

3.5 Prediction

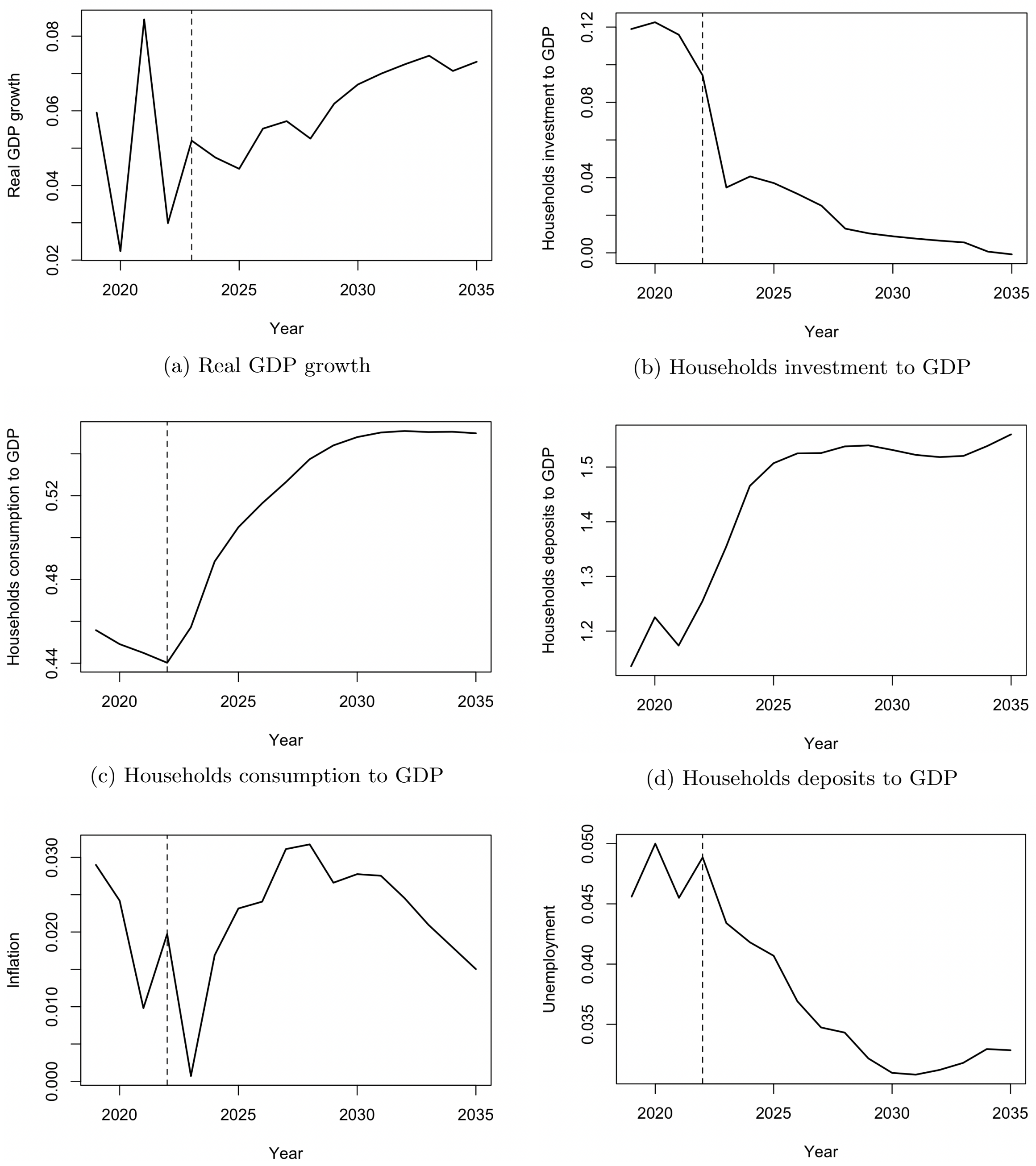
After validating the model, we run a baseline scenario of the model from 2019 to 2035 as a prediction reference. Then, we run a working hour reduction scenario, a wage policy scenario, and an income redistribution scenario. We compare the three scenarios, namely, working hours, wage policy, and redistribution policy, with the baseline to check their impulse response.

Before doing that, we employ the latest available data for the variables and extrapolate the exogenous variables under certain assumptions. We assume all adjustment variables, errors and omissions, and other changes in values are 0. For exogenous domestic prices, we use the last eight years 4-year mean growth rate to extrapolate them, i.e. $\left[\frac{Mean(Variable_{t-8},Variable_{t-7},Variable_{t-6},Variable_{t-5})}{Mean(Variable_{t-4},Variable_{t-3},Variable_{t-2},Variable_{t-1})}\right]^{\frac{1}{4}}-1$. We assume foreign nominal GDP grows at a rate of 5% and foreign price, i.e. import price, grows at a rate of 3%. Population employs the World Bank prediction. The share of renewable energy is assumed to grow at a rate of 2.57% to reach 25% in 2030, which is one of the policy targets of China (14th Five-Year Plan). Other shares and ratios are assumed to be constant.

3.5.1 Baseline

The baseline scenario gives a blurry vision of the Chinese economy in the future, which we consider as a reference. However, we do not claim that the baseline is a precise prediction for the future since it relies on many assumptions on exogenous variables, ratios, and shares and does not consider any structural change.

Figure 3.2 shows the prediction simulation results. The vertical dashed line signifies the end of the data period, where the simulation result starts to display. The Chinese economy slows down after COVID mainly because of the recession of the housing market, which is driven by population, decreasing according to the World Bank's prediction (Figure 3.2a and 3.2b). The economy recovers steadily, mainly driven by household consumption, because of the deposit wealth effect since households increase their deposit savings from less investment in housing (Figure 3.2a, 3.2c and 3.2d). Inflation falls sharply, close to 0 in 2024, because of the high unemployment rate resulting from the recession and recovers back between 2% to 3% in the long run as GDP growth increases and unemployment falls because of the decreasing population (Figure 3.2e and 3.2f). Income inequality peaks in 2021 and decreases over time, mainly driven by the increasing wage shares because of decreasing unemployment (Figure 3.2g and 3.2h). Emissions to air intensity decrease over time because of the commitment to green transition and because of the decreasing energy intensity resulting from GDP growth and decreasing income inequality (Figure 3.2i). However, emissions to air still increase over time because of economic growth, showing that green transition alone is insufficient to stop emissions to air from increasing, which is one of the policy targets of China (14th Five-Year Plan, Figure 3.2j). Similarly, the dissipative use of products increases over time (Figure 3.2k). While emissions to water decrease over time cause emissions to water intensity decrease sufficiently (Figure 3.2l).



(a) Real GDP growth

(b) Households investment to GDP

(c) Households consumption to GDP

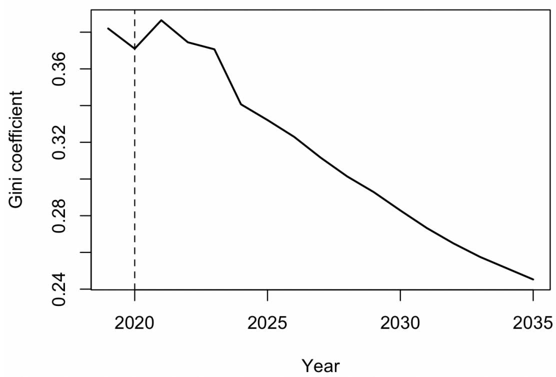
(d) Households deposits to GDP

(e) Inflation

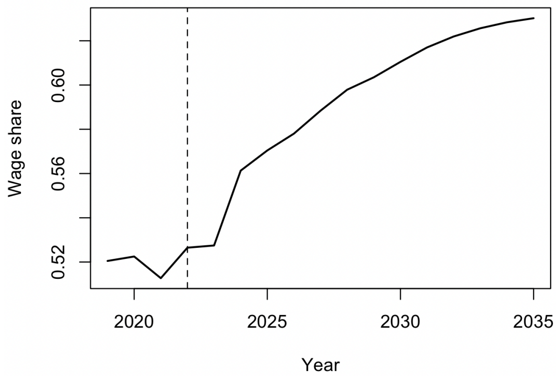
(f) Unemployment rate

Figure 3.2: Baseline scenario

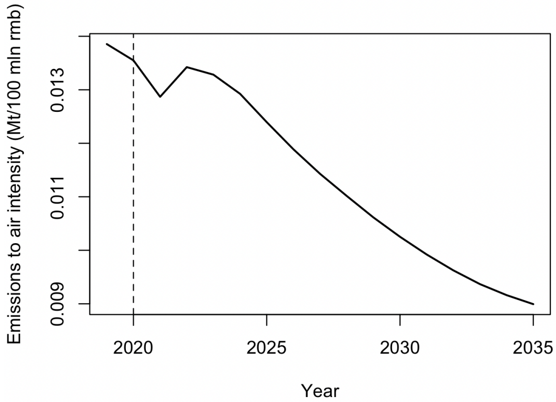
Note: The vertical dashed line signifies the end of the data period, where the simulation result starts to display.



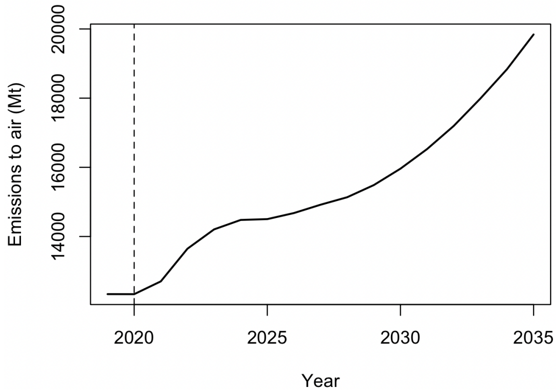
(g) Income inequality



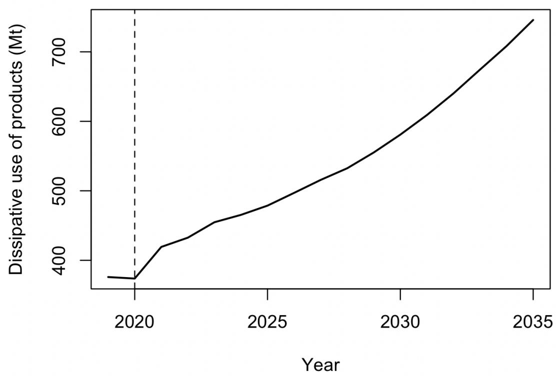
(h) Wage share



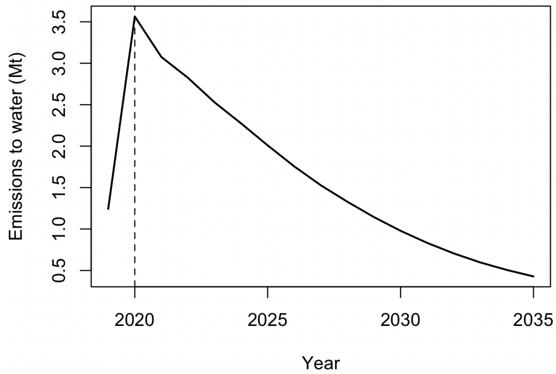
(i) Emissions to air intensity



(j) Emissions to air



(k) Dissipative use of products



(l) Emissions to water

Figure 3.2: Baseline scenario

Note: The vertical dashed line signifies the end of the data period, where the simulation result starts to display.

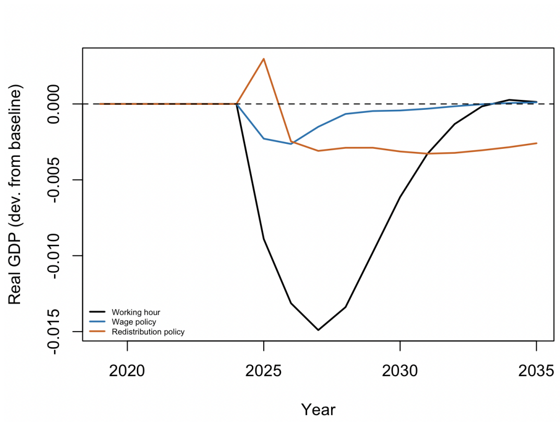
3.5.2 Working hours reduction, wage increase and social benefits

In this section, we study the impulse response of three permanent shocks from 2025 separately: a 1% reduction in working hours, a 1% increase in the nominal wage, and a 1% increase in social benefit to GDP to households (γ_{SB}) financed by firms' production tax. We would like to compare the effect of a working hour reduction policy to a wage increase policy and an income redistribution policy.

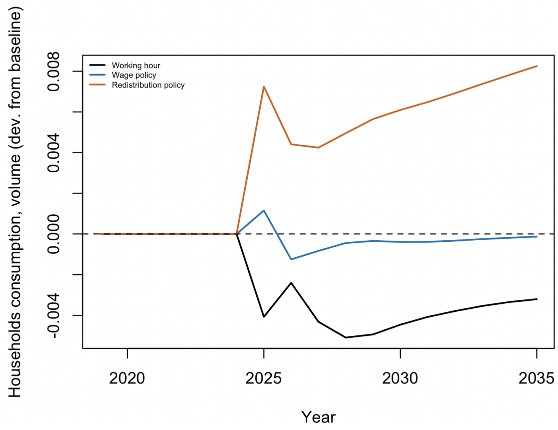
Figure 3.3 shows the impulse response functions of the shocks, which are the deviations from the baseline scenario, $\frac{Shock_t}{Baseline_t} - 1$ for variables in level and $Shock_t - Baseline_t$ for variables in rate. The black line is the working hour reduction scenario (Working hour). The blue line is the wage increase scenario (Wage policy). The orange line represents the income redistribution scenario (Redistribution policy). All three shocks harm real GDP as expected, mainly because firms' investment falls. The redistribution policy scenario increases real GDP in 2025 because firms react to the profit rate in one lag (Figure 3.3a and 3.3c). Household consumption increases under the redistribution scenario because households receive more social benefits. Under the working hour reduction and wage increase scenarios, although households received more wage income, household consumption in volume decreases due to inflation (Figure 3.3b, 3.3e and 3.3h).[13] Firms' investment decreases in all three scenarios because the cost of production increases, firms are paying more wages under working hour reduction and wage policy scenario, paying more taxes under the redistribution scenario (Figure 3.3c). Exports decrease under a working hour reduction and a positive wage shock mainly because domestic products become more expensive (Figure 3.3d and 3.3e). Firms raise prices under higher wages and shorter working hours because they face a higher unit labour cost. In the long run, prices are lower under a working hour reduction shock because of the overshooting of the unemployment rate, which is caused by the adjustment of the labour force to the unemployment rate and its persistence (Figure 3.3e and 3.3f, equation 3.41). Unemployment rises under the wage policy scenario and redistribution policy scenario because of the reduction of real GDP. Although real GDP decreases under the working hour reduction scenario, unemployment decreases because its direct effect on labour demand dominates. In the long run, unemployment rises because of more labour force (Figure 3.3f). Income inequality decreases under the working hour scenario because employment and the wage share increase. Although the unemployment rate is higher and the wage share is lower in the long run, income inequality under the working hour scenario is still lower than the baseline because there is a larger share of workers in the total population. A positive wage shock decreases income inequality by increasing the wage share. The redistribution policy scenario also decreases income inequality because of the income redistribution effect (Figure 3.3f, 3.3g and 3.3h). Energy intensity decreases in all scenarios because of lower income inequality (Figure 3.3i). Emissions of all types are reduced in the three scenarios because of less production and less emissions intensity (Figure 3.3j, 3.3k and 3.3l).

[13] The spikes of household consumption are because of the habit formation in equation (3.50).

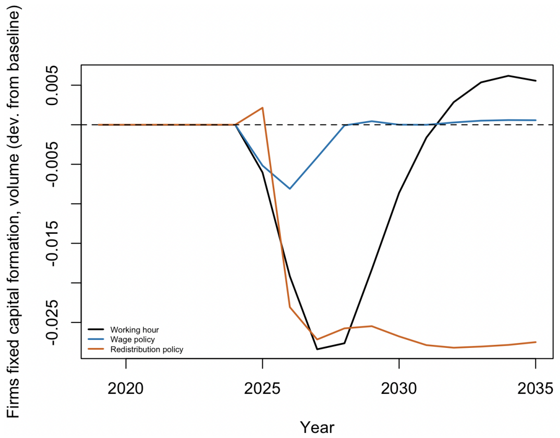
We summarize the effects of the three policies in five different aspects: 1) Real GDP, 2) CPI, 3) Income inequality, 4) Unemployment and 5) Emissions to air; and standardize the effects into -1% reduction of real GDP (Table 3.5). All three policies have a negative effect on real GDP and reduce income inequality and emissions into the air. Reducing working hours and increasing wages only show a short-run negative effect on economic growth because firms can raise the price to compensate for higher labour costs. Working hour reduction and income redistribution policy both have a long-lasting effect in reducing income inequality, while the effect of income redistribution is more significant. In the short run, only reducing working hours can reduce unemployment, whereas the other two policies raise unemployment. As for reducing emissions into the air, working hour reduction has the lowest effect but lasts in the long run. Increasing the wage only shows a short-run effect. The income redistribution policy has the most significant effect on reducing emissions.



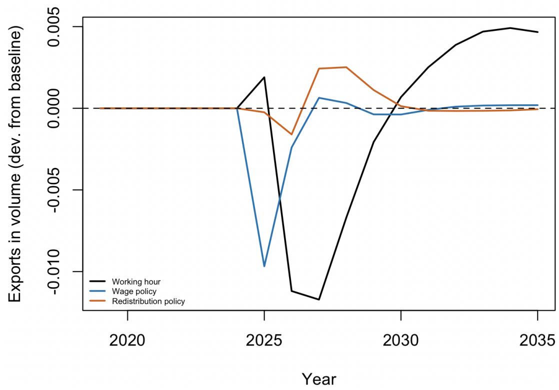
(a) Real GDP



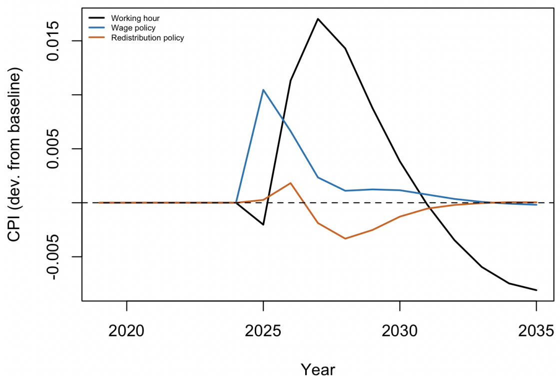
(b) Households consumption, volume



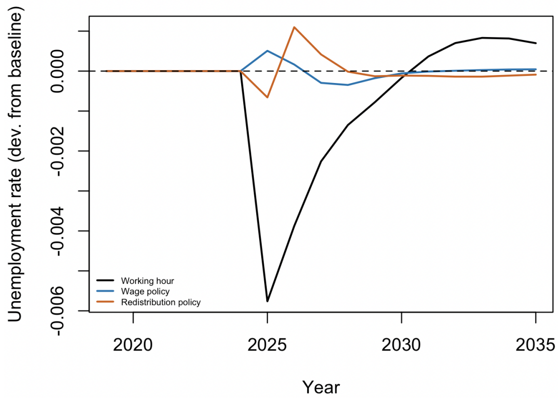
(c) Firms investment, volume



(d) Exports, volume



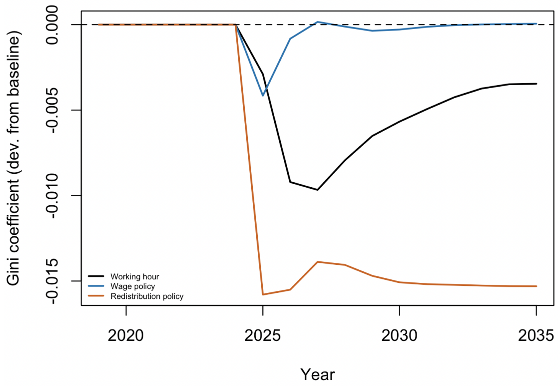
(e) Consumer price index



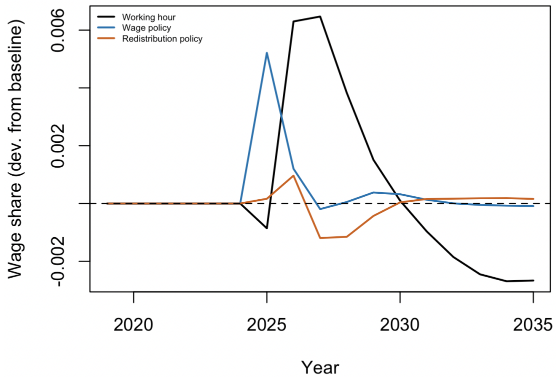
(f) Unemployment rate

Figure 3.3: Policy shocks

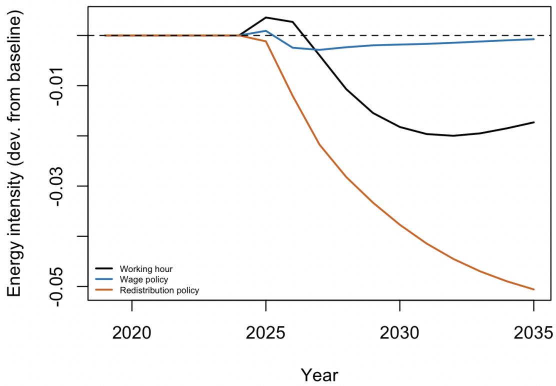
Note: The black line is the impulse response to a 1% permanent reduction in working hours. The blue line is the impulse response to a 1% increase in the real wage. The orange line is the impulse response to a 1% permanent increase in social benefits to households financed by the production tax for firms.



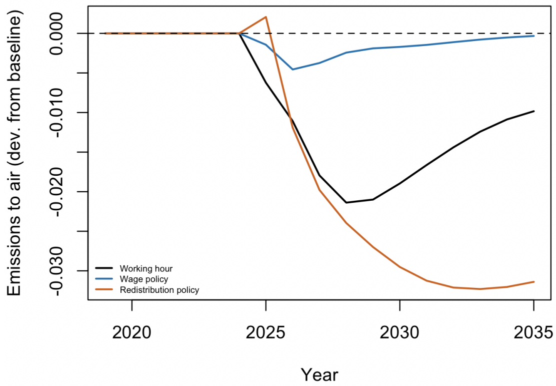
(g) Gini coefficient



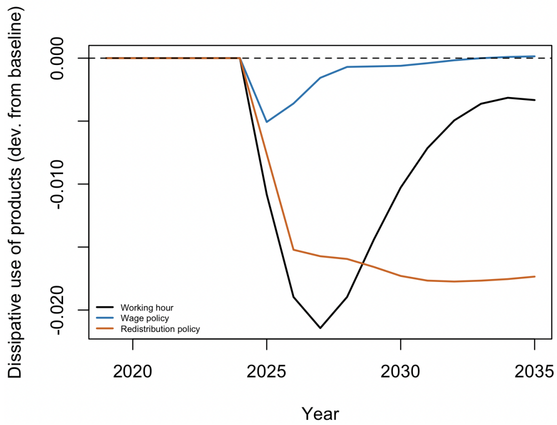
(h) Wage share



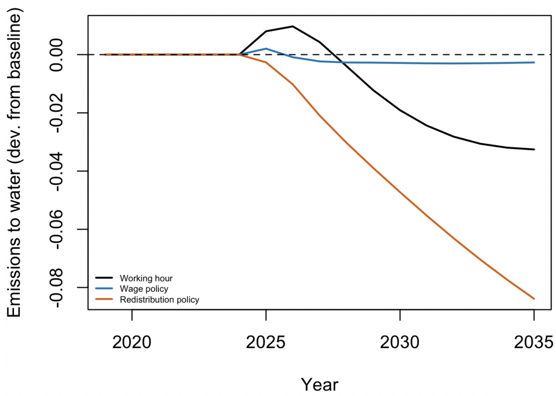
(i) Energy intensity



(j) Emissions to air



(k) Dissipative use of products



(l) Emissions to water

Figure 3.3: Policy shock

Note: The black line is the impulse response to a 1% permanent reduction in working hours. The blue line is the impulse response to a 1% increase in the real wage. The orange line is the impulse response to a 1% permanent increase in social benefits to households financed by the production tax for firms.

Table 3.5: The effect of policy shocks (standardized to -1% reduction of real GDP)

	Real GDP	CPI	Income inequality	Unemployment	Emissions to air
Working hour	short-run -1%	short-run +1.1%	short-run -0.7%	short-run -0.4%	short-run -1.4%
		long-run -0.5%	long-run -0.2%	long-run +0.1%	long-run -0.7%
Wage policy	short-run -1%	short-run +3.3%	short-run -1.3%	short-run +0.3%	short-run -1.7%
Redistribution policy	long-run -1%	short-run -1%	long-run -5%	short-run +0.3%	long-run -10.3%

3.6 Conclusion and Remark

This paper develops an empirical ecological stock-flow consistent model for China. It embeds the Chinese balance sheet and transaction flow matrix and describes institutions' behaviours to mimic the Chinese economy. By including the material and energy balance, the model can link the economy to its effect on the environment. We use the in-sample prediction to validate the model and find that the fitness of the data is fairly good. We run a baseline scenario under a promised green transition, giving a reference to future predictions. The baseline scenario shows that green transition alone is insufficient to reduce emissions. It calls for additional policy interventions. Then, we compare a working hour reduction shock to a wage increase policy and income redistribution policy. All three policies reduce real GDP, income inequality and emissions. A working hour reduction reduces income equality and unemployment more significantly but may trigger inflation in the short run. A wage increase only shows short-run effects in reducing income inequality and emissions and results in high inflation and more unemployment. A redistribution policy will have a long-lasting negative effect on economic growth, but it reduces income inequality and emissions to the air more significantly.

The model can be further explored in some directions. The model does not capture any feedback from the environment to the economy. We could evaluate the damage function of emission; however, within an empirical framework, sufficient detailed data is required. Another perspective is to study the link between material intensity and prices. The cost of production will increase if a type of material is over-demanded. This would happen in a technology change, e.g., batteries for storing renewable energy are made with raw materials.

Appendix

Production:

Final goods or services are produced by domestic sectors given a fixed proportion,

$$Y_{j,t} = \gamma_{Yj}(Y_t - Y_{adj,t}),\ \sum_j \gamma_{Y_j} = 1, \tag{3.74}$$

where $j = f, b, g, h$ denotes firms, banks, governments, and households.

Total errors and omissions in value,

$$EO_t = \sum_i EO_{i,t}, \tag{3.75}$$

where $i = f, b, g, h, r$ denotes firms, banks, governments, households and the rest of the world.

Households:

The gross operating surplus of households is defined as,

$$\Pi_{h,t} = Y_{h,t} + W_{h,t} - TL_{h,t}, \tag{3.76}$$

where $W_{h,t} = \gamma_{W_h} W_t$ is the wage paid by households with γ_{W_h}, the share of wage paid by households, and $TL_{h,t} = \tau_{L_h} Y_{h,t}$, the net production tax paid by households with τ_{L_h} is the net production tax rate paid by households.

The gross disposable income of households is,

$$YD_{g,t} = \Pi_{h,t} + W_t + INT_{rh,t} - INT_{lh,t} + DIV_{h,t} + OIP_{h,t}, \tag{3.77}$$

where $INT_{rh,t} = INT_{dh,t} + INT_{bh,t}$ is the total interest received by households, which is the sum of households' deposit interest, $INT_{dh,t} = r_{rh,t} D_{h,t-1}$, and households' bond interest, $INT_{bh,t} = r_{rh,t} B_{h,t-1}$, $INT_{lh,t} = r_{ph,t} L_{h,t-1}$ is households' loans interest paid, $DIV_{h,t} = \gamma_{DIV_h}(E_{h,t-1} + IFS_{h,t-1})$ is the dividend received by households with γ_{DIV_h} the dividend rate received by households, and $OIP_{h,t} = \gamma_{OIP_h} YD_{g,t}$ is households other income form properties received, which is a fixed proportion of households' gross disposable income for simplicity, γ_{OIP}.

The net disposable income of households is,

$$YD_t = YD_{g,t} - T_{h,t} - SC_t + SB_t + STR_t - O_{h,t}, \tag{3.78}$$

where $T_{h,t}$ is the income tax paid by households, $T_{h,t} = \tau_{h,t} YD_{g,t}$, SC_t is the social contribution paid by households to the governments, proportional to total wages, $SC_t = \tau_{sc} W_t$, SB_t and STR_t are the social benefits and social transfers in kind received from the governments, respectively, and $O_{h,t} = \gamma_{O_h} YD_t$ is households other current transfers paid, proportional to net disposable income for simplicity.

Household savings are disposable income minus consumption, and errors and omissions,

$$S_{h,t} = YD_t - C_{h,t}. \tag{3.79}$$

Households' fixed capital in value equals housing price times the volume,

$$K_{h,t} = P_{k_h,t} k_{h,t}. \tag{3.80}$$

Households' fixed capital formation in value,

$$I_{h,t} = K_{h,t} - K_{h,t-1}(1-\delta_h) - REV_{k_h,t} - OCV_{k_h,t}, \tag{3.81}$$

where δ_h denotes the depreciation rate of households' fixed capital, $REV_{k_h,t}$ is the revaluation effect, and $OCV_{k_h,t}$ is the other changes in value, which is exogenous.

Households' fixed capital formation in volume,

$$i_{h,t} = \frac{I_{h,t}}{P_{k_h,t}}. \tag{3.82}$$

Households fixed capital revaluation equals the price change times the stock in volume in the previous period,

$$REV_{k_h,t} = \Delta P_{k_h,t} k_{h,t-1}. \tag{3.83}$$

Households' net financial investment equals households' savings minus fixed capital formation and plus errors and omissions,

$$NFI_{h,t} = S_{h,t} - I_{h,t} + EO_{h,t}, \tag{3.84}$$

where $EO_{h,t}$ is errors and omissions of households, which is the mismatch between the household's real account and financial account, assumed to be exogenous.

Households' currencies savings equal to the change in stock subtracts other changes in value,

$$\Delta H_t = H_t - H_{t-1} - OCV_{h,t}, \tag{3.85}$$

where $OCV_{h,t}$ are the other changes in value of households' currencies, which are exogenous.

Households' deposit,

$$D_{h,t} = D_{h,t-1} + \Delta D_{h,t} + OCV_{d_h,t}, \tag{3.86}$$

where $OCV_{d_h,t}$ is the other changes in value of households' deposits, which is exogenous.

Household bonds held in volume equal to bonds held in value over the bond price,

$$b_{h,t} = \frac{B_{h,t}}{P_{b_h,t}}. \tag{3.87}$$

Household bonds savings equal to the change in stock value minus the revaluation effect of bonds and other changes in value,

$$\Delta B_{h,t} = B_{h,t} - B_{h,t-1} - REV_{b_h,t} - OCV_{b_h,t}, \tag{3.88}$$

where $REV_{b_h,t}$ is the revaluation effect of households' bonds held, and $OCV_{b_h,t}$ is the other changes in value of households' bonds held, which is exogenous.

Households' bonds held revaluation equal to the price change times the stock in volume in the previous period,

$$REV_{b_h,t} = \Delta P_{b_h,t} b_{h,t}. \tag{3.89}$$

The price of households' bonds held is approximated as the inverse of its interest rate as in Godley and Lavoie, 2006,

$$P_{b_h,t} = \frac{1}{r_{rh,t}}. \tag{3.90}$$

The accumulation of households' loans is

$$L_{h,t} = L_{h,t-1} + \Delta L_{h,t} + OCV_{l_h,t}, \tag{3.91}$$

where $OCV_{l_h,t}$ are the other changes in value of households' loan issued, which are exogenous.

Households' equity held in value equals the stock in value in the previous period plus the revaluation effect,

$$E_{h,t} = E_{h,t-1} + REV_{e_h,t}, \tag{3.92}$$

where $REV_{e_h,t}$ is the revaluation effect of households equity held.

Households' equity held in volume,

$$e_{h,t} = \frac{E_{h,t}}{P_{e_h,t}}, \tag{3.93}$$

where $P_{e_h,t}$ is the price of households' equity held, assumed to be exogenous.

Households' equity held revaluation,

$$REV_{e_h,t} = \Delta P_{e_h,t} e_{h,t-1}. \tag{3.94}$$

Households invest a proportion of their net worth in investment fund shares,

$$IFS_{h,t} = \gamma_{IFS_h} V_{h,t}, \tag{3.95}$$

where γ_{IFS_h} is the share of household investment fund shares held.

Households' investment fund shares held in volume,

$$ifs_{h,t} = \frac{IFS_{h,t}}{P_{ifs,t}}, \tag{3.96}$$

where $P_{ifs,t}$ is the price of investment fund shares, which is exogenous.[14]

Households' investment fund shares savings equal to the change in stock value subtracts the revaluation effect and other changes in value,

$$\Delta IFS_{h,t} = IFS_{h,t} - IFS_{h,t-1} - REV_{ifs_h,t} - OCV_{ifs_h,t}, \tag{3.97}$$

where $REV_{ifs_h,t}$ is the revaluation effect of households' investment fund shares held, $OCV_{ifs_h,t}$ is the other changes in value of households' investment fund shares held, which is exogenous.

Households' investment fund shares held revaluation,

$$REV_{ifs_h,t} = \Delta P_{ifs,t} ifs_{h,t-1}. \tag{3.98}$$

We assume households' insurance is proportional to households' net worth for simplicity,

$$A_{h,t} = \gamma_{A_h} V_{h,t}, \tag{3.99}$$

where γ_{A_h} is households' insurance held to net worth ratio.

Households' insurance savings equal the change in stock value minus other changes in value,

$$\Delta A_t = A_t - A_{t-1} - OCV_{a_h,t}, \tag{3.100}$$

where $OCV_{a_h,t}$ is the other changes in value of households' insurance held, which is exogenous.

We assume other accounts payable/receivables are proportional to households' net worth for simplicity,

$$Z_{h,t} = \gamma_{Z_h} V_{h,t-1}, \tag{3.101}$$

where γ_{Z_h} is households' other accounts payable/receivables to net worth ratio.

[14] Including it as an endogenous variable would break the model simulation convergence.

Households' change in other accounts payable/receivables is

$$\Delta Z_{h,t} = Z_{h,t} - Z_{h,t-1} + OCV_{z_h,t}, \tag{3.102}$$

where $OCV_{z_h,t}$ is the other changes in value of households' other accounts payable/receivables, which is exogenous.

Households' net worth is

$$V_{h,t} = K_{h,t} + H_t + D_{h,t} + B_{h,t} - L_{h,t} + E_{h,t} + A_{h,t} + Z_{h,t}. \tag{3.103}$$

Firms:

The gross operation surplus of firms is

$$\Pi_{f,t} = Y_{f,t} - TL_{f,t} - W_{f,t}, \tag{3.104}$$

where $TL_{f,t} = \tau_{L,f} Y_{f,t}$ is the net production tax paid by firms. $W_{f,t}$ denotes wages paid by firms, assumed to be a proportion of the total wage bill, $W_{f,t} = \gamma_{W_f} W_t$.

The gross disposable income of firms is

$$FP_{g,t} = \Pi_{f,t} + INT_{df,t} - INT_{pf,t} + DIV_{rf,t} - DIV_{pf,t} - OIP_{f,t}, \tag{3.105}$$

where $INT_{df,t} = r_{rf,t} D_{f,t-1}$ is the deposit interest received by firms, $INT_{pf,t} = INT_{bf,t} + INT_{lf,t}$ is the total interest paid by firms, which is the sum of bonds interest paid, $INT_{bf,t} = r_{pf,t} B_{f,t-1}$ and loans interest paid, $INT_{lf,t} = r_{pf,t} L_{f,t-1}$, $DIV_{rf,t} = \gamma_{DIV_{rf}} (E_{af,t-1} + FDI_{out,t-1})$ is the dividend received by firms with $\gamma_{DIV_{rf}}$ the dividend rate received by firms, $DIV_{pf,t}$ is dividend paid by firms, and $OIP_{f,t} = \gamma_{OIP_f} FP_{g,t}$ is firms other income from properties paid, which is a fixed proportion of firms' gross disposable income for simplicity.

Firms' dividend paid is the sum of dividends received by all sectors minus dividends paid by banks,

$$DIV_{pf,t} = DIV_{rf,t} + DIV_{rb,t} + DIV_{g,t} + DIV_{h,t} + DIV_{rr,t} - DIV_{pb,t}. \tag{3.106}$$

Firms' net disposable income is

$$FP_t = FP_{g,t} - T_{f,t} - O_{f,t}, \tag{3.107}$$

where $T_{f,t} = \tau_{f,t} FP_{g,t}$ is the income tax paid by firms and $O_{f,t} = \gamma_{O_f} FP_t$ is firms' other current transfers paid, assumed as fixed a proportion of firms' net disposable income.

Firms fixed capital held in value is

$$K_{1f,t} = K_{1f,t-1}(1 - \delta_{f,t}) + I_{1f,t} + REV_{k_{1f},t} + OCV_{k_{1f},t}, \tag{3.108}$$

where δ_f denotes the depreciation rate of firms' fixed capital, $REV_{k_{1f},t}$ is the revaluation effect, and $OCV_{k_{1f},t}$ are the other changes in value of firms' fixed capital.

Firms' fixed capital in volume is

$$k_{1f,t} = \frac{K_{1f,t}}{P_{k_1,t}}. \tag{3.109}$$

Firms' fixed capital formation in volume,

$$i_{1f,t} = \Delta k_{1f,t} + \frac{\delta_f K_{1f,t-1}}{P_{k_1,t}}. \tag{3.110}$$

Firms' fixed capital revaluation,

$$REV_{k_{1f},t} = \Delta P_{k_1,t} k_{1f,t-1}. \tag{3.111}$$

Firms' inventories in value,

$$K_{2f,t} = K_{2f,t-1} + I_{2f,t} + REV_{k_{2f},t}, \tag{3.112}$$

where $REV_{k_{2f},t}$ is the revaluation effect.

Firms' inventories in volume,

$$k_{2f,t} = \frac{K_{2f,t}}{P_{k_{2f},t}}. \tag{3.113}$$

We assume firms' changes in inventories as a fixed share of real GDP for simplicity,

$$i_{2f,t} = \gamma_{i_{2f}} y_t. \tag{3.114}$$

Firms' inventories revaluation,

$$REV_{k_{2f},t} = \Delta P_{k_{2f},t} k_{2f,t-1}. \tag{3.115}$$

Firms' other non-financial assets in value,

$$K_{3f,t} = P_{k_3} k_{3f,t}. \tag{3.116}$$

Firms' other non-financial assets in volume is proportional to real GDP (accelerator effect),

$$k_{3f,t} = \gamma_{k_{3f}} y_t, \tag{3.117}$$

where $\gamma_{k_{3f}}$ is the accelerator effect parameter of firms' other non-financial assets.

Firms' acquisition less disposal of other non-financial assets in value,

$$I_{3f,t} = K_{3f,t} - K_{3f,t-1} - REV_{k_{3f},t} - OCV_{k_{3f},t}, \tag{3.118}$$

where $REV_{k_{3f},t}$ is the revaluation effect and $OCV_{k_{3f},t}$ is the other changes in value of firms' other non-financial assets, which is exogenous.

Firms' acquisition less disposal of other non-financial assets in volume,

$$i_{3f,t} = \frac{I_{3f,t}}{P_{k_3,t}}. \tag{3.119}$$

Firms' other non-financial assets revaluation,

$$REV_{k_{3f},t} = \Delta P_{k_3,t} k_{3f,t-1}. \tag{3.120}$$

Firms' net financial investment,

$$NFI_{f,t} = FP_t + TRK_t - I_{1f,t} - I_{2f,t} - I_{3f,t} + EO_{f,t}, \tag{3.121}$$

where TRK_t is the capital transfers received by firms, and $EO_{f,t}$ is the errors and omissions of firms, which is exogenous.

The firms' deposit savings are the change in deposit stock value,

$$\Delta D_{f,t} = D_{f,t} - D_{f,t-1} - OCV_{d_f,t}, \tag{3.122}$$

where $OCV_{d_f,t}$ is the other changes in value of firms' deposit, which is exogenous.

Firms' bond borrowing,

$$\Delta B_{f,t} = B_{f,t} - B_{f,t-1} - REV_{b_f,t} - OCV_{b_f,t}, \tag{3.123}$$

where $REV_{b_f,t}$ is firms' bond issued revaluation, and $OCV_{b_f,t}$ is the other changes in value of firms' bond, which is exogenous.

Firms' bonds issued in volume,

$$b_{f,t} = \frac{B_{f,t}}{P_{b_f,t}}, \tag{3.124}$$

where $P_{b_f,t} = \frac{1}{r_{pf,t}}$ is the price of firms' bond.

Firms' bond revaluation,

$$REV_{b_f,t} = \Delta P_{b_f,t} b_{f,t-1}. \tag{3.125}$$

Firms' equity held in value is the stock value in the previous period plus the revaluation effect,

$$E_{af,t} = E_{af,t-1} + REV_{e_af,t}. \tag{3.126}$$

Firms' equity held in volume,

$$e_{af,t} = \frac{E_{af,t}}{P_{e_af,t}}, \tag{3.127}$$

where $P_{e_af,t}$ is the price of firms' equity held, assumed to be exogenous.[15]

Firms' equity held revaluation,

$$REV_{e_af,t} = \Delta P_{e_af,t} e_{af,t-1}. \tag{3.128}$$

Outward FDI stock in volume,

$$fdi_{out,t} = \frac{FDI_{out,t}}{P_{fdi_{out},t}}, \tag{3.129}$$

where $P_{fdi_{out},t}$ is the price of outward FDI, which is exogenous by assumption.

Outward FDI flow,

$$\Delta FDI_{out,t} = FDI_{out,t} - FDI_{out,t-1} - REV_{fdi_{out},t}, \tag{3.130}$$

where $REV_{fdi_{out},t}$ is the revaluation effect of outward FDI.

Outward FDI revaluation,

$$REV_{fdi_{out},t} = \Delta P_{fdi_{out},t} fdi_{out,t}. \tag{3.131}$$

Firms' insurance held is proportional to its net worth,

$$A_{f,t} = \gamma_{Af} E_{lf,t}, \tag{3.132}$$

[15]Including the price of firms' equity held as an endogenous variable would break the model simulation convergence.

where γ_{Af} is the share of firms insurance held.

Firms' insurance savings,

$$\Delta A_{f,t} = A_{f,t} - A_{f,t-1} - OCV_{a_f,t}, \tag{3.133}$$

where $OCV_{a_f,t}$ is the other changes in value of firms' insurance held.

We assume other accounts payable/receivables are proportional to the firm's net worth for simplicity,

$$Z_{f,t} = \gamma_{Z_f} E_{lf,t-1}. \tag{3.134}$$

Firms' change in other accounts payable/receivables is

$$\Delta Z_{f,t} = Z_{f,t} - Z_{f,t-1} - OCV_{z_f,t}, \tag{3.135}$$

where $OCV_{z_f,t}$ is the other changes in value of firms' other accounts payable/receivables.

Firm loans issued,

$$L_{f,t} = L_{f,t-1} + \Delta L_{f,t} + OCV_{l_f,t}, \tag{3.136}$$

where $OCV_{l_f,t}$ is the other changes in value of firms' loans issued.

Firms' loan borrowing closes the financial constraint,

$$\Delta L_{f,t} = \Delta D_{f,t} - \Delta B_{f,t} + \Delta FDI_{out,t} - \Delta FDI_{in,t} + \Delta A_{f,t} + \Delta Z_{f,t} - NFI_{f,t}. \tag{3.137}$$

Banks:

Domestic interest rates, except the government's rate of interest paid, are correlated to the policy rate,

$$r_{j,t} = r_{j0} + (1 - r_{j1}) r_{j,t-1} + r_{j1} r_{\delta,t}, \tag{3.138}$$

where $j = \{pb, pf, ph, rb, rf, rh\}$ denotes paid by banks, paid by firms, paid by households, received by banks, received by firms, received by governments and received by households, respectively, $r_{j0} > 0$ is the interest rate premium, and $r_{j1} > 0$ is the sensitivity to the policy rate.

Banks' gross operating surplus is

$$\Pi_{b,t} = Y_{b,t} - W_{b,t} - TL_{b,t}, \tag{3.139}$$

where $W_{b,t} = \gamma_{W_b} W_t$ is the wage paid by banks, proportional to the total wage bill, and

$TL_{b,t} = \tau_{L_b} Y_{b,t}$ is the net production tax paid by banks.

Banks' gross disposable income is

$$BP_{g,t} = \Pi_{b,t} + INT_{rb,t} - INT_{pb,t} + DIV_{rb,t} - DIV_{pb,t} - OIP_{b,t}, \tag{3.140}$$

where $INT_{rb,t} = INT_{db,t} + INT_{brb,t} + INT_{lb,t}$ is banks' interest received, which is the sum of banks' deposit interest received, $INT_{db,t} = r_{rb,t} D_{b,t-1}$, banks' bond interest received, $INT_{brb,t}$, and banks' loans interest received, $INT_{lb,t}$, $INT_{pb,t} = INT_{d,t} + INT_{bpb,t}$ is banks' interest paid, which is the sum of banks' deposit interest paid, $INT_{d,t}$ and banks' bond interest paid, $INT_{bpb,t} = r_{pb,t} B_{lb,t-1}$, $DIV_{rb,t} = \gamma_{DIV_{rb}}(E_{ab,t-1} + IFS_{ab,t-1})$ is banks' dividend received, $DIV_{pb,t} = \gamma_{DIV_{pb}}(E_{lb,t-1} + IFS_{lb,t-1})$ is banks' dividend paid, and $OIP_{b,t} = \gamma_{OIP_b} BP_{g,t}$ is banks' other income from properties, assumed to be fixed proportion of banks' gross disposable income.

Banks' bond interest received is the sum of all sectors' bond interest paid minus households' bond interest received,

$$INT_{brb,t} = INT_{bf,t} + INT_{bg,t} + INT_{brb,t} - INT_{bh,t}. \tag{3.141}$$

Similarly, banks' loan interest received is the sum of all sectors' loan interest paid minus the RoW loan interest received,

$$INT_{lb,t} = INT_{lf,t} + INT_{lh,t} + INT_{pr,t} - INT_{rr,t}. \tag{3.142}$$

Banks' deposit interest paid is the sum of all sectors' deposit interest received,

$$INT_{d,t} = INT_{db,t} + INT_{df,t} + INT_{dg,t} + INT_{dh,t}. \tag{3.143}$$

Banks' net disposable income is

$$BP_t = BP_{g,t} - T_{b,t} + O_{b,t}, \tag{3.144}$$

where $T_{b,t} = \tau_{b,t} BP_{g,t}$ denotes banks' income tax paid and $O_{b,t} = \gamma_{O_b} BP_t$ is banks' other current transfer received, assumed to be a fixed proportion of banks' disposable income.

Banks' fixed capital held in value,

$$K_{1b,t} = K_{1b,t-1}(1 - \delta_b) + I_{1b,t} + REV_{k_{1b},t} + OCV_{k_{1b},t}, \tag{3.145}$$

where δ_b is the depreciation rate of banks' fixed capital, $REV_{k_{1b},t}$ is the revaluation effect of banks' fixed capital, and $OCV_{k_{1b},t}$ is the other changes in value of banks' fixed capital.

Banks' fixed capital held in volume,

$$k_{1b,t} = \frac{K_{1b,t}}{P_{k_1,t}}. \tag{3.146}$$

Banks' fixed capital formation in volume,

$$i_{1b,t} = \Delta k_{1b,t} + \frac{\delta_b K_{1b,t-1}}{P_{k_1,t}}. \tag{3.147}$$

Banks' fixed capital revaluation,

$$REV_{k_{1b},t} = \Delta P_{k_1,t} k_{1b,t-1}. \tag{3.148}$$

Banks' other non-financial assets in value,

$$K_{3b,t} = P_{k_{3b},t} k_{3b,t}, \tag{3.149}$$

where $P_{k_{3b},t}$ is the price of banks' other non-financial assets, which is exogenous for simplicity.

Since there is no banks' acquisition less disposal of other non-financial assets, banks' other non-financial assets in volume, $k_{3b,t}$, is constant. And we assume the change in stock value is caused by the revaluation effect,

$$REV_{k_{3b},t} = K_{3b,t} - K_{3b,t-1}. \tag{3.150}$$

Banks' net financial investment,

$$NFI_{b,t} = BP_t - I_{1b,t} + EO_{b,t}, \tag{3.151}$$

where $EO_{b,t}$ is the banks' errors and omissions, which is the mismatch between the real account and financial account, assumed to be exogenous.

Banks' deposit savings,

$$\Delta D_{b,t} = D_{b,t} - D_{b,t-1} - OCV_{d_b,t}, \tag{3.152}$$

where $OCV_{d_b,t}$ is the other changes in value of banks' deposit held, which is exogenous.

Banks' deposit issued

$$D_t = D_{t-1} + \Delta D_t + OCV_{d,t}, \quad (3.153)$$

where $OCV_{d,t}$ is the other changes in value of banks' deposit issued.

Banks receive deposit savings from all sectors,

$$\Delta D_t = \Delta D_{b,t} + \Delta D_{f,t} + \Delta D_{g,t} + \Delta D_{h,t}. \quad (3.154)$$

Banks' deposits issued other changes in value is the sum of all deposits' other changes in value,

$$OCV_{d,t} = OCV_{d_b,t} + OCV_{d_f,t} + OCV_{d_g,t} + OCV_{d_h,t}. \quad (3.155)$$

Banks' bonds held in value,

$$B_{ab,t} = B_{ab,t} + \Delta B_{ab,t} + REV_{b_{ab},t} + OCV_{b_{ab},t}, \quad (3.156)$$

where $REV_{b_{ab},t}$ is the revaluation effect of banks' bonds held, and $OCV_{b_{ab},t}$ is the other changes in value of banks' bonds held.

Banks' bonds savings equal the sum of bonds issued by all sectors minus households' bonds savings,

$$\Delta B_{ab,t} = \Delta B_{f,t} + \Delta B_{g,t} + \Delta B_{lb,t} - \Delta B_{h,t}. \quad (3.157)$$

Similarly, banks' bonds held revaluation equals the sum of the revaluation of bonds issued by all sectors minus the revaluation of households' bonds held,

$$REV_{b_{ab},t} = REV_{b_f,t} + REV_{b_g,t} + REV_{b_{lb},t} - REV_{b_h,t}. \quad (3.158)$$

Equivalently, banks' bonds held other changes in value,

$$OCV_{b_{ab},t} = OCV_{b_f,t} + OCV_{b_g,t} + OCV_{b_{lb},t} - OCV_{b_h,t}. \quad (3.159)$$

Banks' bonds issued in volume,

$$b_{lb,t} = \frac{B_{lb,t}}{P_{b_{lb},t}}, \quad (3.160)$$

where $P_{b_{lb},t} = \frac{1}{r_{pb,t}}$ is the price of banks' bonds issued.

Banks' bonds borrowing,

$$\Delta B_{lb,t} = B_{lb,t} - B_{lb,t-1} - REV_{b_{lb},t} - OCV_{b_{lb},t}, \quad (3.161)$$

where $REV_{b_{lb},t}$ is the revaluation effect of banks' bonds issued, and $OCV_{b_{lb},t}$ is the other changes in value of banks' bonds issued, which is exogenous.

Banks' bonds issued revaluation,

$$REV_{b_{lb},t} = \Delta P_{b_{lb},t} b_{lb,t-1}. \tag{3.162}$$

Banks' loans issued,

$$L_{b,t} = L_{b,t-1} + \Delta L_{b,t} + OCV_{l_b,t}, \tag{3.163}$$

where $OCV_{l_b,t}$ is the other changes in value of banks' loans issued.

Banks fulfill the demand for domestic loan borrowing, that is, total loan demand minus foreign loan supply,

$$\Delta L_{b,t} = \Delta L_{f,t} + \Delta L_{h,t} + \Delta L_{lr,t} - \Delta L_{ar,t}. \tag{3.164}$$

Similarly, banks' loans issued other changes in value,

$$OCV_{l_b,t} = OCV_{l_f,t} + OCV_{l_h,t} + OCV_{l_{lr},t} - OCV_{l_{ar},t}. \tag{3.165}$$

Banks' equity held in value,

$$E_{ab,t} = E_{ab,t-1} + REV_{e_{ab},t}, \tag{3.166}$$

where $REV_{e_{ab},t}$ is the revaluation effect of banks' equity held.

Banks' equity held in volume,

$$e_{ab,t} = \frac{E_{ab,t}}{P_{e_{ab},t}}, \tag{3.167}$$

where $P_{e_{ab},t}$ is the price of banks' equity held, which is exogenous.[16]

Banks' equity held revaluation,

$$REV_{e_{ab},t} = \Delta P_{e_{ab},t} e_{ab,t-1}. \tag{3.168}$$

Banks' investment fund shares held in value is proportional to banks' net worth,

$$IFS_{ab,t} = \gamma_{IFS_{ab}} E_{lb,t}. \tag{3.169}$$

[16]Including it as an endogenous variable would break the model simulation convergence.

Banks' investment fund shares held in volume,

$$ifs_{ab,t} = \frac{IFS_{ab,t}}{P_{ifs,t}}. \tag{3.170}$$

Banks' investment fund shares investing,

$$\Delta IFS_{ab,t} = IFS_{ab,t} - IFS_{ab,t-1} - REV_{ifs_{ab},t} - OCV_{ifs_{ab},t}, \tag{3.171}$$

where $REV_{ifs_{ab},t}$ is the revaluation effect of banks' investment fund shares held and $OCV_{ifs_{ab},t}$ is the other changes in value of banks' investment fund shares held, which is exogenous.

Banks' investment fund shares held revaluation,

$$REV_{ifs_{ab},t} = \Delta P_{ifs,t} ifs_{ab,t-1}. \tag{3.172}$$

Banks' investment fund shares issued,

$$IFS_{lb,t} = IFS_{lb,t-1} + \Delta IFS_{lb,t} + REV_{ifs_{lb},t} + OCV_{ifs_{lb},t}, \tag{3.173}$$

where $REV_{ifs_{lb},t}$ is the revaluation effect of banks' investment fund shares issued, and $OCV_{ifs_{lb},t}$ is the other changes in value of banks' investment fund shares issued.

Banks supply investment fund shares to the investment demand,

$$\Delta IFS_{lb,t} = \Delta IFS_{ab,t} + \Delta IFS_{g,t} + \Delta IFS_{h,t}. \tag{3.174}$$

Same for banks' investment fund shares issued revaluation and other changes in value,

$$REV_{ifs_{lb},t} = REV_{ifs_{ab},t} + REV_{ifs_{g},t} + REV_{ifs_{h},t}, \tag{3.175}$$

$$OCV_{ifs_{lb},t} = OCV_{ifs_{ab},t} + OCV_{ifs_{g},t} + OCV_{ifs_{h},t}. \tag{3.176}$$

Banks' insurance issued,

$$A_t = A_{t-1} + \Delta A_t + OCV_{a,t}, \tag{3.177}$$

where $OCV_{a,t}$ is the other changes in value of banks' insurance issued.

Banks fulfill insurance demand,

$$\Delta A_t = \Delta A_{f,t} + \Delta A_{h,t}. \tag{3.178}$$

Banks' insurance issued other changes in value,

$$OCV_{a,t} = OCV_{a_f,t} + OCV_{a_h,t}. \tag{3.179}$$

Banks' other accounts payable/receivables are assumed to be proportional to their net worth,

$$Z_{b,t} = \gamma_{Z_b} E_{lb,t}. \tag{3.180}$$

Changes in banks' other accounts payable/receivables,

$$\Delta Z_{b,t} = Z_{b,t} - Z_{b,t-1} - OCV_{z_b,t}, \tag{3.181}$$

where $OCV_{z_b,t}$ is the other changes in value of banks' other accounts payable/receivables.[17]

Banks' other accounts payable/receivables other changes in value,

$$OCV_{z_b,t} = -OCV_{z_f,t} - OCV_{z_g,t} - OCV_{z_h,t} - OCV_{z_r,t}. \tag{3.182}$$

Governments:

Governments' gross operating surplus is

$$\Pi_{g,t} = Y_{g,t} - W_{g,t}, \tag{3.183}$$

where $W_{g,t} = \gamma_{W_g} W_t$ is the wage paid by governments, proportional to the total wage bill.

Governments' gross disposable income is

$$GP_{g,t} = \Pi g, t + TL_t + INT_{dg,t} - INT_{bg,t} + DIV_{g,t} + OIP_{g,t}, \tag{3.184}$$

where $TL_t = TL_{f,t} + TL_{h,t} + TL_{b,t}$ is the net production tax received by governments, $INT_{dg,t} = r_{rg,t} D_{g,t-1}$ is government deposit interest received, $INT_{bg,t} = r_{pg,t} B_{g,t-1}$ is government bond interest paid, $DIV_{g,t} = \gamma_{DIV_g}(E_{g,t-1} + IFS_{g,t-1})$ is government dividend received with a fixed dividend rate γ_{DIV_g}, and $OIP_{g,t}$ is government other income from properties received.

Governments receive other income from properties from other sectors minus households' other income from properties,

$$OIP_{g,t} = OIP_{f,t} + OIP_{b,t} + OIP_{r,t} - OIP_{h,t}. \tag{3.185}$$

[17] We do not let changes in banks' other accounts payable/receivables close the instrument account because it would make the model fragile.

Governments' net disposable income is

$$GP_t = GP_{g,t} + T_t + SC_t - SB_t - STR_t + O_{g,t}, \tag{3.186}$$

where $T_t = T_{f,t} + T_{b,t} + T_{h,t}$ is the total income tax received by governments, $SB_t = \gamma_{SB} Y_t$ is the social benefits paid to households, proportional to nominal GDP, $STR_t = \gamma_{STR} Y_t$ is social transfers in kind, also proportional to nominal GDP, and $O_{g,t}$ is other current transfers.

Governments receive other current transfers from other sectors minus banks' other current transfers received,

$$O_{g,t} = O_{f,t} + O_{h,t} + O_{r,t} - O_{b,t}. \tag{3.187}$$

Government savings equal net disposable income minus government consumption,

$$S_{g,t} = GP_t - C_{g,t}. \tag{3.188}$$

Governments' fixed capital depreciates at a fixed rate, δ_g. Government fixed capital in value,

$$K_{1g,t} = K_{1g,t-1}(1 - \delta_g) + I_{1g,t} + REV_{k_{1g},t} + OCV_{k_{1g},t}, \tag{3.189}$$

where $REV_{k_{1g},t}$ is the revaluation effect of government fixed capital, $OCV_{k_{1g},t}$ is the other changes in value of government fixed capital, which is exogenous.

Governments' fixed capital in volume,

$$k_{1g,t} = \frac{K_{1g,t}}{P_{k_1,t}}. \tag{3.190}$$

Governments' investment in volume,

$$i_{1g,t} = \Delta k_{1g,t} + 0.025 \frac{K_{1g,t-1}}{P_{k,t}}. \tag{3.191}$$

Governments' fixed capital revaluation,

$$REV_{k_{1g},t} = \Delta P_{k_1,t} k_{1g,t-1}. \tag{3.192}$$

Governments' inventories in value,

$$K_{2g,t} = K_{2g,t-1} + I_{2g,t} + REV_{k_{2g},t}, \tag{3.193}$$

where $REV_{k_{2g},t}$ is the revaluation effect.

Governments inventories in volume,

$$k_{2g,t} = \frac{K_{2g,t}}{P_{k_{2g}}}. \tag{3.194}$$

Government changes in inventories in volume targets to government production,

$$i_{2g,t} = \gamma_{i_{2g}} \frac{Y_{g,t}}{P_{y,t}}, \tag{3.195}$$

where $\gamma_{i_{2g}} > 0$ is the share of government changes in inventories to government production.

Governments' inventories revaluation,

$$REV_{k_{2g},t} = \Delta P_{k_{2g},t} k_{2g,t-1}. \tag{3.196}$$

Government other non-financial assets in value,

$$K_{3g,t} = K_{3g,t-1}(1 - 0.1) + I_{3g,t} + REV_{k_{3g},t} + OCV_{k_{3g},t}, \tag{3.197}$$

where 0.1 is the depreciation rate of the government's other non-financial assets (*China's National Balance Sheet 2018*), $REV_{k_{3g},t}$ is the revaluation effect, and $OCV_{k_{3g},t}$ is the other changes in value, which is exogenous.

Government other non-financial assets in volume are proportional to real GDP,

$$k_{3g,t} = \gamma_{k_{3g}} y_t. \tag{3.198}$$

Governments sell other non-financial assets to firms,[18]

$$I_{3g,t} = -I_{3f,t}. \tag{3.199}$$

Governments' other non-financial assets' revaluation effect,

$$REV_{k_{3g},t} = \Delta P_{k_3,t} k_{3g,t-1}. \tag{3.200}$$

[18] This accounting equation is based on the transaction flow matrix. There is a mismatch between the national balance sheet and the transaction flow matrix from the data, governments' other non-financial assets are increasing over time with negative funds paid (positive funds received). The classification of governments' other non-financial assets includes state-owned construction land (*China's National Balance Sheet 2018*), which mainly comes from legislation.

Governments' net financial investment,

$$NFI_{g,t} = S_{g,t} - TRK_t - I_{1g,t} - I_{2g,t} - I_{3g,t} + EO_{g,t}, \tag{3.201}$$

where $TRK_t = \gamma_{TRK} Y_t$ is capital transfers to firms, which is a fixed proportion of nominal GDP, and $EO_{g,t}$ is governments' errors and omissions, which is exogenous.

Governments save part of their net worth as deposits,

$$D_{g,t} = \gamma_{D_g} V_{g,t}. \tag{3.202}$$

Governments' deposit savings,

$$\Delta D_{g,t} = D_{g,t} - D_{g,t-1} - OCV_{d_g,t}, \tag{3.203}$$

where $OCV_{d_g,t}$ is the other changes in value of governments' deposits held.

Governments' equities held in value,

$$E_{g,t} = E_{g,t-1} + REV_{e_g,t}, \tag{3.204}$$

where $REV_{e_g,t}$ is the revaluation effect of government equities held.

Governments' equities held revaluation closes the revaluation account of equities,

$$REV_{e_g,t} = REV_{e_{lf},t} + REV_{e_{lb},t} - REV_{e_{af},t} - REV_{e_{ab},t} - REV_{e_h,t} - REV_{e_r,t}. \tag{3.205}$$

Governments invest a proportion of net worth in investment fund shares,

$$IFS_{g,t} = \gamma_{IFS_g} V_{g,t}. \tag{3.206}$$

Governments' investment fund shares savings,

$$\Delta IFS_{g,t} = IFS_{g,t} - IFS_{g,t-1} - REV_{ifs_g,t} - OCV_{ifs_g,t}, \tag{3.207}$$

where $REV_{ifs_g,t}$ is the revaluation effect and $OCV_{ifs_g,t}$ is the other changes in value of governments' investment fund shares held, which is exogenous.

Governments' investment fund shares held in volume,

$$ifs_{g,t} = \frac{IFS_{g,t}}{P_{ifs,t}}. \tag{3.208}$$

Governments' investment fund shares held revaluation,

$$REV_{ifs_g,t} = \Delta P_{ifs,t} ifs_{g,t}. \tag{3.209}$$

Governments' other accounts payable/receivables are proportional to net worth,

$$Z_{g,t} = \gamma_{Z_g} V_{g,t}. \tag{3.210}$$

Governments' changes in other accounts payable/receivables,

$$\Delta Z_{g,t} = Z_{g,t} - Z_{g,t-1} - OCV_{z_g,t}, \tag{3.211}$$

where $OCV_{z_g,t}$ is the other changes in value of governments' other accounts payables/receivables, which is exogenous.

Governments' bonds close the fiscal constraint,

$$\Delta B_{g,t} = \Delta D_{g,t} + \Delta IFS_{g,t} + \Delta Z_{g,t} - NFI_{g,t}. \tag{3.212}$$

Governments' bonds issued in value,

$$B_{g,t} = B_{g,t-1} + \Delta B_{g,t} + REV_{b_g,t} + OCV_{b_g,t}, \tag{3.213}$$

where $REV_{b_g,t}$ is the revaluation of government bonds, and $OCV_{b_g,t}$ is the other changes in value of government bonds, which is exogenous.

Governments' bonds issued in volume,

$$b_{g,t} = \frac{B_{g,t}}{P_{b_g,t}}, \tag{3.214}$$

where $P_{b_g,t}$ is the price of government bonds.

Governments' bonds revaluation,

$$REV_{b_g,t} = \Delta P_{b_g,t} b_{g,t-1} \tag{3.215}$$

Assuming each unit of government bonds pays 1 rmb after one year, then the price of government bonds can be derived by the inverse of its interest rate (Godley and Lavoie, 2006),

$$P_{B_g,t} = \frac{1}{r_{pg,t}}. \tag{3.216}$$

Government net worth,

$$V_{g,t} = K_{1g,t} + K_{2g,t} + K_{3g,t} + D_{g,t} - B_{g,t} + E_{g,t} + IFS_{g,t} + Z_{g,t}. \tag{3.217}$$

The rest of the world:

Net exports, by definition, equal exports minus imports plus net export adjustment,

$$NX_t = X_t - M_t + NX_{adj,t}. \tag{3.218}$$

Foreign savings is the net current transfers received by the rest of the world,

$$S_{r,t} = -NX_t - W_{r,t} + INT_{rr,t} - INT_{pr,t} + DIV_{rr,t} - OIP_{r,t} - O_{r,t}, \tag{3.219}$$

where $W_{r,t}$ is the foreign wage paid, $INT_{rr,t} = r_{rr,t}L_{ar,t-1}$ is the rest of the world interest received, $INT_{pr,t} = r_{pr,t}L_{lr,t-1}$ is the rest of the world interest paid, $DIV_{rr,t} = \gamma_{DIV_{rr}}(E_{r,t-1} + FDI_{in,t-1})$ is the dividend received by the rest of the world, $OIP_{r,t} = \gamma_{OIP_r}S_{r,t}$ is the other income from properties paid by the rest of the world, assumed to be proportional to foreign savings, and $O_{r,t} = \gamma_{O_r}S_{r,t}$ are the other current transfers paid by the rest of the world, also assumed to by proportional to foreign savings for simplicity.

Foreign wages paid close row of wage payments,

$$W_{r,t} = W_t - W_{b,t} - W_{f,t} - W_{g,t} - W_{h,t}. \tag{3.220}$$

The current account,

$$CA_t = -S_{r,t}. \tag{3.221}$$

Foreign net financial investment,

$$NFI_{r,t} = S_{r,t} + EO_{r,t}, \tag{3.222}$$

where $EO_{r,t}$ is the errors and omissions of the rest of the world, which is exogenous.

The rest of the world loans held,

$$L_{ar,t} = L_{ar,t-1} + \Delta L_{ar,t} + OCV_{l_{ar},t}, \tag{3.223}$$

where $OCV_{l_{ar},t}$ is the other changes in value of the rest of the world loans held, which is exogenous.

We assume the rest of the world loans borrowing stands for a fixed share of the capital account, i.e. $NFI_{r,t}$,

$$\Delta L_{lr,t} = \gamma_{\Delta L_{lr}} NFI_{r,t}. \tag{3.224}$$

The rest of the world's loans issued,

$$L_{lr,t} = L_{lr,t} + \Delta L_{lr,t} + OCV_{l_{lr},t}, \tag{3.225}$$

where $OCV_{l_{lr},t}$ is the other changes in value of the rest of the world's loans issued.

The rest of the world's equities held in value,

$$E_{r,t} = E_{r,t-1} + REV_{e_r,t}, \tag{3.226}$$

where $REV_{e_r,t}$ is the rest of the world equities' revaluation effect.

The rest of the world's equities held in volume,

$$e_{r,t} = \frac{E_{r,t}}{P_{e_r,t}}. \tag{3.227}$$

The rest of the world's equities held revaluation,

$$REV_{e_r,t} = \Delta P_{e_r,t} e_{r,t-1}. \tag{3.228}$$

Inward FDI stock in value,

$$FDI_{in,t} = FDI_{in,t-1} + \Delta FDI_{in,t} + REV_{fdi_{in},t}, \tag{3.229}$$

Inward FDI stock in volume,

$$fdi_{in,t} = \frac{FDI_{in,t}}{P_{fdi_{in},t}}, \tag{3.230}$$

where $P_{fdi_{in},t}$ is the price of inward FDI, which is exogenous by assumption.[19]

Inward FDI revaluation,

$$REV_{fdi_{in},t} = \Delta P_{fdi_{in},t} fdi_{in,t-1}. \tag{3.231}$$

The rest of the world's changes in other accounts payable/receivables close the horizontal line,

$$\Delta Z_{r,t} = -\Delta Z_{f,t} - \Delta Z_{b,t} - \Delta Z_{g,t} - \Delta Z_{h,t}. \tag{3.232}$$

[19]We failed to find any statistical explanation for the price of inward FDI.

The rest of the world's other accounts payable/receivables,

$$Z_{r,t} = Z_{r,t-1} + \Delta Z_{r,t} + OCV_{z_r,t}, \tag{3.233}$$

where $OCV_{z_r,t}$ is the other changes in value of the rest of the world's other accounts receivables/payables, which is exogenous.

Changes in international reserves close the balance of payment,

$$\Delta G_t = \Delta L_{ar,t} - \Delta L_{lr,t} + \Delta FDI_{in,t} - \Delta FDI_{out,t} + \Delta Z_{r,t} - NFI_{r,t}. \tag{3.234}$$

International reserves in value,

$$G_t = G_{t-1} + \Delta G_t + REV_{g,t}, \tag{3.235}$$

where $REV_{g,t}$ is the revaluation effect of international reserves.

International reserves in volume,

$$g_t = \frac{G_t}{P_{g,t}}, \tag{3.236}$$

where $P_{g,t}$ is the price of international reserves, which is exogenous by assumption.[20]

International reserves revaluation,

$$REV_{g,t} = \Delta P_{g,t} g_t. \tag{3.237}$$

The rest of the world's net worth,

$$V_{r,t} = -G_t + L_{ar,t} - L_{lr,t} + E_{r,t} + FDI_{in,t} - FDI_{out,t} + Z_{r,t}. \tag{3.238}$$

Table 3.6: Variables and their values in 2019

Symbol	Description	Value	Remark/sources
A	Banks' insurance issued (100 million rmb)	185272	Calculated from $A = A_f + A_h$
A_f	Firms' insurance held (100 million rmb)	55582	Based on China's National Balance Sheet
A_h	Households' insurance held (100 million rmb)	129690	Based on China's National Balance Sheet
B_{ab}	Banks' bonds held in value (100 million rmb)	827160	Calculated from $B_{ab} = B_f + B_g + B_{lb} - B_h$
B_f	Firms' bonds in value (100 million rmb)	220142	Based on China's National Balance Sheet

[20]We did not find any statistical explanation for the price of international reserves.

B_g	Government bonds in value (100 million rmb)	352935	Based on China's National Balance Sheet
B_{lb}	Banks' bonds issued in value (100 million rmb)	281419	Based on China's National Balance Sheet
B_h	Households' bonds in value (100 million rmb)	27336	Based on China's National Balance Sheet
BI_{in}	Material inflow balancing items (Mt)	11402	Based on Chen et al. 2022
BI_{out}	Material outflow balancing items (Mt)	7734	Based on Chen et al. (2022)
BP	Banks' net disposable income (100 million rmb)	26706	Based on National Bureau of Statistics of China
BPg	Banks' gross disposable income (100 million rmb)	34833	Based on National Bureau of Statistics of China
b_f	Firms' bonds in volume (100 million rmb)	5339	Calculated from equation (3.124)
b_g	Governments' bonds in volume (100 million rmb)	9141	Calculated from equation (3.214)
b_h	Households' bonds in volume (100 million rmb)	920	Calculated from equation (3.87)
b_{lb}	Banks' bonds issued in volume (100 million rmb)	7077	Calculated from equation (3.160)
C_g	Governments consumption (100 million rmb)	102986	Based on National Bureau of Statistic of China
C_h	Households consumption (100 million rmb)	449646	Based on National Bureau of Statistic of China
CA	Current account surplus/deficit (100 million rmb)	7116	Calculated from equation (3.221)
c_h	Households consumption in volume (100 million rmb)	413119	Calculated from $c_h = \frac{C_h}{P_c}$
c_g	Governments consumption in volume (100 million rmb)	94620	Calculated from $c_g = \frac{C_g}{P_c}$ prices are 1
D	Total deposits (100 million rmb)	2279930	Calculated from $D = D_b + D_f + D_g + D_h$
D_b	Banks' deposits held (100 million rmb)	198935	Based on China's National Balance Sheet
D_f	Firms' deposits (100 million rmb)	621147	Based on China's National Balance Sheet
D_g	Governments' deposits (100 million rmb)	339179	Based on China's National Balance Sheet
D_h	Households' deposits (100 million rmb)	1120669	Based on China's National Balance Sheet
DE	Aggregate domestic extraction (Mt)	12423	Based on Chen et al. (2022)
DE_b	Domestic biomass extraction (Mt)	2047	Based on Chen et al. (2022)
DE_f	Domestic fossil energy materials extraction (Mt)	4181	Based on Chen et al. (2022)
DE_m	Domestic metal ores extraction (Mt)	1321	Based on Chen et al. (2022)
DE_{nm}	Domestic non-metallic materials extraction (Mt)	4874	Based on Chen et al. (2022)
DIV_g	Governments' dividend received (100 million rmb)	11257	Based on National Bureau of Statistics of China
DIV_h	Households' dividend received (100 million rmb)	3467	Based on National Bureau of Statistics of China
DIV_{pb}	Banks' dividend paid (100 million rmb)	7175	Based on National Bureau of Statistics of China
DIV_{pf}	Firms' dividend paid (100 million rmb)	26165	Calculated from equation (3.106)
DIV_{rb}	Banks' dividend received (100 million rmb)	1229	Based on National Bureau of Statistics of China

DIV_{rf}	Firms' dividend received (100 million rmb)	8435	Based on National Bureau of Statistics of China
DIV_{rr}	The rest of the world's dividend received (100 million rmb)	8952	Based on National Bureau of Statistics of China
DMC	Aggregate domestic material consumption (Mt)	14504	Based on Chen et al. (2022)
DMC_b	Domestic biomass consumption (Mt)	2295	Based on Chen et al. (2022)
DMC_f	Domestic fossil energy material consumption (Mt)	5051	Based on Chen et al. (2022)
DMC_m	Domestic metal ores consumption (Mt)	2457	Based on Chen et al. (2022)
DMC_{nm}	Domestic non-metallic material consumption (Mt)	4820	Based on Chen et al. (2022)
DMC_o	Domestic other products consumption (Mt)	-119	Based on Chen et al. (2022)
DMI	Aggregate domestic material input (Mt)	15202	Based on Chen et al. (2022)
DMI_b	Domestic biomass input (Mt)	2359	Based on Chen et al. (2022)
DMI_f	Domestic fossil energy materials input (Mt)	5182	Based on Chen et al. (2022)
DMI_m	Domestic metal ores input (Mt)	2680	Based on Chen et al. (2022)
DMI_{nm}	Domestic non-metallic materials input (Mt)	4962	Based on Chen et al. (2022)
DMI_o	Domestic other products input (Mt)	19.77	Based on Chen et al. (2022)
DPO	Aggregate domestic processed output (Mt)	12712	Based on Chen et al. (2022)
DPO_a	Emissions to air (Mt)	12334	Based on Chen et al. (2022)
DPO_{dup}	Dissipative use of products (Mt)	376	Based on Chen et al. (2022)
DPO_w	Emissions to water (Mt)	1.24	Based on Chen et al. (2022)
ΔA	Banks' insurance borrowing (100 million rmb)	23543	Calculated from equation (3.178)
ΔA_f	Firms' insurance savings (100 million rmb)	1448	Based on National Bureau of Statistics of China
ΔA_h	Households' insurance savings (100 million rmb)	22095	Based on National Bureau of Statistics of China
ΔB_{ab}	Banks' bonds savings (100 million rmb)	118211	Calculated from equation (3.157)
ΔB_f	Firms' bonds borrowing (100 million rmb)	28476	Based on National Bureau of Statistics of China
ΔB_g	Governments' bonds borrowing (100 million rmb)	46025	Based on National Bureau of Statistics of China
ΔB_h	Households' bonds savings (100 million rmb)	2406	Based on National Bureau of Statistics of China
ΔB_{lb}	Banks' bonds borrowing (100 million rmb)	46116	Based on National Bureau of Statistics of China
ΔD	Total deposits saving (100 million rmb)	146868	Calculated from equation (3.154)
ΔD_b	Banks' deposits saving (100 million rmb)	-1608	Based on National Bureau of Statistics of China
ΔD_f	Firms' deposits saving (100 million rmb)	35310	Based on National Bureau of Statistics of China
ΔD_g	Governments' deposits saving (100 million rmb)	8700	Based on National Bureau of Statistics of China
ΔD_h	Households deposits saving (100 million rmb)	104466	Based on National Bureau of Statistics of China
ΔFDI_{in}	FDI inward flow (100 million rmb)	10749	Based on National Bureau of Statistics of China
ΔFDI_{out}	FDI outward flow (100 million rmb)	6740	Based on National Bureau of Statistics of China
ΔG	Change in international reserves (100 million rmb)	-1331	Based on National Bureau of Statistics of China

ΔH	Currencies savings (100 million rmb)	3537	Based on National Bureau of Statistics of China
ΔIFS_{ab}	Banks' investment fund shares savings (100 million rmb)	488365	Based on National Bureau of Statistics of China
ΔIFS_g	Governments' investment fund shares savings (100 million rmb)	374	Based on National Bureau of Statistics of China
ΔIFS_h	Households' investment fund shares savings (100 million rmb)	2380	Based on National Bureau of Statistics of China
ΔIFS_{lb}	Banks' investment fund shares borrowing	4095	Calculated from equation (3.174)
ΔL_{ar}	The rest of the world's loans savings (100 million rmb)	-402	Based on National Bureau of Statistics of China
ΔL_b	Banks' loans savings (100 million rmb)	148274	Calculated from equation (3.164)
ΔL_f	Firms' loans borrowing (100 million rmb)	67631	Based on National Bureau of Statistics of China
ΔL_h	Households loans borrowing (100 million rmb)	79539	Based on National Bureau of Statistics of China
ΔL_{lr}	The rest of the world's loans borrowing (100 million rmb)	702	Based on National Bureau of Statistics of China
ΔZ_b	Banks other payable/receivables flows (100 million rmb)	-5581	Calculated from $\Delta Z_b = NFI_b - \Delta G + \Delta H - \Delta D_b + \Delta D - \Delta B_{ab} + \Delta B_{lb} - \Delta L_b - \Delta IFS_{ab} + \Delta IFS_{lb} + \Delta A$
ΔZ_f	Firms' change in other accounts payable/receivables (100 million rmb)	8259	Calculated from equation (3.137)
ΔZ_g	Governments change in other accounts payable/receivables (100 million rmb)	-17699	Calculated from equation (3.212)
ΔZ_h	Households' change in other accounts payable/receivables (100 million rmb)	31511	Calculated from equation (3.53)
ΔZ_r	The rest of the world's change in other accounts payable/receivables (100 million rmb)	-16489	Calculated from equation (3.234)
E_{ab}	Banks' equities held in value (100 million rmb)	333067	Based on China's National Balance Sheet
E_{af}	Firms' equities held in value (100 million rmb)	61154	Based on China's National Balance Sheet
E_g	Governments' equities held in value (100 million rmb)	850000	Based on China's National Balance Sheet
E_h	Households' equities held in value (100 million rmb)	1702111	Based on China's National Balance Sheet
E_{lb}	Banks' equities issued in value (100 million rmb)	287758	Based on China's National Balance Sheet
E_{lf}	Firms' equities issued in value (100 million rmb)	2692202	Based on China's National Balance Sheet
E_r	The rest of the world's equities held in value (100 million rmb)	33628	Based on China's National Balance Sheet
EB	Energy balancing items (10kt SCE)	5690	Based on National Bureau of Statistics of China
EC	Energy consumption (10 kt SCE)	487488	Based on National Bureau of Statistics

			of China
ECI	Economic complexity index	1.3612	Based on Hidalgo and Hausmann (2009)
EEX	Energy exports (10 kt SCE)	14151	Based on National Bureau of Statistics of China
EIM	Energy imports (10 kt SCE)	119064	Based on National Bureau of Statistics of China
EN	Fossil energy production (10 kt SCE)	321827	Based on National Bureau of Statistics of China
EO	Total errors and omissions in value (100 million rmb)	2563	Calculated from equation (3.75)
EO_b	Banks errors and omissions in value (100 million rmb)	10602	Calculated from equation (3.151)
EO_f	Firms errors and omissions in value (100 million rmb)	31154	Calculated from equation (3.121)
EO_g	Governments errors and omissions in value (100 million rmb)	-31730	Calculated from equation (3.201)
EO_h	Households errors an omissions in value (100 million rmb)	-2324	Calculated from equation (3.84)
EO_r	The rest of the world's errors an omissions in value (100 million rmb)	-5138	Calculated from equation (3.222)
EP	Primary energy production (10 kt SCE)	397317	Based National Bureau of Statistics of China
ER	Renewable energy production (10 kt SCE)	75490	Based National Bureau of Statistics of China
ESC	Energy stock change (10 kt SCE)	-9052	Based on National Bureau of Statistics of China
e_{ab}	Banks' equities held in volume (100 million rmb)	300496	Calculated from equation (3.167)
e_{af}	Firms' equities held in volume (100 million rmb)	432700	Calculated from equation (3.127)
e_h	Households' equities held in volume (100 million rmb)	983856	Calculated from equation (3.93)
e_r	The rest of the world's equities held in volume (100 million rmb)	28048	Calculated from equation (3.227)
eo	Total errors and omissions in volume (100 million rmb)	-10939	Calculated from equation (3.37)
FDI_{in}	FDI inward stock in value (100 million rmb)	205340	Based on China's National Balance Sheet
FDI_{out}	FDI outward stock in value (100 million rmb)	146886	Based on China's National Balance Sheet
FP	Firms' net disposable income (100 million rmb)	188667	Based on National Bureau of Statistics of China
FP_g	Firms' gross disposable income (100 million rmb)	220044	Based on National Bureau of Statistics of China
fdi_{in}	Inward FDI stock in volume (100 million rmb)	223130	Calculated from equation (3.230)
fdi_{out}	Outward FDI stock in volume (100 million rmb)	97956	Calculated from equation (3.129)
ffr	Federal funds rate	0.005	Based on Federal Reserves Economic

			Data
G	International reserves in value (100 million rmb)	217797	Based on China's National Balance Sheet
GP	Governments' net disposable income (100 million rmb)	159352	Calculated from equation (3.186)
GP_g	Governments' gross disposable income (100 million rmb)	124632	Based on National Bureau of Statistics of China
g	International reserves in volume (100 million rmb)	229387	Calculated from equation (3.236)
γ_{LF}	Share of labour force in population	0.5508	Calculated from $\gamma_{LF} = \frac{LF}{POP}$
H	Currencies (100 million rmb)	63840	Based on China's National Balance Sheet
I_{1b}	Banks' fixed capital formation in value (100 million rmb)	2161	Based on National Bureau of Statistics of China
I_{1f}	Firms' fixed capital formation in value (100 million rmb)	259056	Based on National Bureau of Statistics of China
I_{1g}	Governments' fixed capital formation in value (100 million rmb)	43891	Based on National Bureau of Statistics of China
I_h	Households' fixed capital formation in value(100 million rmb)	117344	Based on National Bureau of Statistics of China
I_{2f}	Firms' changes in inventories in value (100 million rmb)	4812	Based on National Bureau of Statistics of China
I_{2g}	Governments' changes in inventories in value (100 million rmb)	10.34	Based on National Bureau of Statistics of China
I_{3f}	Firms' acquisition less disposal of other non-financial assets in value (100 million rmb)	23942	Calculated from equation (3.199)
I_{3g}	Governments' acquisition less disposal of other non-financial assets in value (100 million rmb)	-23941	Based on National Bureau of Statistics of China
IFS_{ab}	Banks investment fund shares held (100 million rmb)	488365	Based on China's National Balance Sheet
IFS_g	Governments' investment fund shares held (100 million rmb)	96545	Based on China's National Balance Sheet
IFS_h	Households' investment fund shares held (100 million rmb)	192424	Based on China's National Balance Sheet
IFS_{lb}	Banks' investment fund shares issued (100 million rmb)	777334	Calculated from $IFS_{lb} = IFS_{ab} + IFS_g + IFS_h$
INT_{bf}	Firms' bonds interest paid (100 million rmb)	4695	Calculated from $INT_{bf} = r_{pf} B_{f,-1}$
INT_{bg}	Governments' bonds interest paid (100 million rmb)	8015	Calculated from $INT_{bg} = r_{pg} B_{g,-1}$
INT_{bh}	Households' bonds interest received (100 million rmb)	885	Calculated from $INT_{bh} = r_{rh} B_{h,-1}$
INT_{brb}	Banks' bonds interest received (100 million rmb)	18252	Calculated from equation (3.141)
INT_{bpb}	Banks' bonds interest paid (100 million rmb)	6428	Calculated from $INT_{bpb} = r_{pb} B_{lb,-1}$
INT_d	Banks' deposits interest paid (100 million rmb)	65306	Calculated from equation (3.143)
INT_{db}	Banks' deposits interest received	4100	Calculated from

	(100 million rmb)		$INT_{db} = r_{rb}D_{b,-1}$
INT_{df}	Firms' deposits interest received (100 million rmb)	20017	Calculated from $INT_{df} = r_{rf}D_{f,-1}$
INT_{dg}	Governments' deposits interest received (100 million rmb)	7437	Calculated from $INT_{dg} = r_{rg}D_{g,-1}$
INT_{dh}	Households' deposits interest received (100 million rmb)	33752	Calculated from $INT_{dh} = r_{rh}D_{h,-1}$
INT_{lb}	Banks' loans interest received (100 million rmb)	43889	Calculated from equation (3.142)
INT_{lf}	Firms' loans interest paid (100 million rmb)	26673	Calculated from $INT_{lf} = r_{pf}L_{f,-1}$
INT_{lh}	Households' loans interest paid (100 million rmb)	12517	Calculated from $INT_{lh} = r_{ph}L_{h,-1}$
INT_{pb}	Banks' interest paid (100 million rmb)	71734	Calculated from $INT_{pb} = INT_d + INT_{bpb}$
INT_{pf}	Firms' interest paid (100 million rmb)	31367	Calculated from $INT_{pf} = INT_{bf} + INT_{lf}$
INT_{pr}	The rest of the world's interest paid (100 million rmb)	6307	Calculated from $IN_{pr} = r_{pr}L_{lr,-1}$
INT_{rb}	Banks' interest received (100 million rmb)	66241	Calculated from $INT_{rb} = INT_{db} + INT_{brb} + INT_{lb}$
INT_{rh}	Households' interest received (100 million rmb)	34636	Calculated from $INT_{rh} = INT_{dh} + INT_{bh}$
INT_{rr}	The rest of the world's interest received (100 million rmb)	1608	Calculated from $INT_{rr} = r_{rr}L_{ar,-1}$
i_{1b}	Banks' fixed capital formation in volume (100 million rmb)	1900	Calculated from $i_{1b} = \frac{I_{1b}}{P_{k_1}}$
i_{1f}	Firms' fixed capital formation in volume (100 million rmb)	227789	Calculated from $i_{1f} = \frac{I_{1f}}{P_{k_1}}$
i_{1g}	Governments' fixed capital formation in volume (100 million rmb)	38593	Calculated from $i_{1g} = \frac{I_{1g}}{P_{k_1}}$
i_h	Households' fixed capital formation in volume (100 million rmb)	82431	Calculated from $i_h = \frac{I_h}{P_{k_h}}$
i_{2f}	Firms' changes in inventories in volume (100 million rmb)	3454	Calculated from $i_{2f} = \frac{I_{2f}}{P_{k_{2f}}}$
i_{2g}	Governments' changes in inventories in volume (100 million rmb)	8.02	Calculated from $i_{2g} = \frac{I_{2g}}{P_{k_{2g}}}$
i_{3f}	Firms' acquisition less disposal of other non-financial assets in volume (100 million rmb)	21064	Calculated from equation (3.119)
ifs_{ab}	Banks' investment fund shares held in volume (100 million rmb)	389235	Calculated from equation (3.170)
ifs_g	Governments' investment fund shares held in volume (100 million rmb)	76948	Calculated from equation (3.208)
ifs_h	Households' investment fund shares held in volume (100 million rmb)	153365	Calculated from equation (3.96)
K_{1b}	Banks' fixed capital in value (100 million rmb)	15928	Based on China's National Balance Sheet
K_{1f}	Firms' fixed capital in value (100 million rmb)	1751211	Based on China's National Balance

			Sheet
K_{1g}	Governments' fixed capital in value (100 million rmb)	209337	Based on China's National Balance Sheet
K_h	Households' fixed capital in value (100 million rmb)	2499331	Based on China's National Balance Sheet
K_{2g}	Governments' fixed capital in value (100 million rmb)	9335	Based on China's National Balance Sheet
K_{2f}	Firms' inventories in value (100 million rmb)	1193439	Based on China's National Balance Sheet
K_{3b}	Banks' other non-financial assets in value (100 million rmb)	18282	Based on China's National Balance Sheet
K_{3f}	Firms' other non-financial assets in value (100 million rmb)	474852	Based on China's National Balance Sheet
K_{3g}	Governments' other non-financial assets in value (100 million rmb)	447314	Based on China's National Balance Sheet
k_{1b}	Banks' fixed capital in volume (100 million rmb)	14006	Calculated from equation (3.146)
k_{1f}	Firms' fixed capital in volume (100 million rmb)	1539850	Calculated from equation (3.109)
k_{1fu}	Firms' fixed capital utilized in volume (100 million rmb)	1156581	Calculated from equation (3.57)
k_{1g}	Governments' fixed capital in volume (100 million rmb)	184071	Calculated from equation (3.190)
k_h	Households' fixed capital in volume (100 million rmb)	1755710	Calculated from equation (3.80)
k_{2f}	Firms' inventories in volume (100 million rmb)	856711	Calculated from equation (3.113)
k_{2g}	Governments' inventories in volume (100 million rmb)	7240	Calculated from equation (3.194)
k_{3f}	Firms' other non-financial assets in volume (100 million rmb)	417768	Calculated from equation (3.116)
k_{3g}	Governments' other non-financial assets in volume (100 million rmb)	447314	Calculated from $k_{3g} = \frac{K_{3g}}{P_{k3}}$
L_{ar}	The rest of the world's loans held (100 million rmb)	57843	Based on China's National Balance Sheet
L_b	Banks loans held (100 million rmb)	1820063	Calculated from $L_b = L_f + L_h + L_{lr} + L_{ar}$
L_f	Firms' loans (100 million rmb)	1180596	Based on China's National Balance Sheet
L_h	Households loans (100 million rmb)	609179	Based on China's National Balance Sheet
L_{lr}	The rest of the world's loans issued (100 million rmb)	88131	Based on China's National Balance Sheet
LF	Labour force (100 million)	7.7532	Based on World Bank
M	Imports in value (100 million rmb)	172444	Based on World Bank
MEX	Aggregate material export (Mt)	698	Based on Chen et al. (2022)
MEX_b	Biomass export (Mt)	64.06	Based on Chen et al. (2022)
MEX_f	Fossil energy materials export (Mt)	131	Based on Chen et al. (2022)
MEX_m	Metal ores export (Mt)	222	Based on Chen et al. (2022)
MEX_{nm}	Non-metallic materials export (Mt)	142	Based on Chen et al. (2022)
MEX_o	Other products export (Mt)	139	Based on Chen et al. (2022)
MIM	Aggregate material import (Mt)	2779	Based on Chen et al. (2022)

MIM_b	Biomass import (Mt)	311	Based on Chen et al. (2022)
MIM_f	Fossil energy materials import (Mt)	1001	Based on Chen et al. (2022)
MIM_m	Metal ores import (Mt)	1359	Based on Chen et al. (2022)
MIM_{nm}	Non-metallic materials import (Mt)	87.68	Based on Chen et al. (2022)
MIM_o	Non-metallic materials import (Mt)	19.77	Based on Chen et al. (2022)
MS	Aggregate material stock (Mt)	187670	Based on Chen et al. (2022)
m	Imports in volume (100 million rmb)	149380	Calculated from $m = \frac{M}{P_m}$
N	Employment (100 million)	7.3997	Based on World Bank
NAS	Net additions to material stock (Mt)	5460	Based on Chen et al. 2022
NFI_b	Banks' net financial investment	35147	Calculated from $NFI_b = -(NFI_f$ $+NFI_g + NFI_h + NFI_r)$
NFI_f	Firms' net financial investment (100 million rmb)	-55099	Based on National Bureau of Statistics of China
NFI_g	Governments' net financial investment (100 million rmb)	-54651	Based on National Bureau of Statistics of China
NFI_h	Households' net financial investment (100 million rmb)	86856	Based on National Bureau of Statistics of China
NFI_r	The rest of the world's net financial investment (100 million rmb)	-12254	Based on National Bureau of Statistics of China
NX	Net exports (100 million rmb)	9174	Based on National Bureau of Statistics of China
NX_{adj}	Net exports adjustment in value (100 million rmb)	-0.0024	Calculated from equation (3.218)
nx_{adj}	Net exports adjustment in volume (100 million rmb)	-0.0022	Calculated from $nx_{adj} = \frac{NX_{adj}}{Px}$
ν_{dup}	Coefficient of dissipative use of products	0.18	Calculated from equation (3.27)
ν_w	Emissions to water intensity (Mt/100 million rmb)	1.39e-06	Calculated from equation (3.29)
O_b	Banks' other current transfers paid (100 million rmb)	749	Calculated from equation (3.144)
O_f	Firms' other current transfers paid (100 million rmb)	2949	Calculated from equation (3.107)
O_g	Governments' other current transfers received (100 million rmb)	9226	Calculated from equation (3.186)
O_h	Households' other current transfers paid (100 million rmb)	6319	Calculated from equation (3.78)
O_r	The rest of the world's other current transfers paid (100 million rmb)	706	Calculated from equation (3.187)
OCS	Other change in material stock (Mt)	0	Based on Chen et al. (2022)
OCV_a	Other changes in value of banks' insurance issued (100 million rmb)	-2339	Calculated from equation (3.177)
OCV_{a_f}	Other changes in value of firms' insurance held (100 million rmb)	4928	Calculated from equation (3.133)
OCV_{a_h}	Other changes in value of households' insurance held (100 million rmb)	-7267	Calculated from equation (3.100)
$OCV_{b_{ab}}$	Other changes in value of banks bonds held	-8570	Calculated from equation (3.156)
OCV_{b_f}	Other changes in value of firms bonds issued	-22773	Calculated from equation (3.123)

OCV_{b_g}	Other changes in value of governments bonds issued	-13469	Calculated from equation (3.213)
OCV_{b_h}	Other changes in value of households bonds held	-457	Calculated from equation (3.88)
$OCV_{b_{lb}}$	Other changes in value of banks bonds issued	-8636	Calculated from equation (3.161)
OCV_d	Other changes in value of banks deposits issued (100 million rmb)	30554	Calculated from equation (3.153)
OCV_{d_b}	Other changes in value of banks deposits held (100 million rmb)	16232	Calculated from equation (3.152)
OCV_{d_f}	Other changes in value of firms deposits held (100 million rmb)	-3268	Calculated from equation (3.122)
OCV_{d_g}	Other changes in value of governments deposits held (100 million rmb)	4160	Calculated from equation (3.203)
OCV_{d_h}	Other changes in value of households deposits held (100 million rmb)	13430	Calculated from equation (3.86)
$OCV_{ifs_{ab}}$	Other changes in value of banks investment fund shares held (100 million rmb)	-21235	Calculated from equation (3.171)
OCV_{ifs_g}	Other changes in value of governments investment fund shares held (100 million rmb)	9420	Calculated from equation (3.207)
OCV_{ifs_h}	Other changes in value of households investment fund shares held (100 million rmb)	16588	Calculated from equation (3.97)
$OCV_{ifs_{lb}}$	Other changes in value of banks investment fund shares issued (100 million rmb)	-21235	Calculated from equation (3.173)
$OCV_{k_{1b}}$	Other changes in value of banks fixed capital (100 million rmb)	-1208	Calculated from equation (3.145)
$OCV_{k_{1f}}$	Other changes in value of firms fixed capital (100 million rmb)	-16817	Calculated from equation (3.108)
$OCV_{k_{1g}}$	Other changes in value of government fixed capital (100 million rmb)	-15938	Calculated from equation (3.189)
OCV_{k_h}	Other changes in value of households fixed capital (100 million rmb)	-19540	Calculated from equation (3.81)
$OCV_{k_{3f}}$	Other changes in value of firms other non-financial assets (100 million rmb)	35314	Calculated from equation (3.116)
$OCV_{k_{3g}}$	Other changes in value of governments other non-financial assets (100 million rmb)	72383	Calculated from equation (3.197)
$OCV_{l_{ar}}$	Other changes in value of the rest of the world loans held (100 million rmb)	2472	Calculated from equation (3.223)
OCV_{l_f}	Other changes in value of firms loans (100 million rmb)	13259	Calculated from equation (3.136)
OCV_{l_b}	Other changes in value of banks loans issued (100 million rmb)	9071	Calculated from equation (3.163)
OCV_{l_h}	Other changes in value of households loans (100 million rmb)	840	Calculated from equation (3.91)

$OCV_{l_{lr}}$	Other changes in value of the rest of world loans issues (100 million rmb)	-2556	Calculated from equation (3.225)
OCV_{z_b}	Other changes in value of banks' other accounts payable/receivables (100 million rmb)	11721	Calculated from equation (3.181)
OCV_{z_f}	Other changes in value of firms' other accounts payable/receivables (100 million rmb)	-16621	Calculated from equation (3.135)
OCV_{z_g}	Other changes in value of governments' other accounts payable/receivables (100 million rmb)	22243	Calculated from equation (3.211)
OCV_{z_h}	Other changes in value of households' other accounts payable/receivables (100 million rmb)	-31510	Calculated from equation (3.102)
OCV_{z_r}	Other changes in value of the rest of the world's other accounts payable/receivables (100 million rmb)	14166	Calculated from equation (3.233)
OIP_b	Banks' other income from properties paid (100 million rmb)	1561	Calculated from equation (3.140)
OIP_f	Firms' other income from properties paid (100 million rmb)	7848	Calculated from equation (3.105)
OIP_g	Governments' other income from properties received (100 million rmb)	4785	Calculated from equation (3.184)
OIP_h	Households other income from properties received (100 million rmb)	5900	Calculated from equation (3.77)
OIP_r	The rest of the world's other income from properties paid (100 million rmb)	1276	Calculated from equation (3.185)
P_{b_f}	Price of firms' bonds	41.23	Calculated from $P_{b_f} = \frac{1}{r_{pf}}$
P_{b_g}	Price of government bonds	38.59	Calculated from equation (3.216)
P_{b_h}	Price of households bonds	29.71	Calculated from equation (3.90)
$P_{b_{lb}}$	Price of banks bonds issued	39.76	Calculated from $P_{b_{lb}} = \frac{1}{r_{pb}}$
P_c	Consumer price index (2015 = 1)	1.0884	Based on World Bank
$P_{e_{ab}}$	Price of banks equity held (2015 = 1)	1.1084	Calculated from equation (3.168)
$P_{e_{af}}$	Price of firms equity held (2015 = 1)	0.14	Calculated from equation (3.128)
P_{e_h}	Price of households equity held (2015 = 1)	1.73	Calculated from equation (3.94)
P_{e_g}	Price governments equity held (2015 = 1)	1.8017	Calculated from $\frac{\Delta P_{e_g}}{P_{e_g,-1}} = \frac{REV_{eg}}{E_{g,-1}}$
$P_{e_{lb}}$	Price of banks equity issued (2015 = 1)	1.5822	Calculated from equation (3.35)
$P_{e_{lf}}$	Price of firms equity issued (2015 = 1)	1.323	Calculated from equation (3.35)
P_{e_r}	Price of the rest of the world equity held (2015 = 1)	1.1989	Calculated from equation (3.228)
P_{eo}	Price of errors and omissions (2015 = 1)	-0.2343	Calculated from $P_{eo} = \frac{EO}{eo}$
$P_{fdi_{in}}$	Price of inward FDI (2015 = 1)	0.9203	Calculated from equation (3.231)
$P_{fdi_{out}}$	Price of outward FDI (2015 = 1)	1.5	Calculated from equation (3.131)
P_{ifs}	Price of investment fund shares (2015 = 1)	1.2547	Calculated from equation $\frac{\Delta P_{ifs}}{P_{ifs,-1}} = \frac{REV_{ifs_{lb}}}{IFS_{lb,-1}}$
P_g	Price of international reserves (2015 = 1)	0.9495	Calculated from equation (3.237)
P_{k_1}	Fixed capital price index (2015 = 1)	1.1373	Based on National Bureau of Statistics

			of China
P_{k_h}	Housing price index (2015 = 1)	1.4235	Based on National Bureau of Statistics of China and China's National Balance Sheet
$P_{k_{2f}}$	Price of firms inventories (2015 = 1)	1.393	Calculated from equation (3.115)
$P_{k_{2g}}$	Price of government inventories (2015 = 1)	1.2894	Calculated from equation (3.196)
P_{k_3}	Price of other non-financial assets (2015 = 1)	1.1366	Based on National Bureau of Statistics of China and China's National Balance Sheet
$P_{k_{3b}}$	Price of banks' other non-financial assets (2015 = 1)	1.2415	Calculated from equation (3.150)
P_m	Import price index (2015 = 1)	1.1544	Based on National Bureau of Statistics of China
P_x	Export price index (2015 = 1)	1.0886	Based on National Bureau of Statistics of China
P_y	GDP deflator (2015 = 1)	1.1081	Based on World Development Indicators
POP	Total population (100 million)	14.08	Based on World Bank
Π_b	Banks' gross operating surplus (100 million rmb)	47833	Calculated from equation (3.139)
Π_f	Firms' gross operating surplus (100 million rmb)	256972	Calculated from equation (3.104)
Π_g	Governments' gross operating surplus (100 million rmb)	11535	Calculated from equation (3.183)
Π_h	Households' gross operating surplus (100 million rmb)	136534	Calculated from equation (3.76)
π	CPI inflation	0.029	Calculated from $\pi = \frac{\Delta P_c}{P_{c,-1}}$
$REV_{b_{ab}}$	Banks' bonds held revaluation (100 million rmb)	-14633	Calculated from equation (3.158)
REV_{b_f}	Firms' bonds revaluation (100 million rmb)	-14966	Calculated from equation (3.125)
REV_{b_g}	Governments' bonds revaluation (100 million rmb)	11081	Calculated from equation (3.215)
REV_{b_h}	Households' bonds revaluation (100 million rmb)	-902	Calculated from equation (3.89)
$REV_{b_{lb}}$	Banks' bonds issued revaluation (100 million rmb)	-11650	Calculated from equation (3.162)
$REV_{e_{ab}}$	Banks' equity held revaluation (100 million rmb)	5836	Calculated from equation (3.166)
$REV_{e_{af}}$	Firms' equity held revaluation (100 million rmb)	9312	Calculated from equation (3.126)
REV_{e_g}	Governments' equity held revaluation (100 million rmb)	91000	Calculated from equation (3.204)
REV_{e_h}	Households' equity held revaluation (100 million rmb)	244924	Calculated from equation (3.92)
$REV_{e_{lb}}$	Banks' equity issued revaluation (100 million rmb)	33615	Calculated from equation (3.34)
$REV_{e_{lf}}$	Firms' equity issued revaluation (100 million rmb)	323045	Calculated from equation (3.34)
REV_{e_r}	The rest of the world's equity held revaluation (100 million rmb)	5588	Calculated from equation (3.226)

$REV_{fdi_{in}}$	Inward FDI revaluation (100 million rmb)	-61	Calculated from equation (3.229)
$REV_{fdi_{out}}$	Outward FDI revaluation (100 million rmb)	3659	Calculated from equation (3.130)
REV_g	International reserves revaluation (100 million rmb)	2643	Calculated from equation (3.235)
$REV_{ifs_{ab}}$	Banks' investment fund shares held revaluation (100 million rmb)	-15389	Calculated from equation (3.172)
REV_{ifs_g}	Governments' investment fund shares issued revaluation (100 million rmb)	-2627	Calculated from equation (3.209)
REV_{ifs_h}	Households' investment fund shares held revaluation (100 million rmb)	-5252	Calculated from equation (3.98)
$REV_{ifs_{lb}}$	Banks' investment fund shares issued revaluation (100 million rmb)	-23268	Calculated from equation (3.175)
$REV_{k_{1b}}$	Banks' fixed capital revaluation (100 million rmb)	389	Calculated from equation (3.148)
$REV_{k_{1f}}$	Firms' fixed capital revaluation (100 million rmb)	39902	Calculated from equation (3.111)
$REV_{k_{1g}}$	Governments' fixed capital revaluation (100 million rmb)	4711	Calculated from equation (3.192)
REV_{k_h}	Households' fixed capital revaluation (100 million rmb)	189286	Calculated from equation (3.83)
$REV_{k_{2f}}$	Firms' inventories revaluation (100 million rmb)	98056	Calculated from equation (3.112)
$REV_{k_{2g}}$	Governments' inventories revaluation (100 million rmb)	1321	Calculated from equation (3.193)
$REV_{k_{3b}}$	Banks' other non-financial assets revaluation	968	Calibrated from equation (3.150)
$REV_{k_{3f}}$	Firms' other non-financial assets revaluation (100 million rmb)	12812	Calculated from equation (3.120)
$REV_{k_{3g}}$	Governments' other non-financial assets revaluation (100 million rmb)	13616	Calculated from equation (3.200)
RoE	Recovery of energy (10 kt SCE)	0	Based on National Bureau of Statistics of China
r_δ	Discount rate	0.029	Based on International Financial Statistics
r_{pb}	Banks rate of interest paid	0.0251	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{pf}	Firms rate of interest paid	0.0243	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{pg}	Governments rate of interest paid	0.0259	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{ph}	Households rate of interest paid	0.0237	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{pr}	The rest of the world rate of interest paid	0.0701	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{rb}	Banks rate of interest received	0.0222	Based on National Bureau of Statistics

			of China and China's National Balance Sheet
r_{rf}	Firms' rate of interest received	0.034	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{rg}	Governments' rate of interest received	0.0228	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{rh}	Households' rate of interest received	0.0337	Based on National Bureau of Statistics of China and China's National Balance Sheet
r_{rr}	The rest of the world's rate of interest received	0.0288	Based on National Bureau of Statistics of China and China's National Balance Sheet
S_g	Governments' savings (100 million rmb)	9928	Calculated from equation (3.188)
S_h	Households' savings (100 million rmb)	206525	Based on National Bureau of Statistics of China
S_r	The rest of the world's savings (100 million rmb)	-7116	Calculated from equation (3.219)
SB	Social benefits (100 million rmb)	70238	Based on National Bureau of Statistics of China
SC	Social contributions (100 million rmb)	64049	Based on National Bureau of Statistics of China
STR	Social transfers in kind (100 million rmb)	62458	Based on National Bureau of Statistics of China
T	Income tax received by governments (100 million rmb)	47703	Calculated from $T = T_f + T_b + T_h$
T_b	Income tax paid by banks (100 million rmb)	8876	Based on National Bureau of Statistics of China
T_f	Income tax paid by firms (100 million rmb)	28428	Based on National Bureau of Statistics of China
T_h	Income tax paid by households (100 million rmb)	10399	Based on National Bureau of Statistics of China
TL	Net production tax received by governments (100 million rmb)	97632	Calculated from $TL = TL_f + TL_b + TL_h$
TL_b	Net production tax paid by banks (100 million rmb)	7593	Based on National Bureau of Statistics of China
TL_f	Net production tax paid by firms (100 million rmb)	88546	Based on National Bureau of Statistics of China
TL_h	Net production tax paid by households (100 million rmb)	1493	Based on National Bureau of Statistics of China
TRK	Capital transfers to firms (100 million rmb)	12890	Based on National Bureau of Statistics of China
θ	Share of renewable energy production	0.19	Based on National Bureau of Statistics of China
U_k	Capacity utilization rate	0.7511	Based on Wang and Zeng (2022)[21]
ULC	Unit labour cost (rmb)	0.5767	Calculated from equation (3.44)

[21] Chinese article. Wang and Zeng (2022). Research on the Macro Measurement Indicators and Methods of Capital Utilization Rate. *Statistical Research, 39*(7), 43-55.

u	Unemployment rate	0.0456	Based on World Bank
ε	Energy intensity	0.4509	Calculated from equation (3.2)
V_h	Households' net worth (100 million rmb)	5126224	Calculated from equation (3.103)
V_g	Governments' net worth (100 million rmb)	1628347	Calculated from equation (3.217)
V_r	The rest of the world's net worth (100 million rmb)	-135543	Calculated from equation (3.238)
W	Total wage bill (100 million rmb)	513472	Based on National Bureau of Statistics of China
W_b	Wage paid by banks (100 million rmb)	20824	Based on National Bureau of Statistics of China
W_f	Wage paid by firms (100 million rmb)	266647	Based on National Bureau of Statistics of China
W_g	Wage paid by governments (100 million rmb)	89253	Based on National Bureau of Statistics of China
W_h	Wage paid by households (100 million rmb)	136534	Based on National Bureau of Statistics of China
W_r	Wage paid by the rest of the world (100 million rmb)	214	Based on National Bureau of Statistics of China
w^{nom}	Nominal wage (rmb)	69391	Calculated from equation (3.43)
X	Exports in value (100 million rmb)	181617	Based on World Bank
XR	Nominal effective exchange rate	0.9086	Based on European Central Bank
x	Exports in volume (100 million rmb)	166830	Calculated from $\frac{X}{P_x}$
Y	Nominal GDP (100 million rmb)	986515	Based on National Bureau of Statistics of China
Y_{adj}	Nominal GDP adjustment (100 million rmb)	-0.0077	Calculated from equation (3.74)
Y_b	Banks' output (100 million rmb)	76251	Based on National Bureau of Statistics of China
Y_f	Firms' output (100 million rmb)	612165	Based on National Bureau of Statistics of China
Y_g	Governments' output (100 million rmb)	100788	Based on National Bureau of Statistics of China
Y_h	Households' output (100 million rmb) (100 million rmb)	197312	Based on National Bureau of Statistics of China
Y_r	Nominal GDP of the rest of the world (100 million US dollar)	4610107	Based on World Bank
YD	Households' net disposable income (100 million rmb)	656170	Based on National Bureau of Statistics of China
YD_g	Households' gross disposable income (100 million rmb)	604242	Based on National Bureau of Statistics of China
y	Real GDP (100 million rmb)	890305	Calculated from $\frac{Y}{P_y}$
y_{adj}	Real GDP adjustment (100 million rmb)	-0.007	Calculated from $y_{adj} = \frac{Y_{adj}}{P_y}$
y_N	Labor productivity (rmb per employment)	120317	Calculated from equation (3.38)
Z_b	Banks' other accounts payable/receivables (100 million rmb)	-44044	Calculated from equation (3.33)
Z_f	Firms' other accounts payable/receivables (100 million rmb)	-5991	Calculated from equation (3.32)
Z_g	Governments' other accounts payable/receivables (100 million rmb)	29572	Based on China's National Balance Sheet
Z_h	Households other accounts payable/receivable	2.39	Calculated from equation

	(100 million rmb)		$Z_h = -(Z_b + Z_f + Z_g + Z_r)$
Z_r	The rest of the world other accounts payable/receivables (100 million rmb)	20460	Based on China's National Balance Sheet

Table 3.7: Values for parameters

Symbol	Description	Value	Remark/sources
α_1	Short-run elasticity of the price of fixed capital to import price	0.2346	Estimated from OLS regression
α_2	Short-run elasticity of the price of fixed capital to unit labour cost	0.4646	Estimated from OLS regression
α_3	Long-run correction parameter of the price of fixed capital	-0.2993	Estimated from OLS regression
α_4	Mark-up of the price of fixed capital	0.3591	Estimated from OLS regression
α_5	Long-run elasticity of the price of fixed capital to import price	0.2178	Estimated from OLS regression
α_6	Long-run elasticity of the price of fixed capital to unit labour cost	0.5407	Estimated from OLS regression
b_{f0}	Firms bond issued preference	0.1539	Estimated from OLS regression
b_{f1}	Sensitivity of firms bonds to net disposable income	-1.1726	Estimated from OLS regression
b_{h0}	Households bond held preference	-0.0062	Estimated from OLS regression
b_{h1}	persistence of the share of households' bonds held	0.7566	Estimated from OLS regression
b_{h2}	sensitivity of households' bonds held to real interest rate received	0.0312	Estimated from OLS regression
b_{h3}	Income effect on households' bonds	0.0523	Estimated from OLS regression
b_{lb0}	Banks liquidity demand for issuing bonds	1.0519	Estimated from OLS regression
b_{lb1}	Sensitivity of banks bonds issued to real rate of interest paid	-5.6078	Estimated from OLS regression
β_0	Autonomous firms' fixed capital formation rate	-0.312	Estimated from OLS regression
β_1	Sensitivity of firms' fixed capital formation rate to the net profit rate	0.5812	Estimated from OLS regression
β_2	Sensitivity of firms' fixed capital formation rate to capacity utilization rate	0.4589	Estimated from OLS regression
c_0	Autonomous consumption growth	0.0532	Estimated from OLS regression
c_1	Households consumption short-run income effect	0.4225	Estimated from OLS regression
c_2	Households consumption long run correction	-0.2812	Estimated from OLS regression
c_3	Households autonomous consumption	0.3521	Estimated from OLS regression
c_4	Households consumption habit formation	0.632	Estimated from OLS regression
c_5	Households consumption long-run income effect	0.241	Estimated from OLS regression
c_6	Households consumption wealth effect	0.0899	Estimated from OLS regression
car	Coverage ratio of fossil energy production	76.97	Calculated from equation (3.13)
car_{ex}	Coverage ratio of energy exports	107.86	Calculated from equation (3.21)
car_{im}	Coverage ratio of energy imports	118.92	Calculated from equation (3.16)
$comb_{in}$	Combustion inflow coefficient	2.257	Calculated from equation (3.24)
$comb_{out}$	Combustion outflow coefficient	1.531	Calculated from equation (3.31)

d_{b0}	Banks deposit held preference	0.7014	Estimated from OLS regression
d_{b1}	Sensitivity of banks deposits held to real rate of interest received	5.5918	Estimated from OLS regression
d_{f0}	Liquidity preference of firms	0.1726	Estimated from OLS regression
d_{f1}	Sensitivity of firms deposits to real rate of interest received	0.5008	Estimated from OLS regression
d_{f2}	Sensitivity of firms deposits to net disposable income	1.595	Estimated from OLS regression
dup_0	Short-run exogenous reduction of dissipative use of products to biomass extraction	-0.0187	Estimated from OLS regression
dup_1	Short-run elasticity of the coefficient of dissipative use of products to the Gini coefficient	0.672	Estimated from OLS regression
dup_2	Long-run correction parameter of the coefficient of dissipative use of products	-0.4124	Estimated from OLS regression
dup_3	Level of the coefficient of dissipative use of products in logarithm when the Gini coefficient equals 1 and real GDP equals 100 million rmb	0.4768	Estimated from OLS regression
dup_4	long-run elasticity of the coefficient of dissipative use of products to the Gini coefficient	1.0128	Estimated from OLS regression
dup_5	Elasticity of the coefficient of dissipative use of products to real GDP	-0.1805	Estimated from OLS regression
δ_b	Banks' fixed capital depreciation rate	0.025	Based on China's National Balance Sheet
δ_f	Firms' fixed capital depreciation rate	0.0428	Based on China's National Balance Sheet
δ_g	Governments' fixed capital depreciation rate	0.025	Based on China's National Balance Sheet
δ_h	Households' fixed capital depreciation rate	0.0193	Based on China's National Balance Sheet
η	Working hours	1	Standardized
fdi_{out0}	Firms outward FDI preference	0.1	Estimated from OLS regression
fdi_{out1}	Sensitivity of outward FDI to firms net profit rate	-0.2912	Estimated from OLS regression
fdi_{out2}	Sensitivity of outward FDI to the real rate of interest paid by firms	-0.2119	Estimated from OLS regression
fdi_{in0}	Autonomous FDI inward accumulation rate	-0.0823	Estimated from OLS regression
fdi_{in1}	Sensitivity of FDI inward to domestic firms'	0.8986	Estimated from OLS regression gross profit rate
$gini_0$	Area below the equality line times two	0.9276	Estimated from OLS regression
$gini_1$	Coefficient of the product of employment share and wage share	-1.6148	Estimated from OLS regression
$gini_2$	Sensitivity of the Gini coefficient to the ratio of social benefit to nominal GDP	-1.5237	Estimated from OLS regression
γ_{A_f}	Firms' insurance held to net worth ratio	0.0206	Calculated from equation (3.132)
γ_{A_h}	Households' insurance held to net worth ratio	0.0253	Calculated from equation (3.99)
γ_{c_g}	Share of governments' consumption	0.1063	Calculated from equation (3.66)
γ_{D_g}	Share of governments' deposits held	0.2083	Calculated from equation (3.202)
γ_{DIV_g}	Governments rate of dividend received	0.0148	Calculated from $\gamma_{DIV_g} = \frac{DIV_g}{E_{g,-1}+IFS_{g,-1}}$

γ_{DIV_h}	Households rate of dividend received	0.0021	Calculated from $\gamma_{DIV_h} = \frac{DIV_h}{E_{h,-1}+IFS_{h,-1}}$
$\gamma_{DIV_{pb}}$	Banks rate of dividend paid	0.0069	Calculated from $\gamma_{DIV_{pb}} = \frac{DIV_{pb}}{E_{lb,-1}+IFS_{lb,-1}}$
$\gamma_{DIV_{rb}}$	Banks rate of dividend received	0.0014	Calculated from $\gamma_{DIV_{rb}} = \frac{DIV_{rb}}{E_{ab,-1}+IFS_{ab,-1}}$
$\gamma_{DIV_{rf}}$	Firms rate of dividend received	0.0448	Calculated from $\gamma_{DIV_{rf}} = \frac{DIV_{rf}}{E_{af,-1}+FDI_{out,-1}}$
$\gamma_{DIV_{rr}}$	The rest of the world rate of dividend received	0.0677	Calculated from $\gamma_{DIV_{rr}} = \frac{DIV_{rr}}{E_{r,-1}+FDI_{in,-1}}$
$\gamma_{\Delta L_{lr}}$	Share of the rest of the world loans borrowing	-0.0573	Calculated from equation (3.224)
$\gamma_{IFS_{ab}}$	Share of banks investment fund shares held	1.6971	Calculated from equation (3.169)
γ_{IFS_g}	Share of government investment fund shares held	0.0593	Calculated from equation (3.206)
γ_{IFS_h}	Share of household investment fund shares held	0.0375	Calculated from equation (3.95)
$\gamma_{i_{2f}}$	Share of firms' changes in inventories in volume	0.0063	Calculated from equation (3.114)
$\gamma_{i_{2g}}$	Share of government changes in inventories in volume	8.8e-05	Calculated from equation (3.195)
$\gamma_{k_{3f}}$	Accelerator effect of firms' other non-financial assets	0.4692	Calculated from equation (3.117)
$\gamma_{k_{3g}}$	Accelerator effect of governments' other non-financial assets	0.442	Calculated from equation (3.198)
γ_m	Share of import in volume	0.1678	Calculated from equation (3.71)
γ_{O_b}	Share of banks other current transfers received	0.028	Calculated from $\gamma_{O_b} = \frac{O_b}{BP_g}$
γ_{O_h}	Share of households other current transfers paid	0.0096	Calculated from $\gamma_{O_h} = \frac{O_h}{YD}$
γ_{O_f}	Share of firms other current transfers paid	0.0156	Calculated from $\gamma_{O_f} = \frac{O_f}{FP_g}$
γ_{O_r}	Share of the rest of the world other current transfers paid	-0.0993	Calculated from $\gamma_{O_r} = \frac{O_r}{Sr}$
γ_{OIP_b}	Share of banks other income from properties paid	0.0448	Calculated from $\gamma_{OIP_b} = \frac{OIP_b}{BP_g}$
γ_{OIP_f}	Share of firms other income from properties received	0.0357	Calculated from $\gamma_{OIP_f} = \frac{OIP_f}{FP_g}$
γ_{OIP_h}	Share of households other income from properties received	0.0098	Calculated from $\gamma_{OIP_h} = \frac{OIP_h}{YD_g}$
γ_{OIP_r}	Share of the rest of the world other income from properties paid	-0.1793	Calculated from $\gamma_{OIP_r} = \frac{OIP_r}{S_r}$
γ_{SB}	Social benefit to GDP	0.0712	Calculated from $\gamma_{SB} = \frac{SB}{Y}$
γ_{STR}	Social transfers in kind to GDP	0.0633	Calculated from $\gamma_{STR} = \frac{STR}{Y}$
γ_{TRK}	Capital transfers to GDP	0.0131	Calculated from $\gamma_{TRK} = \frac{TRK}{Y}$
γ_{W_b}	Share of banks' wage paid	0.0406	Calculated from $\gamma_{W_b} = \frac{W_b}{W}$
γ_{W_f}	Share of firms' wage paid	0.5193	Calculated from $\gamma_{W_f} = \frac{W_f}{W}$
γ_{W_g}	Share of governments wage paid	0.1738	Calculated from $\gamma_{W_g} = \frac{W_g}{W}$
γ_{W_h}	Share of households wage paid	0.2659	Calculated from $\gamma_{W_h} = \frac{W_h}{W}$
γ_{W_r}	Share of the rest of the world wage paid	0.0004	Calculated from $\gamma_{W_h} = \frac{W_r}{W}$
γ_{Y_b}	Share of banks' output	0.0773	Calculated from equation (3.74)
γ_{Y_f}	Share of firms' output	0.6205	Calculated from equation (3.74)
γ_{Y_g}	Share of governments' output	0.1022	Calculated from equation (3.74)
γ_{Z_b}	Banks' other accounts payable/receivables to net worth ratio	-0.1531	Calculated from equation (3.180)
γ_{Z_f}	Firms' other accounts payable/receivables	-0.0022	Calculated from equation (3.134)

	to net worth ratio		
γ_{Z_g}	Governments' other accounts payable/receivables to net worth ratio	0.0182	Calculated from equation (3.210)
γ_{Z_h}	Households' other accounts payable/ receivables to net worth ratio	4.66e-7	Calculated from equation (3.101)
h_0	Households preference for currencies	-0.0358	Estimated from OLS regression
h_1	Income effect on household currencies	0.3846	Estimated from OLS regression
i_{b0}	Banks autonomous fixed capital accumulation rate	-0.0304	Estimated from OLS regression
i_{b1}	Sensitivity of banks fixed capital accumulation rate to gross profit rate	0.2837	Estimated from OLS regression
i_{g1}	Sensitivity of government investment to net disposable income	0.1458	Estimated from OLS regression
i_{g2}	Sensitivity of government investment to the unemployment rate	2.7609	Estimated from OLS regression
k_{h1}	Short-run speculation behaviour of housing demand	0.1468	Estimated from OLS regression
k_{h2}	Short-run elasticity of housing demand to population	6.3169	Estimated from OLS regression
k_{h3}	Long-run correction parameter of housing demand	-0.1271	Estimated from OLS regression
k_{h4}	Intercept of the long-run correction equation of housing demand	-3.573	Estimated from OLS regression
k_{h5}	Long-run speculation behaviour of housing demand	0.4697	Estimated from OLS regression
k_{h6}	Long-run elasticity of housing demand to population	4.2459	Estimated from OLS regression
l_{ar1}	Sensitivity of RoW loan held to rate of interest received by the RoW	1.1193	Estimated from OLS regression
l_{h0}	Preference for loan borrowing	0.3711	Estimated from OLS regression
l_{h1}	Sensitivity of household loans borrowing ratio to the real rate of interest received	16.31	Estimated from OLS regression
l_{h2}	Sensitivity of household loans borrowing ratio to the real rate of interest paid	-17.79	Estimated from OLS regression
l_{h3}	Sensitivity of households loan borrowing to real housing price growth	1.4617	Estimated from OLS regression
lf_0	Exogenous change of the labour force share	0.0056	Estimated from OLS regression
lf_1	Persistence of the change of labour force share	0.7581	Estimated from OLS regression
lf_2	Sensitivity of the change of labour share to the unemployment rate	-0.1359	Estimated from OLS regression
μ_b	Biomass intensity	0.0023	Calculated from equation (3.12)
$\mu_{b,ex}$	Biomass export intensity	0.0004	Calculated from equation (3.20)
$\mu_{b,im}$	Biomass import intensity	0.0021	Calculated from equation (3.15)
μ_m	Metal ores intensity	0.0015	Calculated from equation (3.12)
$\mu_{m,ex}$	Metal ores export intensity	0.0013	Calculated from equation (3.20)
$\mu_{m,im}$	Metal ores import intensity	0.0091	Calculated from equation (3.15)
μ_{nm}	Non-metallic materials intensity	0.0055	Calculated from equation (3.12)
$\mu_{nm,ex}$	Non-metallic materials export intensity	0.0009	Calculated from equation (3.20)
$\mu_{nm,im}$	Non-metallic materials import intensity	0.0006	Calculated from equation (3.15)

$\mu_{o,ex}$	Other products export intensity	0.0008	Calculated from equation (3.20)
$\mu_{o,im}$	Other products import intensity	0.0001	Calculated from equation (3.15)
ν_{w1}	Short-run elasticity of emissions to water intensity to real GDP	-1.8949	Estimated from OLS regression
ν_{w2}	Long-run correction parameter of emissions to water intensity	-0.0623	Estimated from OLS regression
ν_{w3}	Level of emissions to water intensity in logarithm when the Gini coefficient equals 1 and real GDP equals 100 million rmb	10.45	Estimated from OLS regression
ν_{w4}	Elasticity of emissions to water intensity to the Gini coefficient	12.66	Estimated from OLS regression
ν_{w5}	Long-run elasticity of emissions to water intensity to real GDP	-2.0985	Estimated from OLS regression
p_{c1}	Short-run persistence of CPI	0.2604	Estimated from OLS regression
p_{c2}	Short-run elasticity of CPI to unit labour cost	0.5116	Estimated from OLS regression
p_{c3}	Parameter of long-run correction of CPI	-0.5989	Estimated from OLS regression
p_{c4}	Mark-up of CPI	0.3355	Estimated from OLS regression
p_{c5}	Long-run persistence of CPI	0.2699	Estimated from OLS regression
p_{c6}	Long-run elasticity of CPI to unit labour cost	0.4958	Estimated from OLS regression
p_{kh1}	Short-run inversed demand elasticity of housing	1.3932	Estimated from OLS regression
p_{kh2}	Long-run correction parameter of housing price	-0.1213	Estimated from OLS regression
p_{kh3}	Nominal housing price level in logarithm when the lagged level equals 1 and housing stock equals 100 million rmb	-3.8105	Estimated from OLS regression
p_{kh4}	Persistence of housing price	0.8221	Estimated from OLS regression
p_{kh5}	Long-run inversed demand elasticity of housing	0.273	Estimated from OLS regression
p_{x1}	Short-run elasticity of export price to unit labour cost	0.443	Estimated from OLS regression
p_{x2}	Elasticity of export price to the exchange rate	-0.6409	Estimated from OLS regression
p_{x3}	Long-run correction parameter of export price	-0.3595	Estimated from OLS regression
p_{x4}	Level of export price in logarithm when the unit labour cost and the exchange rate equal 1	0.2198	Estimated from OLS regression
p_{x5}	Long-run elasticity of export price to unit labour cost	0.4146	Estimated from OLS regression
p_{x6}	Elasticity of export price to the exchange rate	-0.8931	Estimated from OLS regression
$r_{\delta 0}$	Lower bound of the policy rate	0.0124	Estimated from OLS regression
$r_{\delta 1}$	Persistence of the policy rate	0.4927	Estimated from OLS regression
$r_{\delta 2}$	Sensitivity of the policy rate to CPI inflation	0.1315	Estimated from OLS regression
r_{pb0}	Banks rate of interest paid premium	-0.0015	Estimated from OLS regression
r_{pb1}	Sensitivity of banks rate of interest paid to the policy rate	0.8777	Estimated from OLS regression
r_{pf1}	Sensitivity of firms rate of interest paid to the policy rate	0.4831	Estimated from OLS regression
r_{ph1}	Sensitivity of Households rate of interest paid to the policy rate	0.6258	Estimated from OLS regression
r_{pr1}	Sensitivity of the rest of the world rate of interest paid to NEER growth	-0.1623	Estimated from OLS regression
r_{pr2}	Sensitivity of the rest of the world rate of interest paid to federal funds rate	0.2077	Estimated from OLS regression

r_{rb0}	Banks rate of interest received premium	-0.0017	Estimated from OLS regression
r_{rb1}	Sensitivity of banks rate of interest received to the policy rate	0.5628	Estimated from OLS regression
r_{rf1}	Sensitivity of firms rate of interest received to the policy rate	0.2013	Estimated from OLS regression
r_{rh1}	Sensitivity of households rate of interest received to the policy rate	0.4178	Estimated from OLS regression
τ_b	Income tax rate paid by banks	0.2548	Calculated from $\tau_b = \frac{T_b}{BP_g}$
τ_f	Income tax rate paid by firms	0.1292	Calculated from $\tau_f = \frac{T_f}{FP_g}$
τ_h	Income tax rate paid by households	0.0172	Calculated from $\tau_h = \frac{T_h}{YD_g}$
τ_{L_b}	Net production tax rate paid by banks	0.0996	Calculated from $\tau_{L_b} = \frac{TL_b}{Y_b}$
τ_{L_f}	Net production tax rate paid by firms	0.1446	Calculated from $\tau_{L_f} = \frac{TL_f}{Y_f}$
τ_{L_h}	Net production tax rate paid by households	0.0076	Calculated from $\tau_{L_h} = \frac{TL_h}{Y_h}$
τ_{sc}	Social contribution ratio over wage bill	0.1247	Calculated from $\tau_{sc} = \frac{SC}{W}$
v_1	Short-run elasticity of firms' utilized fixed capital to firms' production in volume	0.2787	Estimated from OLS regression
v_2	Short-run decreasing return to scale of firms' fixed capital	0.7817	Estimated from OLS regress
v_3	Long-run correction parameter of firms' utilized fixed capital	-0.3601	Estimated from OLS regression
v_4	Level of firms' utilized fixed capital in logarithm when firms' production and firms' fixed capital equal 100 million rmb	-1.0238	Estimated from OLS regression
v_5	Long-run elasticity of firms' utilized fixed capital to firms' production	0.2841	Estimated from OLS regression
v_6	Long-run decreasing return to scale of firms' fixed capital	0.7871	Estimated from OLS regression
ε_{ex}	Energy intensity of exports	0.0798	Calculated from equation (3.6)
ε_{im}	Energy intensity of imports	0.7398	Calculated from equation (3.7)
ε_1	Short-run elasticity of energy intensity to real GDP	-0.3989	Estimated from OLS regression
ε_2	Long-run correction parameter of energy intensity	-0.2183	Estimated from OLS regression
ε_3	Level of energy intensity in logarithm when the Gini coefficent equals 1 and real GDP equals 100 million rmb	1.9875	Estimated from OLS regression
ε_4	Elasticity of energy intensity to the Gini coefficient	3.815	Estimated from OLS regression
ε_5	Long-run elasticity of energy intensity to real GDP	-0.308	Estimated from OLS regression
w_1	Short-run elasticity of nominal wage to CPI	1.0118	Estimated from OLS regression
w_2	Short-run elasticity of nominal wage to labour productivity	1.1172	Estimated from OLS regression
w_3	Long-run correction parameter of nominal wage	-0.5551	Estimated from OLS regression
w_4	Nominal wage level in logarithm with full employment, CPI equals 1 and labour productivity equals 1 rmb per labour	-2.9218	Estimated from OLS regression
w_5	Long-run elasticity of nominal wage to CPI	0.752	Estimated from OLS regression
w_6	Sensitivity of nominal wage to unemployment	-4.5625	Estimated from OLS regression
w_7	Long-run elasticity of nominal wage to labour productivity	1.2158	Estimated from OLS regression
x_1	Short-run elasticity of export to foreign demand	1.033	Estimated from OLS regression
x_2	Short-run elasticity of export to the economic	1.2726	Estimated from OLS regression

	complexity		
x_3	Export long-run correction parameter	-0.5425	Estimated from OLS regression
x_4	Long-run elasticity of export to foreign demand	0.7564	Estimated from OLS regression
x_5	Long-run elasticity of export to the economic complexity	1.4791	Estimated from OLS regression
xr_1	Elasticity of NEER to interest rate parity	0.8275	Estimated from OLS regression
y_{n1}	Short-run persistence of labour productivity	0.2505	Estimated from OLS regression
y_{n2}	Short-run Kaldor-Verdoorn effect	0.7143	Estimated from OLS regression
y_{n3}	Parameter of labour productivity long-run correction	-0.1702	Estimated from OLS regression
y_{n4}	Intercept of the long-run equation of labour productivity in logarithm	-0.6425	Estimated from OLS regression
y_{n5}	Long-run persistence of on labour productivity	0.4765	Estimated from OLS regression
y_{n6}	Long-run Kaldor-Verdoorn effect	0.4955	Estimated from OLS regression

Chapter 4

A Comparison of an Empirical Stock Flow Consistent Model and a New Keynesian Model of China

Abstract

This paper develops a New Keynesian model under the same structure as an empirical ecological stock-flow model. Instead of having demand-led and endogenous money, the model is supply-driven, and money is neutral. To purely compare the differences between the theories, we employ the same methodology to estimate the parameters as in an empirical SFC framework, which does not rely on finding a steady state and calibration to data but uses long-term correction and is purely based on regression. We employ the implication of a DSGE model and transform it into structural equations. This allows us to compare the performance of the two models in terms of fitting the historical data. It shows that the New Keynesian model performs relatively poorly compared to the SFC model because the behaviour equations generated from the optimisation problem are more restricted. Then, we run baseline scenarios for prediction using the two models to compare the economic growth demand-led and supply-led. Lastly, we run a nominal wage increase shock. The baseline scenario shows that supply-led growth is much smoother and mainly driven by capital accumulation. On the contrary, household consumption is the main driver in the SFC model baseline scenario. Real GDP in the New Keynesian model shares a similar response to a positive nominal wage shock with the SFC model, but causes more unemployment because of the substitution effect between capital and labour. Unlike the results from the SFC model, a nominal wage increase may worsen income inequality and result in more air emissions in the New Keynesian model.

Keywords: *income inequality, stock-flow consistent modelling, energy balance, material emissions*

JEL codes: *D63, E12, Q43, Q58*

4.1 Introduction

> A model, we shall say, is a *story* with a specific structure: to explain this catch phrase is to explain what a model is. The *structure* is given by the logical and mathematical form of a set of postulates, the *assumptions* of the model. .... Often the assumptions of a model are chosen not to approximate reality, but to exaggerate or isolate some feature of reality. .... The hypothesis may be that the conclusions of an applied model are approximately true, and that that is because its assumptions are sufficiently close to the truth. In some such cases, the hypothesis is tested casually; in others, econometrically; quite different kinds of models lend themselves to the two kinds of testing. The hypothesis may, on the other hand, be that a conclusion of the applied model depicts a tendency of the situation, and that this is because the assumption caricature features of the situation and conclusion is robust under changes of caricature (Gibbard & Varian, 1978).

Economic models, as tools, have been evolving throughout history to explain economic phenomena. Starting from the Classical economics models, dominated by Marshall (1890), they could not solve the Great Depression during the 1930s. Those models identified high wages as the cause of high unemployment, but cutting wages did not solve the problem then. It gave rise to Keynesian economics, showing the link between the goods market and labour market, low demand for goods results in low demand for labour (Keynes, 1937). Hicks (1937) simplifies Keynes' idea into the well-known IS/LM model. Later, in the 1970s, the major challenge for macroeconomists was stagflation, which expansionary fiscal policy, as suggested by the IS/LM model, failed to solve. New tools were needed, giving rise to the Neo-classical theory and New Keynesian theory, which have become the mainstream economics until now. However, the failure to forecast the Global Financial Crisis in 2007 has brought attention to the financial side of the economy, i.e. credit. And the recent modelling needs to face Climate Change has brought researchers to seek alternative tools, e.g. heterodox economics (Fontana & Sawyer, 2016).

Stock-flow consistent (SFC) models, rooted back to the so-called pitiful approach, in Tobin's Nobel prize lecture (Tobin, 1982), were developed by Godley and Lavoie (2006), explicitly including the financial account in a demand-led model. This approach has flourished in studying ecological macroeconomics (Dafermos et al., 2017, Dafermos et al., 2018, Jacques et al., 2023, Carnevali et al., 2024).

Lavoie (2022) has criticised orthodox economics, arguing that the mainstream theory is unrealistic, and has given a list of theoretical proofs showing the limitations of orthodox economics in capital controversies and the Cobb-Douglas production function. However, the literature has no concrete example of comparing the two theories, New-Keynesian economics and Post-Keynesian economics.

This paper provides a modelling exercise on the case of China, comparing a New Keynesian model (based on Smets and Wouters, 2003) with an SFC model (An, 2024a) in the same accounting structure. We employ the same methodology to estimate the parameters as in an empirical SFC framework, which does not rely on finding a steady state and calibration to data but uses long-term correction and is purely based on regression (G. Zezza & Zezza, 2019). We compare the two models in terms of fitting historical data, predicting the future, and responding to a nominal wage increase shock. Social policies, such as wage policy, could be as effective as green growth policy in reducing emissions and, additionally, achieve long-lasting reduction in inequality (D'Alessandro et al., 2020).

The following section describes the New Keynesian model. Section 4.3 briefly introduces the data sources and parameter estimations. Section 4.4 presents the in-sample predictions of the New Keynesian and SFC models. Section 4.5 shows the baseline scenario for future predictions of the two models with a nominal wage increase shock. Lastly, section 4.6 concludes the paper and discusses the theoretical and technical issues.

4.2 The New Keynesian model

The ecological block contains the energy and material balance as in An (2024a). Material and energy use are driven by real GDP. The share of renewable energy is exogenous, which determines the emission intensity. Energy intensity, emission to water intensity, and the coefficient of dissipative use of products depend on real GDP (Kaldor-Verdoon law) and income inequality (Boyce, 1994 and Jun et al., 2011), measured in Gini coefficient.

As in An (2024a), the economy comprises five institutional sectors: households, firms, banks, governments, and the rest of the world (RoW). Households and governments consume the final good according to their consumption functions. Through investment decisions, households (mainly real estate acquisition), firms and governments (final good production) make investments. Banks receive deposits and issue bonds and loans. The Central Bank, which is included in the banking sector, runs an inflation-biased Taylor rule by adjusting the policy rate. Accounting equations, such as changes in loans and bonds, and the accumulation of assets and liabilities, are modelled to guarantee stock-flow consistency. The ecological block includes China's material and energy balance. They account for material and energy inflows and outflows linked to economic activities.

The New Keynesian model shares the same accounting equations with the empirical stock flow consistent model in An (2024a), except that real GDP is supply driven, i.e. the production function. The main differences are the behaviour equations of the private sectors, i.e. households, firms and banks, which are derived from the optimisation problem of the agents and then verified by econometric regression based on historical data (Table 4.1).

Table 4.1: Behaviour equations

	Stock flow consistent	New Keynesian
Household consumption	Habit formation (+), income effect (+), wealth effect (+)	Real deposit rate (+), population (+)
Housing investment	Population (+)	Population (+), housing depreciation rate (-), shadow price (+), real housing price (-)
Firm investment	profit rate (+), capacity utilization (+)	Total factor productivity (+), firm lending rate (-), real price of capital (-), nominal wage (+)
Prices	Unit labour cost (+), import price (+), housing demand (+), exchange rate (-)	Nominal wage(+)
Production function	Leontieff	Cobb-Douglas
Labour productivity	Kaldor-Verdoorn law	Total factor productivity (+), nominal wage (+), firm lending rate (-), price of capital (-)
Nominal wage	CPI (+), labour productivity (+), unemployment rate (-)	Inflation (+), shadow price (+), employment share (+), social contribution rate (-)
Capital productivity	Kaldor-Verdoorn law, scale effect (-)	Total factor productivity (+), firm lending rate (+), real price of capital (+), nominal wage (-)
Financial assets/liabilities	Tobin profolio theory	Shadow price (+), rate of interest return (+), rate of interest payment (-), population (+)
Government consumption	Fixed share of real GDP	
Government investment	Government disposable income (+), price of capital (-), unemployment rate (+)	
Export	Foreign demand (+), export price (-), exchange rate (+), economic complexity index (+)	
Import	Fixed share of real GDP	
Exchange rate	Uncovered interest rate parity	
Central bank policy rate	Inflation biased Taylor rule	
Interest rates	Policy rate (+)	
Income inequality	Wage share (+), employment share (+), social benefits to GDP (+)	
Labour force	Population (+), unemployment rate (-)	

(+) denotes a positive effect and (-) denotes a negative effect.

4.2.1 Households

The model consists of a unit mass of 1 of representative households maximize their intertemporal utility with respect to consumption, $c_{h,t}$, housing, $k_{h,t}$, currencies, H_t, deposits, $D_{h,t}$, bonds held, $b_{h,t}$, and loans borrowed, $L_{h,t}$, subjected to their budget constraint,

$$\max_{c_{h,t},k_{h,t},H_t,D_{h,t},b_{h,t},L_{h,t}} E_t \sum_{t=0}^{\infty} \beta^t u^h(c_{h,t}, N_t, k_{h,t}, H_t, b_{h,t}, L_{h,t}) \tag{4.1}$$

$$\begin{aligned} s.t.\ & P_{c,t}c_{h,t} + P_{k_h,t}k_{h,t} + H_t + D_{h,t} + P_{b_h,t}b_{h,t} - L_{h,t} \\ &= (1-\tau_{sc,t})w_tN_t + (P_{k_h,t} - \delta_h P_{k_h,t-1})k_{h,t-1} + H_{t-1} + (1+r_{rh,t})D_{h,t-1} \\ &\quad + \left(\frac{P_{b_h,t}}{P_{b_h,t-1}} + r_{rh,t}\right) P_{b_h,t-1}b_{h,t-1} - (1+r_{ph,t})L_{h,t-1} + \Omega_{h,t}, \end{aligned} \tag{4.2}$$

where $0 < \beta < 1$ denotes the subjective discount rate of households, $u^h(\cdot)$ denotes the utility function of households, $P_{c,t}$ denotes the consumer price index, $P_{k_h,t}$ denotes the housing price, $P_{b_h,t}$ denotes the price of bonds, $\tau_{sc,t}$ denotes the social contribution payment rate, w_t denotes the nominal wage, N_t denotes employment, $\delta_{h,t}$ is the housing depreciation rate, $r_{rh,t}$ and $r_{ph,t}$ denote the rate of interest received and paid by households, respectively, and $\Omega_{h,t}$ includes other transactions in the household budget constraint that are not related to the optimization problem (see equation 4.77 in Appendix).

We solve the household problem by constructing a Lagrange function with the Lagrange multiplier, λ_t,

$$\begin{aligned} \mathcal{L} = E_t \sum_{t=0}^{\infty} \beta^t u^h(c_{h,t}, N_t, k_{h,t}, H_t, b_{h,t}, L_{h,t}) - \lambda_t \Big[& P_{c,t}c_{h,t} + P_{k_h,t}k_{h,t} + H_t + D_{h,t} + P_{b_h,t}b_{h,t} - L_{h,t} \\ & - (1-\tau_{sc,t})w_tN_t - (P_{k_h,t} - \delta_h P_{k_h,t-1})k_{h,t-1} - H_{t-1} - (1+r_{rh,t})D_{h,t-1} \\ & - \left(\frac{P_{b_h,t}}{P_{b_h,t-1}} + r_{rh,t}\right) P_{b_h,t-1}b_{h,t-1} + (1+r_{ph,t})L_{h,t-1} - \Omega_{h,t} \Big]. \end{aligned} \tag{4.3}$$

Taking the partial derivative with respect to consumption, housing, currencies, deposits, bonds held and loans borrowed, we get the following first-order conditions,

$$0 = \frac{\partial \mathcal{L}}{\partial c_{h,t}} = \frac{\partial u_t^h}{\partial c_{h,t}} - \lambda_t P_{c,t}, \tag{4.4}$$

$$0 = \frac{\partial \mathcal{L}}{\partial k_{h,t}} = \frac{\partial u_t^h}{\partial k_{h,t}} - \lambda_t P_{k_h,t} + \beta E_t[\lambda_{t+1}(P_{k_h,t+1} - \delta_{h,t}P_{k_h,t})], \tag{4.5}$$

$$0 = \frac{\partial \mathcal{L}}{\partial H_t} = \frac{\partial u_t^h}{\partial H_t} - \lambda_t + \beta E_t \lambda_{t+1}, \tag{4.6}$$

$$0 = \frac{\partial \mathcal{L}}{\partial D_{h,t}} = -\lambda_t + \beta E_t[\lambda_{t+1}(1+r_{rh,t+1})], \tag{4.7}$$

$$0 = \frac{\partial \mathcal{L}}{\partial b_{h,t}} = \frac{\partial u_t^h}{\partial b_{h.t}} - \lambda_t P_{b_h,t} + \beta E_t \left[\lambda_{t+1}\left(\frac{P_{b_h,t+1}}{P_{b_h,t}} + r_{rh,t+1}\right) P_{b_h,t}\right], \tag{4.8}$$

$$0 = \frac{\partial \mathcal{L}}{\partial L_{h,t}} = \frac{\partial u_t^h}{\partial L_{h.t}} + \lambda_t - \beta E_t \lambda_{t+1}(1+r_{ph,t+1}). \tag{4.9}$$

Equation (4.4) gives us the shadow price, λ_t, equals the marginal utility of consumption deflated by CPI, $\frac{\partial u_t^h/\partial c_{h,t}}{P_{c,t}}$.

Combining equation (4.4) and (4.7), we get the Euler equation,

$$\frac{\partial u_t^h/\partial c_{h,t}}{P_{c,t}} = \beta E_t \left[\frac{\partial u_{t+1}^h/\partial c_{h,t+1}}{P_{c,t+1}} (1 + r_{rh,t}) \right]. \tag{4.10}$$

Assuming rational expectation and an Isoelastic utility for consumption, such that $\frac{\partial u_t^h}{\partial c_{h,t}} = c_{h,t}^{-\sigma}$, $0 < \sigma < 1$, we get,

$$\left(\frac{c_{h,t}}{c_{h,t-1}} \right)^{-\sigma} = \frac{1 + \pi_t}{\beta(1 + r_{rh,t})}, \tag{4.11}$$

where $\pi_t = \frac{\Delta P_{c,t}}{P_{c,t-1}}$ denotes CPI inflation.

After empirical verification, we get the household consumption function in our model,

$$\Delta \ln \frac{c_{h,t}}{POP_t} = c_{h1} \ln \frac{1 + r_{rh,t}}{1 + \pi_t}, \tag{4.12}$$

where POP_t denotes population, $c_{h1} \approx \frac{1}{\sigma}$ denotes the inverse of household constant relative risk aversion coefficient. We employ consumption per capita in our model because we assume a unit mass of 1 for the representative household when solving the decision of the households.

Combining equation (4.4) and (4.5), we have,

$$\frac{P_{k_h,t}}{P_{c,t}} \frac{\partial u_t^h}{\partial c_{h,t}} = \frac{\partial u_t^h}{\partial k_{h,t}} + \beta E_t \left[\frac{\partial u_{t+1}^h/\partial c_{h,t+1}}{P_{c,t+1}} (P_{k_h,t+1} - \delta_{h,t} P_{k_h,t}) \right]. \tag{4.13}$$

Assuming static expectation and rearranging the equation, we have,

$$\frac{\partial u_t^h}{\partial k_{h,t}} = [1 - \beta(1 - \delta_{h,t})] \frac{\partial u_t^h}{\partial c_{h,t}} \frac{P_{k_h,t}}{P_{c,h}}. \tag{4.14}$$

After empirical verification, we get the housing demand in our model,

$$\begin{aligned} \Delta \ln \frac{k_{h,t}}{POP_t} = {} & k_{h1} \Delta \ln \delta_{h,t} + k_{h2} \Delta \ln \frac{c_{h,t}}{POP_t} + k_{h3} \Delta \ln \frac{P_{k_h,t}}{P_{c,t}} \\ & + k_{h4} \left(\ln \frac{k_{h,t-1}}{POP_{t-1}} - k_{h5} - k_{h6} \ln \delta_{h,t-1} - k_{h7} \ln \frac{c_{h,t-1}}{POP_{t-1}} \right), \end{aligned} \tag{4.15}$$

where $k_{h1} < 0$ denotes the short-run elasticity of housing per capita to housing depreciation rate, $k_{h2} > 0$ denotes the short-run elasticity of housing per capita to household consumption per capita, $k_{h3} < 0$ denotes the short-run elasticity of housing per capita to real housing price per capita, $-1 < k_{h4} < 0$ is the long-run correction parameter of housing per capita, k_{h5} is the level of housing per capita in logarithm under full depreciation rate and household consumption per capita is 1 million rmb, $k_{h6} < 0$ is the long-run elasticity of housing per capita to housing depreciation rate, and $k_{h7} > 0$ is the long-run elasticity fo housing per capita to household consumption per capita.

Combining equation (4.4) and (4.6), we have,

$$\frac{\partial u_t^h}{\partial H_t} = \frac{\partial u_t^h / \partial c_t^h}{P_{c,t}} - \beta E_t \frac{\partial u_{t+1}^h / \partial c_{t+1}^h}{P_{c,t+1}}. \tag{4.16}$$

Assuming static expectation and rearranging the equation, we have,

$$\frac{\partial u_t^h}{\partial H_t} = (1-\beta) \frac{\partial u_t^h / \partial c_{h,t}}{P_{c,t}}. \tag{4.17}$$

After empirical verification, we get the currency demand in our model,

$$\Delta \ln \frac{H_t}{POP_t} = h_1 \Delta \ln \frac{c_{h,t}}{POP_t}, \tag{4.18}$$

where $h_1 > 0$ denotes the sensitivity of the growth rate of currency per capita to the growth rate of household consumption per capita.

Similarly, from equations (4.4) and (4.8), and by assuming $P_{b_h,t} = \frac{1}{r_{rh,t}}$ (Godley & Lavoie, 2006), we have household bonds demand,

$$\Delta \ln \frac{b_{h,t}}{POP_t} = b_{h1} \Delta \ln r_{rh,t}, \tag{4.19}$$

where $b_{h1} > 0$ is the sensitivity of the growth rate of household bonds per capita to the growth rate of interest rate received by households.

And, from equations (4.4) and (4.9), we have household loans borrowed,

$$\Delta \ln \frac{L_{h,t}}{POP_t} = l_{h1} \ln \frac{c_{h,t}}{POP_t}, \tag{4.20}$$

where $l_{h1} > 0$ is the sensitivity of the growth rate of household loans borrowed to the growth rate of household consumption.

Households supply a unit mass of one heterogeneous labourer. Labourers are bundled through a Dixit-Stiglitz constant elasticity substitution (CES) technology. The labour bundler solves the following profit maximisation problem,

$$\max_{N_{j,t}} w_t N_t - \int_0^1 w_{j,t} N_{j,t} dj \tag{4.21}$$

$$s.t.\ N_t = \left(\int_0^1 N_{j,t}^{\frac{\psi_n - 1}{\psi_n}} \right)^{\frac{\psi_n}{\psi_n - 1}}, \tag{4.22}$$

where $j \in [0, 1]$ is the subscript of a specific type of labour, and $\psi_n \in (0,1) \cup (1, +\infty)$ is the elasticity of substitution between labours. Solving the first-order condition, we derive the specific labour demand for type j,

$$N_{j,t} = N_t \left(\frac{w_t}{w_{j,t}} \right)^{\psi_n}. \tag{4.23}$$

Substituting equation (4.23) into equation (4.22), we get the aggregation of wage,

$$w_t = \left(\int_0^1 w_{j,t}^{1-\psi_n} dj \right)^{\frac{1}{1-\psi_n}}. \tag{4.24}$$

We assume sticky wages à la Calvo (Calvo, 1983). In period t, a θ_w fraction of households cannot choose their wages and their wages only update with the inflation rate in a one-period delay, $w_{j,t} = (1+\pi_{t-1})w_{j,t-1}$. The other $1-\theta_w$ fractions of households that can choose wages in period t knows that, even choosing optimal wages $w_{j,t}^*$ for the period, it faces a θ_w^k probability of these wages equal $w_{j,t} \prod_{s=1}^k (1 + \pi_{t+s-1})$ for k future periods. They solve the following optimisation problem to supply labour,

$$\max_{w_{j,t}} E_t \sum_{t=0}^{\infty} (\beta\theta_w)^k \left\{ u_t^h(N_{j,t+k}) - \lambda_{t+k} \left[-(1-\tau_{sc,t}) w_{j,t} \prod_{s=1}^{k} (1 + \pi_{t+s-1}) N_{j,t+k} \right] \right\}, \tag{4.25}$$

$$s.t.\ N_{j,t+k} = N_{t+k} \left[\frac{w_{t+k}}{w_{j,t} \prod_{s=1}^k (1 + \pi_{t+s-1})} \right]^{\psi_n}. \tag{4.26}$$

From the first-order condition, we derive the optimal wage for labour j,

$$w_{j,t}^* = \frac{\psi_n}{(1-\tau_{sc,t})(1-\psi_n)} \left[P_{c,t} \frac{\partial u_t^h / \partial N_t}{\partial u_t^h / \partial c_{h,t}} + E_t \sum_{k=1}^{\infty} \frac{(\partial u_{t+k}^h / \partial N_{t+k}) P_{c,t+k}}{(\partial u_{t+k}^h / \partial c_{h,t+k}) \prod_{s=1}^k (1 + \pi_{t+s-1})} \right]. \tag{4.27}$$

Assuming static expectation, we have,

$$w_{j,t}^* = \frac{\psi_n (1+\pi_t) P_{c,t} \partial u_t^h / \partial N_t}{(1-\tau_{sc,t})(1-\psi_n)\pi_t \partial u_t^h / \partial c_{h,t}}. \tag{4.28}$$

Also, from equation (4.24), we get the aggregate wage,

$$w_t^{1-\psi_n} = \int_0^{\theta_w} [(1+\pi_{t-1}))w_{t-1}]^{1-\psi_n} dj + \int_{\theta_w}^1 (w_t^*)^{1-\psi_n} dj,$$

$$w_t = \{\theta_w[(1-\pi_{t-1})w_{t-1}]^{1-\psi_n} + (1-\theta_w)(w_t^*)^{1-\psi_n}\}^{\frac{1}{1-\psi_n}}. \tag{4.29}$$

After empirical verification, we get the labour supply in our model,

$$\begin{aligned}\Delta \ln w_t = {} & w_1 \Delta \ln \frac{c_{h,t}}{POP_t} + w_2 \Delta \ln \frac{P_{c,t}}{1-\tau_{sc,t}} \\ & + w_3 \left\{ \ln w_{t-1} - w_4 \ln[(1-\pi_{t-2})w_{t-2}] - w_5 \ln \frac{c_{h,t-1}}{POP_{t-1}} - w_6 \ln \frac{N_{t-1}}{POP_{t-1}} \right\},\end{aligned} \tag{4.30}$$

where $w_1 > 0$ denotes the short-run elasticity of nominal wage to real consumption per capita, $w_2 > 0$ denotes the short-run elasticity of of nominal wage to CPI over one minus social contribution rate, $-1 < w_3 < 0$ denotes the long-run correction parameter of nominal wage, $0 < w_4 < 1$ represents the stickiness of nominal wage, $w_5 > 0$ denotes the long-run elasticity of nominal wage to real consumption per capita, and $w_6 > 0$ denotes the elasticity of nominal wage to employment per capita.

4.2.2 Firms

The production process occurs in two processes; a unit mass of one wholesale firm produces heterogeneous intermediate goods, $y_{i,t}$, for $i \in [0,1]$, and competes in a monopolistic competition market; retail firms bundle intermediate goods to produce four types of final goods, namely, consumption good, capital good, housing, export good, and compete in a perfect competition market.

Wholesale firms employ fixed capital and labour to produce intermediate goods. They minimize their expenditure with respect to labour and fixed capital subject to their production technology in the form of a Cobb-Douglas function,

$$\min_{N_{i,t}, k_{i,1f,t}} w_t N_{i,t} + r_{pf,t} P_{k_1,t-1} k_{i,1f,t-1} + \tau_{L_f,t} y_{i,t}, \tag{4.31}$$

$$s.t.\ y_{i,t} = TFP_{i,t} k_{i,1f,t-1}^{\alpha} N_{i,t}^{1-\alpha},\ 0 < \alpha < 1, \tag{4.32}$$

where $r_{pf,t}$ denotes the interest rate paid by firms, $P_{k_1,t}$ denotes the price of fixed capita, $k_{i,1f,t}$ denotes the fixed capital in volume of firm i, $0 < \tau_{L_f,t} < 1$ is the net production tax rate paid by firms, $TFP_{i,t}$ denotes the total factor productivity of firm i.

We divide both side of equation (4.32) by $TFP_{i,t}$ and $N_{i,t}$ (Solow, 1956),

$$\frac{y_{i,t}}{TFP_{i,t} N_{i,t}} = \left(\frac{k_{i,1f,t-1}}{N_{i,t}} \right)^{\alpha}. \tag{4.33}$$

Assuming wholesale firms are identical, we run the following regression and get our production equation in the model,

$$\Delta \ln \frac{y_t}{TFP_t N_t} = y_1 \Delta \ln \frac{k_{1f,t-1}}{N_t}, \tag{4.34}$$

where $y_1 \approx \alpha$ denotes the elasticity of effective labour productivity to capital labour intensity.

Let's denote $\mu_{i,t}$ as the marginal cost of production of wholesale firm i. We construct a Lagrange function to solve the above expenditure minimisation problem,

$$\mathcal{L}^f = w_t N_{i,t} + r_{pf,t} P_{k_1,t-1} k_{i,1f,t-1} + \tau_{L_f,t} y_{i,t} + \mu_{i,t}[y_{i,t} - TFP_{i,t} k^{\alpha}_{i,1f,t-1} N^{1-\alpha}_{i,t}]. \tag{4.35}$$

Solving the first-order condition, we have,

$$0 = \frac{\partial \mathcal{L}^f}{\partial N_{i,t}} = w_t - (1-\alpha)\mu_{i,t} \frac{y_{i,t}}{N_{i,t}}, \tag{4.36}$$

$$0 = \frac{\partial \mathcal{L}^f}{\partial k_{i,1f,t}} = E_t \left(r_{pf,t+1} P_{k_1,t} - \alpha \mu_{i,t+1} \frac{y_{i,t+1}}{k_{i,t}} \right). \tag{4.37}$$

Assuming static expectation, equation (4.37) becomes

$$r_{pf,t} P_{k_1,t} = \alpha \mu_{i,t} \frac{y_{i,t}}{k_{i,t}}. \tag{4.38}$$

One can derive the marginal cost of production from equations (4.31), (4.32), (4.36) and (4.37) (see Appendix),

$$\mu_{i,t} = \frac{1}{TFP_{i,t}} \left(\frac{w_t}{1-\alpha} \right)^{1-\alpha} \left(\frac{r_{pf,t} P_{k_1,t-1}}{\alpha} \right)^{\alpha} + \tau_{L_f,t}. \tag{4.39}$$

From equations (4.36) and (4.39), we run the following regression and get the determinant of labour demand in our model,

$$\Delta \ln \frac{y_t}{N_t} = n_1 \Delta \ln(r_{pf,t} P_{k_1,t}) + n_2 \Delta \ln w_t, \tag{4.40}$$

where $n_1 < 0$ denotes the sensitivity of the growth rate of labour productivity to the growth rate of capital cost of production and $n_2 > 0$ denotes the sensitivity of the growth rate of labour productivity to the growth rate of labour cost of production, i.e. nominal wage.

Similarly, from equations (4.37) and (4.39), we have capital demand in the model determined by,

$$\Delta \ln \frac{y_t}{k_{1f,t}} = k_1 \Delta \ln TFP_t + k_2 \Delta \ln(r_{pf,t} P_{k_1,t}) + k_3 \Delta \ln w_t + k_4 \left(\ln \frac{y_{t-1}}{k_{1f,t-1}} - k_5 - k_6 \ln TFP_{t-1} - k_7 \ln w_{t-1} \right), \quad (4.41)$$

where $k_1 > 0$ denotes the short-run elasticity of capital productivity to total factor productivity, $k_2 > 0$ denotes the short-run elasticity of capital productivity to the capital cost of production, $k_3 < 0$ denotes the short-run elasticity of capital productivity to the labour cost of production, $-1 < k_4 < 0$ denotes the long-run correction parameter of capital productivity, k_5 is the level of capital productivity in logarithm when total factor productivity equals one and nominal wage equals 1 million rmb, $k_6 > 0$ denotes the long-run elasticity of capital productivity to total factor productivity, and $k_7 < 0$ denotes the long-run elasticity of capital productivity to nominal wage.

Retail firms buy the intermediate goods produced by the wholesale firms and produce final goods through a Dixit-Stiglitz CES technology. They solve the following profit maximisation problem,

$$\max_{y_{i,t}} \pi_t = P_t y_t - \int_0^1 P_{i,t} y_{i,t} di, \quad (4.42)$$

$$s.t.\ y_t = \left(\int_0^1 y_{i,t}^{\frac{\psi-1}{\psi}} \right)^{\frac{\psi}{\psi-1}}, \quad (4.43)$$

where $\psi \in (0,1) \cup (1,+\infty)$ denotes the elasticity of substitution between intermediate goods. Solving the first-order condition, we derive the demand for intermediate good i,

$$y_{i,t} = \left(\frac{y_t}{y_{i,t}} \right)^{\psi}. \quad (4.44)$$

Substituting equation (4.44) into equation (4.43), we get the aggregation of price,

$$P_t = \left(\int_0^1 P_{i,t}^{1-\psi} di \right)^{\frac{1}{1-\psi}}. \quad (4.45)$$

Similarly to sticky wages, we assume sticky prices à la Calvo (Calvo, 1983). In period t, a θ fraction of wholesale firms cannot change their prices and their only update is with the inflation rate in one period delay, $P_{i,t} = (1 + \pi_{t-1}) P_{i,t-1}$. The other $1 - \theta$ fractions of whole-sale firms that can choose prices in period t know that, even choosing optimal prices $P_{i,t}^*$ for the period, it faces a θ^k probability of these prices equal $P_{i,t} \prod_{s=1}^{k} (1 + \pi_{t+s-1})$ for k future periods. They solve the following profit maximisation problem to set prices,

$$\max_{P_{i,t}} E_t \sum_{k=0}^{\infty} (\beta\theta)^k \left[P_{i,t} \prod_{s=1}^{k} (1+\pi_{t+s-1}) y_{i,t+k} - \mu_{i,t+k} y_{i,t+k} \right], \tag{4.46}$$

$$s.t.\ y_{i,t+k} = y_{t+k} \left[\frac{P_{t+k}}{P_{i,t} \prod_{s=1}^{k} (1+\pi_{t+s-1})} \right]^{\psi}. \tag{4.47}$$

From the first-order condition, we derive the optimal price for wholesale firm i,

$$P^*_{i,t} = \frac{\psi}{\psi - 1} \left[\mu_{i,t} + E_t \sum_{k=1}^{\infty} \frac{\mu_{i,t+k}}{\prod_{s=1}^{k} (1+\pi_{t+s-1})} \right]. \tag{4.48}$$

Assuming static expectation, we have,

$$P^*_{i,t} = \frac{\psi(1+\pi_t)}{(\psi - 1)\pi_t} \mu_{i,t}. \tag{4.49}$$

Also, from equation (4.45), we get the aggregate price,

$$P_t^{1-\psi} = \int_0^{\theta} [(1+\pi_{t-1}) P_{t-1}]^{1-\psi} di + \int_{\theta}^{1} (P_t^*)^{1-\psi} di,$$

$$P_t = \{\theta[(1-\pi_{t-1}) P_{t-1}]^{1-\psi} + (1-\theta)(P_{t^*})^{1-\psi}\}^{\frac{1}{1-\psi}}. \tag{4.50}$$

After empirical verification, we get CPI, price of fixed capital, price of housing and price of exports, $P_{x,t}$, in our model,

$$\Delta \ln P_{\zeta,t} = p_{\zeta 1} \Delta \ln w_t, \tag{4.51}$$

where $\zeta = c_h, k_1, k_h, x$ denotes the subscript for consumption goods, fixed capital, housing and exports, respectively. $p_{\zeta 1} > 0$ is the sensitivity of the price growth of a specific final good to the growth of the nominal wage.

As for firm financial investment or borrowing decision, they have preferences in saving deposits, $D_{f,t}$, borrowing bonds, $b_{f,t}$, and investing abroad in the form of outward foreign direct investment (FDI), $fdi_{out,t}$.[1] They maximise their utility with respect to these financial instruments, subject to their budget constraint,

$$\max_{D_{f,t}, b_{f,t}, fdi_{out,t}} E_t \sum_{t=0}^{\infty} \beta^t u^f(D_{f,t}, b_{f,t}, fdi_{out,t}), \tag{4.52}$$

[1] The purpose of assuming preferences on firm assets and liabilities is to derive the demand or supply of these assets and liabilities from the optimization problem through a non-linear utility function.

$$s.t.\ D_{f,t} + (P_{b_f,t} - r_{pf,t}P_{b_f,t-1})b_{f,t-1} + P_{fdi_{out},t}fdi_{out,t}$$
$$= (1 + r_{rf,t} - r_{pf,t})D_{f,t-1} + P_{b_f,t}b_{f,t} + [P_{fdi_{out},t} + (\gamma_{DIV_{rf}} - r_{pf,t})P_{fdi_{out},t-1}]fdi_{out,t-1} + \Omega_{f,t}, \tag{4.53}$$

where $u^f(\cdot)$ denotes the utility function of firms, $P_{b_f,t}$ denotes the price of firm bonds, $P_{fdi_{out},t}$ denotes the price of outward foreign direct investment, $r_{rf,t}$ and $r_{pf,t}$ denote the rate of interest received and paid by firms, respectively. $\gamma_{DIV_{rf}}$ denotes the dividend rate received by firms, and $\Omega_{f,t}$ includes other transactions in the firm budget constraint that are not related to the optimization problem (see Appendix equation 4.88). Since the subjective discount factor is already determined by household deposit demand, i.e. the Euler equation (equation 4.10), we consider firm loan interest payment as an opportunity cost when they save in deposits, borrowed through bond, or invest abroad through outward FDI in equation (4.53).

We construct a Lagrange function as in the household problem with the shadow price, λ_t, as the multiplier,

$$\mathcal{L}^{\mathcal{F}} = E_t \sum_{t=0}^{\infty} \beta^t \{u^f(D_{f,t}, b_{f,t}, fdi_{ou,t})$$
$$- \lambda_t[D_{f,t} + (P_{b_f,t} - r_{pf,t}P_{b_f,t-1})b_{f,t-1} + P_{fdi_{in},t}fdi_{out,t} - (1 + r_{rf,t} - r_{pf,t})D_{f,t-1}]\} \tag{4.54}$$

Taking the partial derivative with respect to deposits, bonds, and outward FDI, we get the following first-order conditions,

$$0 = \frac{\partial \mathcal{L}^{\mathcal{F}}}{\partial D_{f,t}} = \frac{\partial u_t^f}{\partial D_{f,t}} - \lambda_t + \beta E_t \lambda_{t+1}(1 + r_{rf,t+1} - r_{pf,t+1}), \tag{4.55}$$

$$0 = \frac{\partial \mathcal{L}^{\mathcal{F}}}{\partial b_{f,t}} = \frac{\partial u_t^f}{\partial b_{f,t}} + \lambda_t(P_{b_f,t} - r_{pf,t}P_{b_f,t-1}) - \beta E_t \lambda_{t+1} P_{b_f,t+1}, \tag{4.56}$$

$$0 = \frac{\partial \mathcal{L}^{\mathcal{F}}}{\partial fdi_{out,t}} = \frac{\partial u_t^f}{\partial fdi_{out,t}} - \lambda_t P_{fdi_{out},t} + \beta E_t \lambda_{t+1}[P_{fdi_{out},t+1} + (\gamma_{DIV_{rf}} - r_{pf,t+1})P_{fdi_{out},t}]. \tag{4.57}$$

Similarly to the household problem, from equations (4.4) and (4.55), we get firm deposit demand,

$$\Delta \ln \frac{D_{f,t}}{POP_t} = d_{f1} \Delta \ln \frac{c_{h,t}}{POP_t} + d_{f2}\left[\ln \frac{D_{f,t-1}}{POP_{t-1}} - d_{f3} - d_{f4} \ln \frac{c_{h,t-1}}{POP_{t-1}} - d_{f5}(r_{rf,t-1} - r_{pf,t-1})\right], \tag{4.58}$$

where $d_{f1} > 0$ denotes the short-run elasticity of firm deposit per capita to real household consumption per capita, $-1 < d_{f2} < 0$ denotes the long-run correction parameter of firm deposit per capita, d_{f3} denotes the level of firm deposit per capita in logarithm when household consumption per capita equals 100 million rmb and the rate of interest received and paid by firms are equal, $d_{f4} > 0$ denotes the long-run elasticity of firm deposit per capita to real household consumption per capita, and $d_{f5} > 0$ denotes the semi-elasticity of firm deposit per capita to the difference between the rates of interest received and paid by firms.

From equations (4.4) and (4.56), we get firm bond supply,

$$\Delta \ln \frac{b_{f,t}}{POP_t} = b_{f1} \Delta \ln \frac{c_{h,t}}{POP_t}, \tag{4.59}$$

where $b_{f1} > 0$ denotes the sensitivity of the growth rate of firm bond in volume per capita to the growth rate of real household consumption per capita.

And from equations (4.4) and (4.57), we get outward FDI demand,

$$\begin{aligned} \Delta \ln \frac{fdi_{out,t}}{POP_t} &= fdi_{out1} \Delta \ln \frac{c_{h,t}}{POP_t} \\ &+ fdi_{out2} \left(\ln \frac{fdi_{out,t-1}}{POP_{t-1}} - fdi_{out3} - fdi_{out4} \ln \frac{c_{h,t-1}}{POP_t - 1} - fdi_{out5} \ln \frac{P_{fdi_{out},t-1}}{P_{c,t-1}} \right), \end{aligned} \tag{4.60}$$

where $fdi_{out1} > 0$ denotes the short-run elasticity of outward FDI in volume per capita to real household consumption per capita, $-1 < fdi_{out2} < 0$ denotes the long-run correction parameter of outward FDI in volume per capita, fdi_{out3} denotes the level of outward FDI in volume per capita in logarithm when real households consumption per capita equal 100 million rmb and the price outward FDI equal CPI, $fdi_{out4} > 0$ denotes the long-run elasticity of outward FDI in volume per capita to real household consumption per capita, $fdi_{out5} < 0$ denotes the elasticity of outward FDI in volume per capita to the price of inward FDI deflated by CPI.

4.2.3 Banks

Banks set interest rates based on the policy rate. They receive currencies and deposits, buy bonds, and provide loans to the other sectors. Bank fixed capital, $k_{1b,t}$, interbank assets and liabilities, i.e. deposits held by banks, $D_{b,t}$, and bonds issued by banks $B_{lb,t}$, is determined by the following optimization problem, subject to bank budget constraint,

$$\max_{k_{1b,t}, D_{b,t}, b_{lb,t}} E_t \sum_{t=0}^{\infty} u^b(D_{b,t}, b_{lb,t}), \tag{4.61}$$

$$\begin{aligned} s.t.\ & P_{k_1,t} k_{1b,t} + D_{b,t} + (1 + r_{pb,t}) P_{b_{lb},t-1} b_{lb,t-1} \\ &= (1 - \tau_{L_b,t}) P_{y,t} y_{b,t} + (P_{k_1,t} - \delta_b) k_{1b,t-1} + (1 + r_{rb,t}) D_{b,t-1} + P_{b_{lb},t} b_{lb,t} + \Omega_{b,t}, \end{aligned} \tag{4.62}$$

where $u^b(\cdot)$ denotes the utility function of banks, $r_{pb,t}$ denotes the rate of interest paid by banks, $P_{b_{lb},t-1}$ denotes the price of bank bond issued, $\tau_{L_b,t}$ denotes the net production tax rate paid by banks, $P_{y,t}$ denotes the GDP deflator, $y_{b,t}$ denotes bank value added in volume, δ_b denotes bank fixed capital depreciation rate, $r_{rb,t}$ denotes the rate of interest received by banks, and $\Omega_{b,t}$ includes other transactions in the bank budget constraint that are not related to the optimization problem (see equation 4.93 in Appendix).

We construct a Lagrange function as in the household and firm problems with the shadow price, λ_t, as the multiplier,

$$\mathcal{L}^b = E_t \sum_{t=0}^{\infty} \beta^t \{u^b(D_{b,t}, b_{lb,t}) - \lambda_t [P_{k_1,t} k_{1b,t} + D_{b,t} + (1 + r_{pb,t}) P_{b_{lb},t-1} b_{lb,t-1} \\ - (1 - \tau_{L_b,t}) P_{y,t} y_{b,t} - (P_{k_1,t} - \delta_b) k_{1b,t-1} - (1 + r_{rb,t}) D_{b,t-1} - P_{b_{lb},t} b_{lb,t} - \Omega_{b,t}]\}. \quad (4.63)$$

Taking the partial derivative with respect to fixed capital in volume, deposits held, and bonds issued, we get the following first-order conditions,

$$0 = \frac{\partial \mathcal{L}^b}{\partial k_{1b,t}} = -\lambda_t \left[P_{k_1,t} - (1 - \tau_{L_b,t}) P_{y,t} \frac{\partial y_{b,t}}{\partial k_{1b,t}} \right] + \beta E_t \lambda_{t+1} (P_{k_1,t+1} \delta_{b,t+1} P_{k_1,t}), \quad (4.64)$$

$$0 = \frac{\partial \mathcal{L}^b}{\partial D_{b,t}} = \frac{\partial u_t^b}{\partial D_{b,t}} - \lambda_t + \beta E_t \lambda_{t+1} (1 + r_{rb,t+1}), \quad (4.65)$$

$$0 = \frac{\partial \mathcal{L}^b}{\partial b_{lb,t}} = \frac{\partial u_t^b}{\partial b_{lb,t}} + \lambda_t P_{b_{lb},t} - \beta E_t \lambda_{t+1} (1 + r_{pb,t+1}) P_{b_{lb},t}. \quad (4.66)$$

Combining equations (4.4) and (4.64), and by assuming $y_{b,t} = TFP_t k_{1b,t}^{\alpha_b}$, $0 < \alpha_b < 1$, we get bank fixed capital demand after empirical verification,

$$\Delta \ln \frac{k_{1b,t}}{POP_t} = k_{b1} \Delta \ln \left[\frac{(1 + r_{rh,t})(1 - \tau_{L_b,t}) P_{y,t} TFP_t}{(r_{rh,t} + \delta_{b,t}) P_{k_1,t}} \right], \quad (4.67)$$

where $k_{b1} > 0$.

Similarly to household and firm problems, from equations (4.4) and (4.65), we get bank deposit demand,

$$\Delta \ln \frac{D_{b,t}}{POP_t} = d_{b1} \Delta \ln \frac{c_{h,t}}{POP_t} + d_{b2} \Delta \ln r_{rb,t}, \quad (4.68)$$

where $d_{b1} > 0$ and $d_{b2} > 0$ denote the sensitivity of the growth rate of bank deposits held per capita to the growth rate of household consumption per capita and to the growth rate of bank interest rate received, respectively.

And, from equation (4.4) and (4.92), we get bank bond supply,

$$\Delta \ln \frac{b_{lb,t}}{POP_t} = b_{lb1}\pi_t, \tag{4.69}$$

where $b_{lb1} > 0$ denotes the sensitivity of the growth rate of bank bonds issued per capita to CPI inflation.

4.2.4 Final good market

The difference between aggregate supply and aggregate demand for final goods results in changes in firm inventories,

$$i_{2f,t} = y_t - (c_{h,t} + c_{g,t} + i_{1f,t} + i_{1b,t} + i_{1g,t} + i_{h,t} + i_{2g,t} + x_t - m_t + nx_{adj,t} - eo_t + y_{adj,t}), \tag{4.70}$$

where $c_{g,t}$ denotes government consumption in volume, $i_{1f,t}$ denotes firm fixed capital formation in volume, $i_{1b,t}$ denotes bank fixed capital formation in volume, $i_{1g,t}$ denotes government fixed capital formation in volume, $i_{h,t}$ denotes housing investment in volume, $i_{2g,t}$ denotes changes in government inventories, x_t denotes exports in volume, m_t denotes imports in volume, $nx_{adj,t}$ denotes net exports adjustment in volume, eo_t denotes total errors and omissions in volume, $y_{adj,t}$ denotes real GDP adjustment.

4.3 Data and parameters

We employ the same data set of An (2024a) with an additional variable, total factor productivity, from the Federal Reserve Economic Data (FRED). Table 4.3 in the Appendix gives an overall description of parameters for the New Keynesian model behaviour equations in Section 4.2. Parameters in the behaviour equations are estimated by running simple OLS regressions with the Durbin-Watson test to ensure they do not reject the homoskedasticity hypothesis. Moreover, we run Augmented Dickey-Fuller (ADF) tests on the residuals to ensure co-integrations between the variables. Other parameters, such as ratios and shares, are calculated based on the data, same with An (2024a).

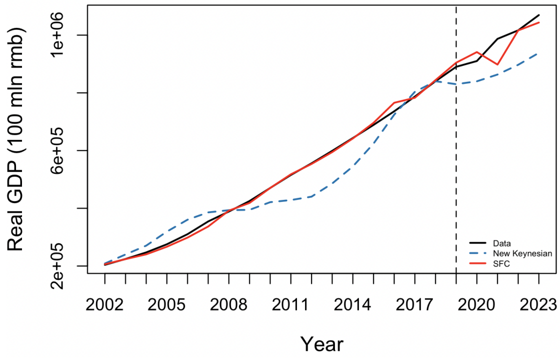
4.4 Model validation

We run an in-sample prediction to check the model's performance. Specifically, we run a dynamic simulation of the model from 2002 to 2023 and compare it with the data and the in-sample prediction of the SFC model in An (2024a).[2] Endogenous variables only employ the 2002 values as the initial values. Exogenous variables employ the data. Ratios and shares become moving parameters and employ the data.

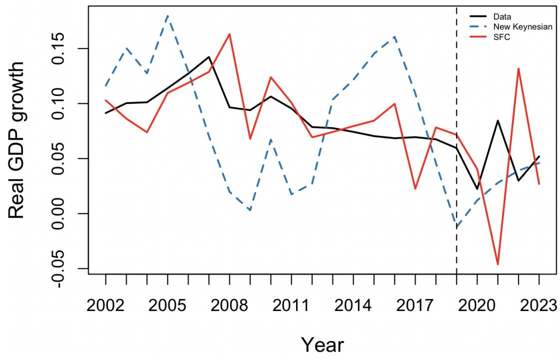
Figure 4.1 shows the in-sample prediction results. The solid black line represents the data. The solid red line is the in-sample prediction of An (2024a). The blue dashed line is the in-sample prediction of the New-Keynesian model. The vertical dashed line represents the year 2019, which is the last period of available data for the stock variables. Compared to the SFC model, the New-Keynesian model performs some business cycle features and underestimates GDP growth in the long run. (Figure 4.1a, 4.1b). It can also be observed from the production inputs, fixed capital of firms and labour (Figure 4.1c and 4.1d). The New-Keynesian model performs more stably than the SFC model in predicting CPI inflation (Figure 4.1e). The Gini coefficient is more volatile because of the volatility of the unemployment rate (Figure 4.1f). The financial side is poorly predicted (Figure 4.1i). Energy intensity fluctuates significantly because of the fluctuation of real GDP and Gini coefficient (Figure 4.1i). Emissions to air, dissipative use of products and emissions water fit relatively bad with the data, compared to the SFC model (Figure 4.1j, 4.1k and 4.1l).

Overall, the New-Keynesian model in the paper performs worse than the SFC model in fitting the historical trend, except for price inflation. Our results partly provide evidence that New-Keynesian models, e.g., DSGE models, aim to explain the economy in the short run, but not to describe longer-run movements in capital, output, or employment (Vines & Wills, 2020).

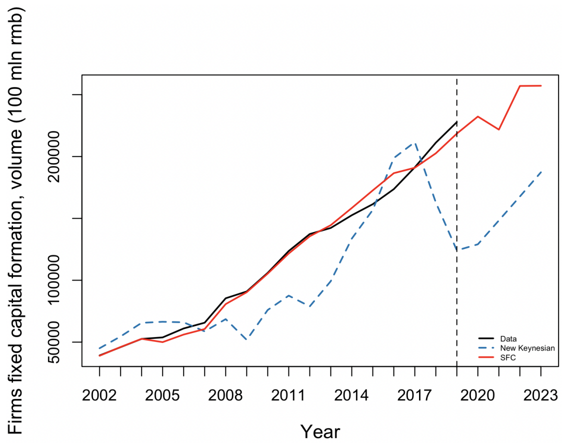
[2] A dynamic simulation accumulates model errors over time. We could also run a static simulation, which will have a better performance but only show model errors of each year because it employs the data for the lagged variables. This model is built for future scenario prediction. It would be reasonable to check the model validation dynamically.



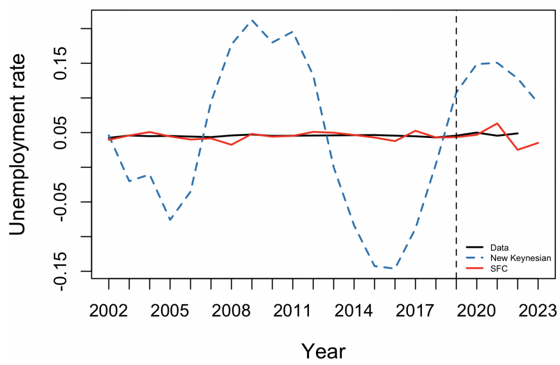
(a) Real GDP



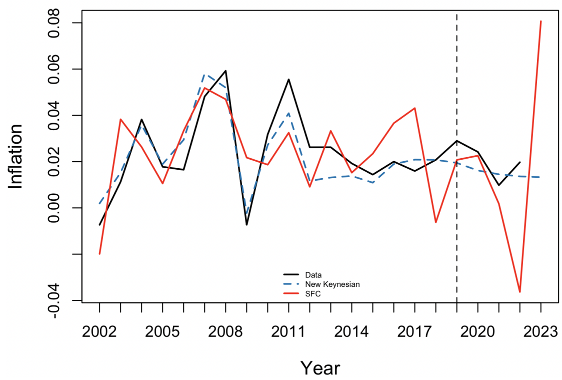
(b) Real GDP growth



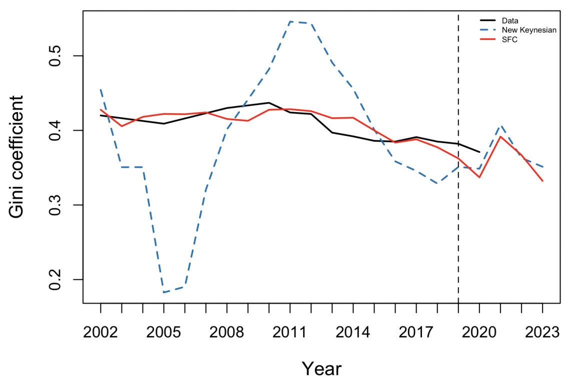
(c) Firm investment



(d) Unemployment rate



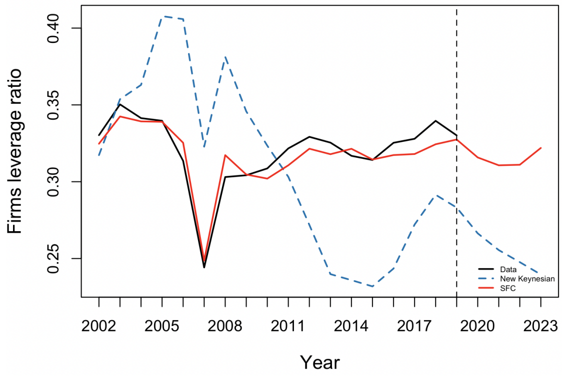
(e) Inflation



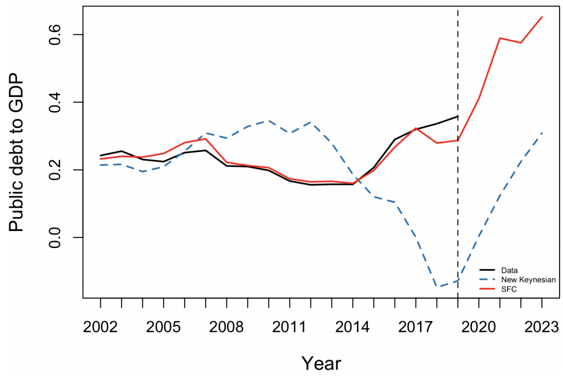
(f) Gini coefficient

Figure 4.1: In-sample prediction

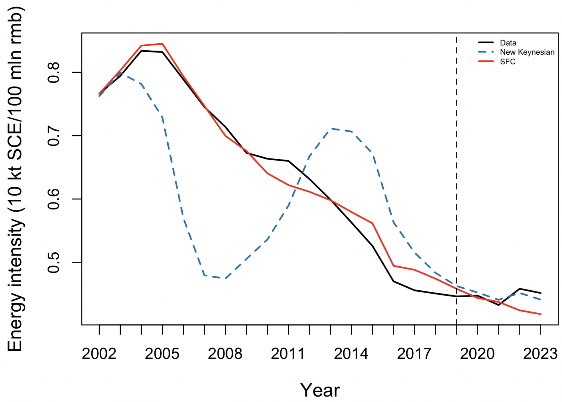
Note: The black solid line is the data. The red solid line is the in-sample prediction of An (2024a). The blue dashed line represents the in-sample prediction of the New Keynesian model. The black vertical dashed line is the year 2019, which is the last period of data availability for the stock variables.



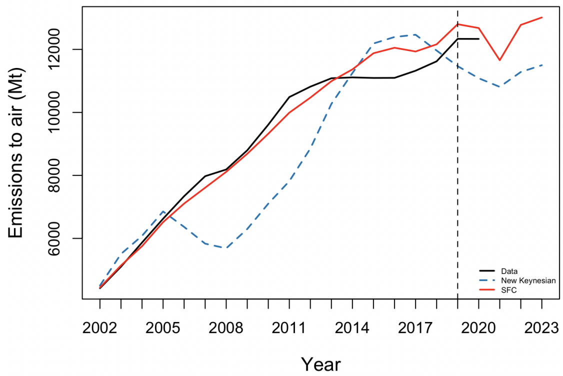
(g) Firms' leverage ratio



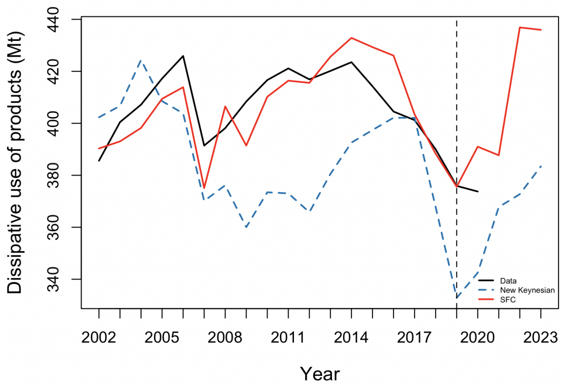
(h) Public debt to GDP



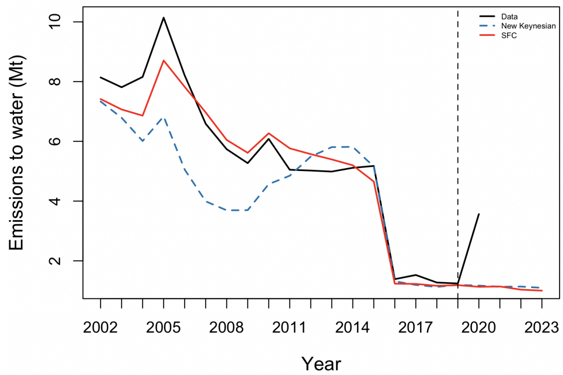
(i) Energy intensity



(j) Emissions to air



(k) Dissipative use of products



(l) Emissions to water

Figure 4.1: In-sample prediction

Note: The black solid line is the data. The red solid line is the in-sample prediction of An (2024a). The blue dashed line represents the in-sample prediction of the New Keynesian model. The black vertical dashed line is the year 2019, which is the last period of data availability for the stock variables.

4.5 Prediction

In this section, we run a model's baseline scenario from 2019 to 2035 as a prediction reference. Since the New Keynesian model cannot explain the long-term trend well, we calibrate the real GDP of the New Keynesian model to be close to that of the SFC model, extrapolating a total factor productivity decrease at a rate of 0.35% after 2019 (Figure 4.2).[3] Then, we run a wage policy scenario (nominal wage increases by 1%). We compare the wage policy scenario with the baseline to check its impulse response and with the same impulse responses of the SFC model.

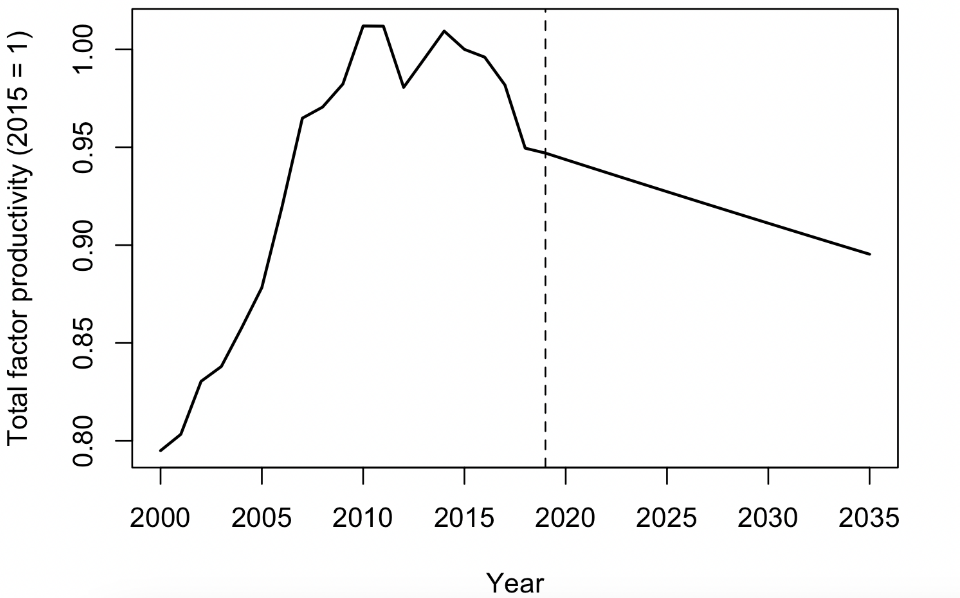


Figure 4.2: Total factor productivity

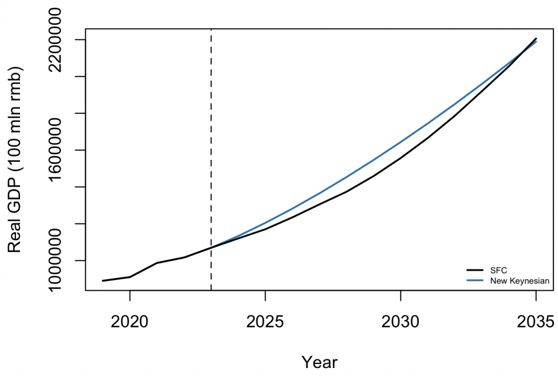
Note: The vertical dashed line signifies the end of the data period.

Before doing so, we utilise the latest available data for the variables and extrapolate the exogenous variables under specific assumptions. We assume that all adjustment variables, errors and omissions, and other changes in values are 0. For exogenous domestic prices, we use the 4-year mean growth rate of the last eight years to extrapolate them, i.e. $\left[\frac{Mean(Variable_{t-8},Variable_{t-7},Variable_{t-6},Variable_{t-5})}{Mean(Variable_{t-4},Variable_{t-3},Variable_{t-2},Variable_{t-1})}\right]^{\frac{1}{4}} - 1$. We assume that the nominal foreign GDP grows at a rate of 5% and the foreign price, i.e., the import price, grows at a rate of 3%. The population uses the prediction of the World Bank. The share of renewable energy is expected to grow at a rate of 2.57% to reach 25% in 2030, which is one of the policy goals of China (14th Five-Year Plan). Other shares and ratios are assumed to be constant.

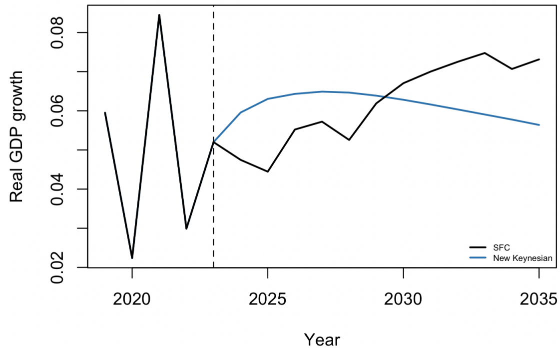
[3] We do not find any reliable future prediction on China's total factor productivity.

4.5.1 Baseline

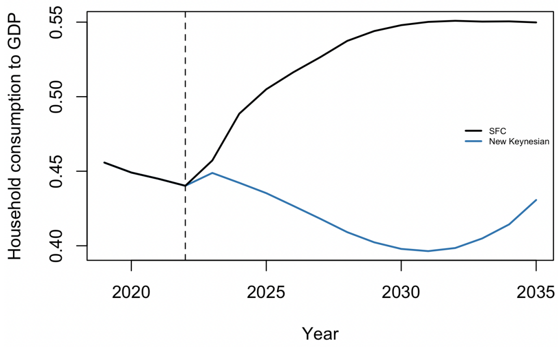
Figure 4.3 shows the prediction simulation results. The solid black line is the simulation of the SFC model. The solid blue line is the simulation of the New Keynesian model. The vertical dashed line indicates the end of the data period, at which point the simulation results begin to display. The New Keynesian model exhibits smoother economic growth compared to the SFC model (Figures 4.3a and 4.3b). Capital accumulation is the primary driver of economic growth in the New Keynesian model. At the same time, household consumption is the primary driver of economic growth in the SFC model (Figures 4.3c and 4.3d). Inflation in the New Keynesian is exceptionally stable, remaining around 1.5% for a decade (Figure 4.3e). The simulation of unemployment exhibits a larger inverted hump-shaped curve than the SFC model (Figure 4.3f). Income inequality decreases in large part in the long run due to the increase in the wage share (Figures 4.3g and 4.3h). Emissions to air intensity decrease over time due to the commitment to the green transition and due to the decreasing energy intensity resulting from GDP growth and decreasing income inequality (Figure 4.3i). Emissions to the air continue to increase over time due to economic growth, indicating that the green transition alone is insufficient to halt the rise in emissions, which is one of China's policy objectives (14th Five-Year Plan). However, the New Keynesian model predicts lower air emissions in the long run due to reduced income inequality (Figure 4.3j). Similarly, the dissipative use of products in the New Keynesian model slows down in the long run (Figure 4.3k). However, there is no significant difference in emissions to water between the New Keynesian model and the SFC model (Figure 4.3l).



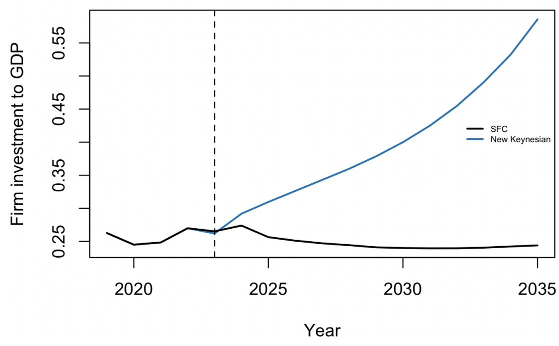
(a) Real GDP



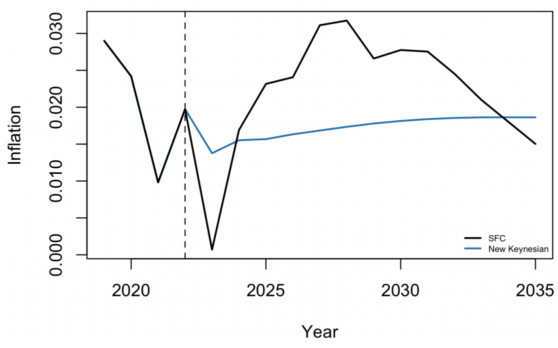
(b) Real GDP growth



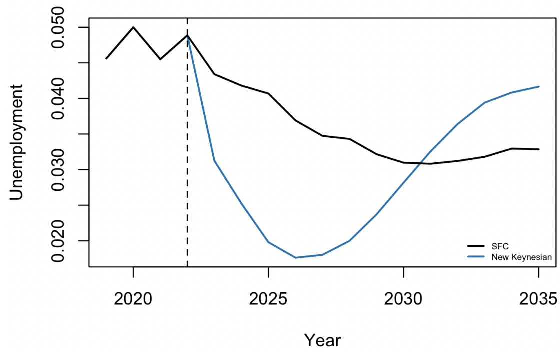
(c) Household consumption to GDP



(d) Firm investment to GDP



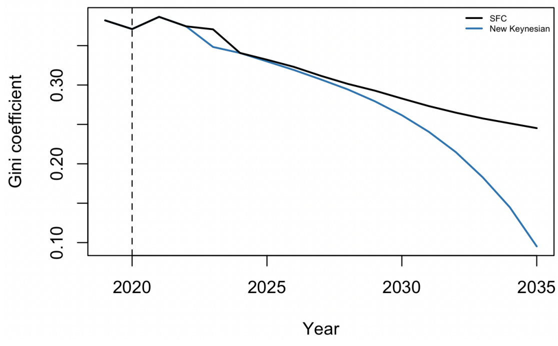
(e) Inflation



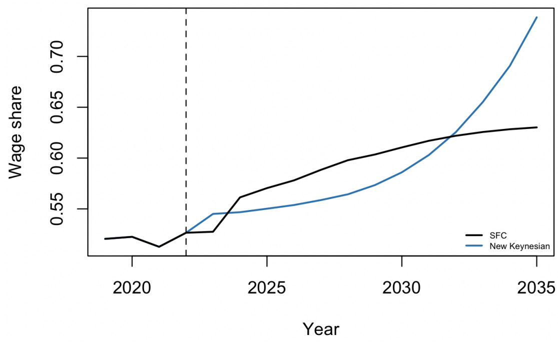
(f) Unemployment rate

Figure 4.3: Baseline scenario

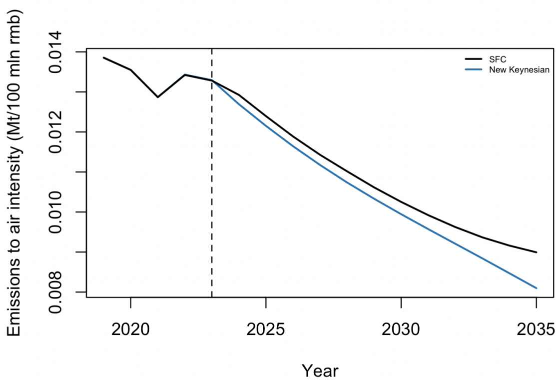
Note: The solid black line is the simulation of the SFC model. The solid blue line is the simulation of the New-Keynesian model. The vertical dashed line signifies the end of the data period, where the simulation result starts to display.



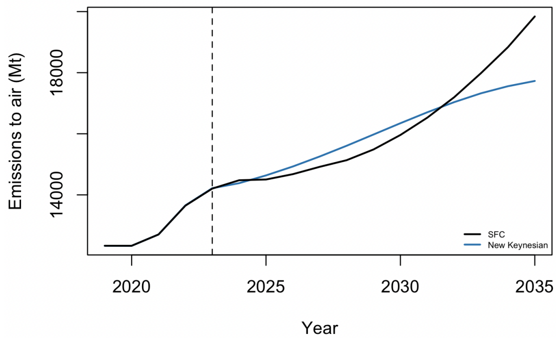
(g) Income inequality



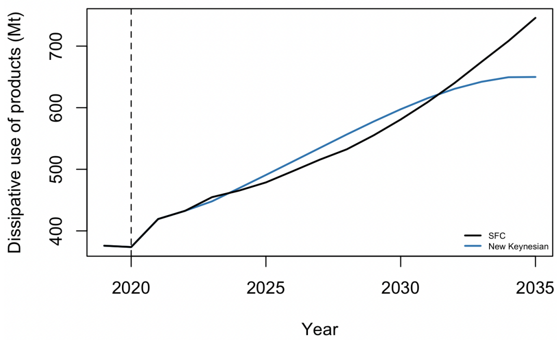
(h) Wage share



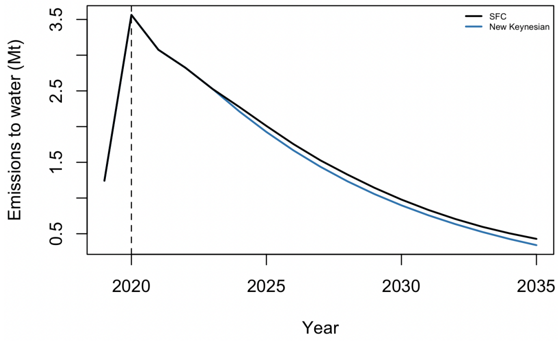
(i) Emissions to air intensity



(j) Emissions to air



(k) Dissipative use of products



(l) Emissions to water

Figure 4.3: Baseline scenario

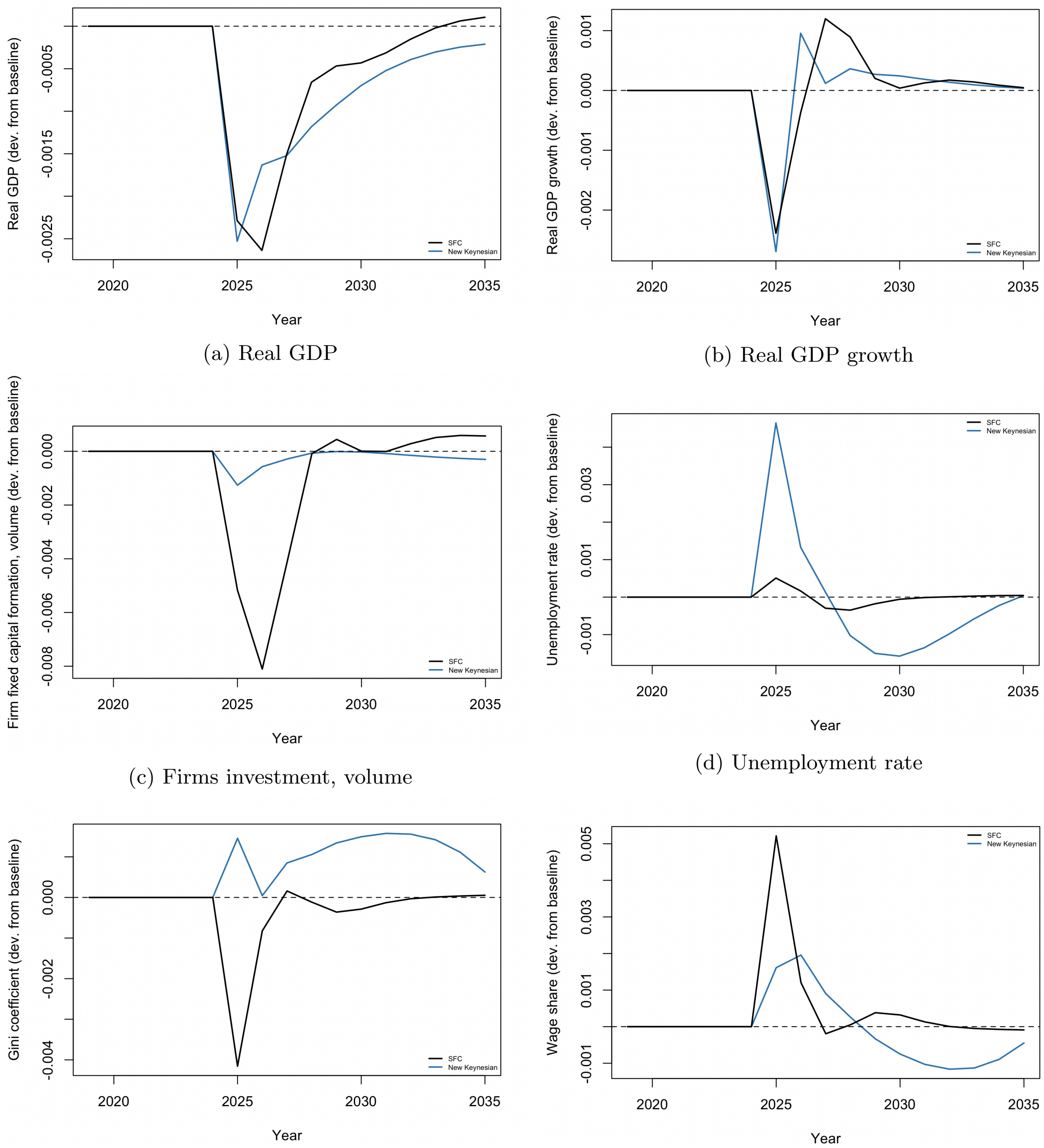
Note: The solid black line is the simulation of the SFC model. The solid blue line is the simulation of the New-Keynesian model. The vertical dashed line signifies the end of the data period, where the simulation result starts to display.

4.5.2 Wage policy

Figure 4.4 shows the impulse responses to an 1% increase in nominal wage in 2025. The black line is the impulse response of the SFC model. The blue line is the impulse response of the New Keynesian model. The two models show a similar response of real GDP to a nominal wage shock regarding the magnitude of GDP reduction and recovery timing (Figures 4.4a and 4.4b).

However, with respect to production inputs, the New Keynesian model shows less reduction in firm fixed capital but a larger reduction in labour due to the substitution between labour and capital. When labour becomes more expensive, firms would invest more in fixed capital for production (Figure 4.4c and 4.4d).[4] Income inequality in the New Keynesian model does not decrease but slightly increases, because of the rise in unemployment in the short term and the drop in the wage share in the medium term (Figure 4.4e and 4.4f). Energy intensity increases with more income inequality. As a consequence, emissions to air in the New Keynesian model increase in the long term, though it decreases in the short term because of the drops in real GDP (Figure 4.4g and 4.4h).

[4]Unemployment in the New Keynesian model increases in the short run and starts to recover as the economy recovers. But it shows an overshooting effect in the medium run, because the labour force adjusts to unemployment. Workers leave the labour market when the unemployment rate is high.



(a) Real GDP

(b) Real GDP growth

(c) Firms investment, volume

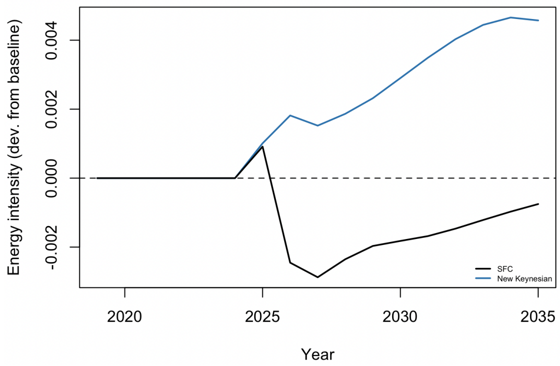
(d) Unemployment rate

(e) Gini coefficient

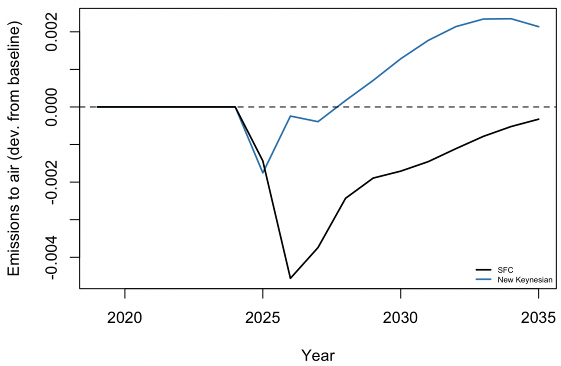
(f) Wage share

Figure 4.4: Nominal wage increase

Note: The black line is the impulse response of the SFC model. The blue line is the impulse response of the New Keynesian model.



(g) Energy intensity



(h) Emissions to air

Figure 4.4: Nominal wage increase

Note: The black line is the impulse response of the SFC model. The blue line is the impulse response of the New Keynesian model.

4.6 Conclusion and discussion

Economic theories help us understand the economy by linking variables. However, the story can be very different under different assumptions. This paper compares a New Keynesian model, which is supply-driven, with an SFC model, in which the economy is demand-driven. We run in-sample predictions to examine the performance of the two models. The results show that the New Keynesian model cannot explain the historical trend of the data compared to the SFC model, except that inflation simulated by the New Keynesian model is more stable. We argue that the behaviour equations derived from the agent optimisation problem are too restricted. For example, household consumption depends solely on intertemporal substitution, i.e., the Euler equation, which neglects any income or wealth effects. Also, Vines and Wills (2020) raises the point,

> We no longer think that this [microfounded manner] is an appropriate restriction of the macroeconomic research programme; structural economic models must be constructed alongside models of the NK-DSGE (New Keynesian Dynamic Stochastic General Equilibrium) kind, in which behaviour need not be fully microfounded.

Then, we run a baseline scenario simulation for future predictions from 2019 to 2035. The New Keynesian model exhibits smoother real GDP growth compared to the SFC model. The former is mainly driven by firm investment. The latter is due to household consumption. Regarding income inequality and environmental quality, the New Keynesian model yields more optimistic long-term results, characterised by lower income inequality and reduced emissions.

Our results coincide with Rezai et al. (2013), which argues that this unrealistic smoothness is a common shortcoming of supply-led models.

Based on the baseline scenario, we tested a wage policy shock: a 1% increase in nominal wage. A nominal wage shock in the New Keynesian model yields a similar response in real GDP to that in the SFC model. We arrive at the same conclusion using two different economic theories, suggesting that the impact of a wage shock on real GDP is robust. However, due to the substitution between capital and labour, firm fixed capital is more favoured in the production process, which declines significantly less than the SFC model, and labour demand decreases further than the SFC model. Consequently, the wage share decreases, income inequality increases, energy intensity increases, and air emissions increase. Our findings suggest that policymakers should be aware of these differences when making policy decisions based on a specific economic theory to model the economy.

An issue with the New Keynesian model in this paper is that it lacks a fiscal policy response. One may argue that the model should not close the final good market by firm inventories, but with household consumption, which determines the real interest rate. But this is not the case when introducing nominal rigidities and monetary policy, in which the central bank determines the real interest rate by setting the nominal interest rate, in response to developments in the inflation rate, according to a Taylor rule (Vines & Wills, 2020). An alternative approach is to incorporate feedback from inventories into firm price setting. When there is more excess supply of goods, firm inventories increase, and prices should fall. When there is excess demand, firm inventories fall, and prices should rise. However, we did not find a robust negative relationship between firm inventories and CPI in the data (see Figure 4.5, equation 4.94, 4.95 and 4.96 in Appendix). It is challenging to introduce public expenditure into a supply-led context (Costa, 2018, p.190). One possible solution is to introduce public consumption in the form of goods consumed by households, thereby affecting household utility. However, the effect of public consumption in this setup leads to a reduction in labour supply, i.e., nominal wage increases, because the shadow price increases, and also reduces private consumption due to the substitution effect (Aiyagari et al., 1992). In contrast, a demand-led model does not need this additional assumption to introduce public spending.

We found a technical issue in this modelling exercise: the simultaneity between real GDP and firm fixed capital. China has experienced remarkable economic growth over the past few decades, driven by robust investment. Firm fixed capital formation, as a significant component of real GDP, makes the model unstable when both firm fixed capital and real GDP are simultaneously determined. One solution is to employ the lag variable as in equation (4.32). But when the final good market closes on the demand side components, taking the lag does not make any sense from a theoretical perspective; alternative solutions will be needed.

Appendix

Households

Household budget constraint,

$$\begin{aligned} P_{c,t}c_{h,t} + I_{h,t} + W_{h,t} + TL_{h,t} + r_{ph,t}L_{h,t-1} + T_{h,t} + \tau_{sc,t}w_tN_t + O_{h,t} \\ + \Delta H_t + \Delta D_{h,t} + \Delta B_{h,t} + \Delta IFS_{h,t} + \Delta A_{h,t} + \Delta Z_{h,t} \\ = Y_{h,t} + w_tN_t + r_{rh,t}D_{h,t-1} + r_{rh,t}B_{h,t-1} + DIV_{h,t} + OIP_{h,t} + SB_t + STR_t + EO_{h,t} + \Delta L_{h,t}, \end{aligned} \tag{4.71}$$

where $I_{h,t}$ denotes household fixed capital formation in value (mainly housing), $W_{h,t}$ denotes the wage bill paid by households, $TL_{h.t}$ denotes net production tax paid by households, $T_{h,t}$ denotes income tax paid by households, $O_{h,t}$ denotes other current transfers paid by households, $\Delta IFS_{h,t}$ denotes the household investment in investment fund shares, ΔA_t denotes household acquisition of insurance, $\Delta Z_{h,t}$ denotes household acquisition of other accounts payable/receivable, $Y_{h,t}$ denotes household value added, $DIV_{h,t}$ denotes dividend received by households, $OIP_{h,t}$ denotes household other income from properties, SB_t denotes social transfers received by households, STR_t denotes social transfers in kind received by households, $EO_{h,t}$ denotes household errors and omissions.

Household fixed capital formation in value,

$$I_{h,t} = P_{k_h,t}k_{h,t} - P_{k_h,t-1}k_{h,t-1}(1-\delta_{h,t}) - \Delta P_{k_h,t}k_{h,t-1} - OCV_{k_h,t}, \tag{4.72}$$

where $OCV_{k_h,t}$ denotes other changes in value of household fixed assets.

Household currency savings,

$$\Delta H_t = H_t - H_{t-1} - OCV_{h,t}, \tag{4.73}$$

where $OCV_{h,t}$ denotes other changes in value of household currencies.

Household deposit saving,

$$\Delta D_{h,t} = D_{h,t} - D_{h,t-1} - OCV_{d_h,t}, \tag{4.74}$$

where $OCV_{d_h,t}$ denotes other changes in value of household deposits.

Household bond investment,

$$\Delta B_{h,t} = P_{b_h,t}b_{h,t} - P_{b_h,t-1}b_{h,t-1} - OCV_{b_h,t}, \tag{4.75}$$

where $OCV_{b_h,t}$ denotes other changes in value of household bonds held.

Household loan borrowing,

$$\Delta L_{h,t} = L_{h,t} - L_{h,t-1} - OCV_{l_h,t}, \tag{4.76}$$

where $OCV_{l_h,t}$ denotes other changes in value of household loans borrowed.

Substituting equations (4.72), (4.74), (4.75), (4.75) and (4.76) into equation (4.71), we get equation (4.2), with

$$\begin{aligned}\Omega_{h,t} \equiv Y_{h,t} - W_{h,t} - TL_{h,t} + DIV_{h,t} + OIP_{h,t} - T_{h,t} + SB_t + STR_t - O_{h,t} + EP_{h,t} \\ - \Delta IFS_{h,t} - \Delta A_{h,t} - \Delta Z_{h,t} + OCV_{k_h,t} + OCV_{h,t} + OCV_{b_h,t} - OCV_{l_h,t}.\end{aligned} \tag{4.77}$$

Firms:

Combining equations (4.36) and (4.37), we get the labour-capital production frontier,

$$N_{i,t} = \frac{(1-\alpha)r_{pf,t}P_{k_1,t-1}k_{i,1f,t-1}}{\alpha w_t}. \tag{4.78}$$

Substituting equation (4.78) into equation (4.32), we derive capital demand in terms of production and input cost ratio,

$$k_{i,1f,t-1} = \frac{y_{i,t}}{TFP_{i,t}}\left[\frac{\alpha w_t}{(1-\alpha)r_{pf,t}P_{k_1,t-1}}\right]^{1-\alpha}. \tag{4.79}$$

Same for labour,

$$N_{i,t} = \frac{y_{i,t}}{TFP_{i,t}}\left[\frac{\alpha w_t}{(1-\alpha)r_{pf,t}P_{k_1,t-1}}\right]^{-\alpha} \tag{4.80}$$

Substituting equations (4.79) and (4.80) into (4.31), we get the total cost of whole-sale firm production,

$$TC_{i,t} = \frac{y_{i,t}}{TFP_{i,t}}\left(\frac{w_t}{1-\alpha}\right)^{1-\alpha}\left(\frac{r_{pf,t}P_{k_1,t-1}}{\alpha}\right)^{\alpha} + \tau_{L_f,t}y_{i,t}. \tag{4.81}$$

By definition, we derive the marginal cost of production of whole-sale firms by taking the partial derivative of the total cost of whole-sale firm production with respect to the quantity of production, $\mu_{i,t} = \frac{\partial TC_{i,t}}{\partial y_{i,t}}$, and get equation (4.39).

Firm budget constraint,

$$
\begin{aligned}
I_{1_f,t} + I_{2_f,t} + I_{3,t} + W_{f,t} + TL_{f,t} + r_{pf,t}P_{b_f,t-1}b_{f,t-1} + r_{pf,t}L_{f,t-1} + DIV_{p_f,t} + T_{f,t} + O_{f,t} \\
+ \Delta D_{f,t} + \Delta FDI_{out,t} + \Delta A_{f,t} + \Delta Z_{f,t} \\
= Y_{f,t} + r_{rf,t}D_{f,t-1} + \gamma_{DIV_{rf}}(E_{af,t-1} + P_{fdi_{out},t-1}fdi_{out,t-1}) + OIP_{f,t} + TRK_t + EO_{f,t} \\
+ \Delta B_{f,t} + \Delta L_{f,t} + \Delta FDI_{in,t}, \quad (4.82)
\end{aligned}
$$

where $I_{1_f,t}$ denotes firm fixed capital formation in value, $I_{2_f,t}$ denotes firm change in inventories in value, $I_{3f,t}$ denotes firm acquisition/disposal of other non-financial assets, $W_{f,t}$ denotes the wage bill paid by firm, $TL_{f,t}$ denotes the net production tax paid by firms, $DIV_{pf,t}$ denotes the dividend paid by firms, $T_{f,t}$ denotes the income tax paid by firms, $O_{f,t}$ denotes other current transfers paid by firms, $\Delta D_{f,t}$ denotes firm deposits savings, $\Delta FDI_{out,t}$ denotes the flow of outward foreign direct investment in value, $\Delta A_{f,t}$ denotes firm insurance acquisition, $\Delta Z_{f,t}$ denotes firm changes in other account payable/receivables, $Y_{f,t}$ denotes firm value added, $E_{af,t}$ denotes firm equity held, $OIP_{f,t}$ denotes the other income from properties received by firms, TRK_t denotes capital transfers received by firms, $EO_{f,t}$ denotes firm errors and omissions, $\Delta B_{f,t}$ denotes firm bond borrowing in value, $\Delta FDI_{in,t}$ denotes the flow of inward FDI in value.

Firm deposit savings,

$$\Delta D_{f,t} = D_{f,t} - D_{f,t-1} - OCV_{d_f,t}, \quad (4.83)$$

where $OCV_{d_f,t}$ denotes other changes in value of firm deposits.

Firm bond borrowing,

$$\Delta B_{f,t} = P_{b_f,t}(b_{f,t} - b_{f,t-1}) - OCV_{b_f,t}, \quad (4.84)$$

where $OCV_{b_f,t}$ denotes other changes in value of firm bonds.

Firm equity issued (zero net worth),

$$E_{lf,t} = K_{1_f,t} + K_{2_f,t} + K_{3_f,t} + D_{f,t} - P_{b_f,t}b_{f,t} - L_{f,t} + E_{af,t} + P_{fdi_{out},t}fdi_{out,t} - FDI_{in,t} + A_{f,t} + Z_{f,t}, \quad (4.85)$$

where $K_{1_f,t}$ denotes firm fixed capital in value, $K_{2_f,t}$ denotes firm inventories in value, $K_{3_f,t}$ denotes firm other non-financial assets in value, $FDI_{in,t}$ denotes the stock of inward FDI in value, $A_{f,t}$ denotes firm insurance held, and $Z_{f,t}$ denotes firm other account payable/receivables.

From equation (4.85), we get firm loan issued satisfies

$$L_{f,t} = K_{1_f,t}+K_{2_f,t}+K_{3_f,t}+D_{f,t}-P_{b_f,t}b_{f,t}+E_{af,t}-E_{lf,t}+P_{fdi_{out},t}fdi_{out,t}-FDI_{in,t}+A_{f,t}+Z_{f,t}. \tag{4.86}$$

Firm outward FDI flow in value,

$$\Delta FDI_{out,t} = P_{fdi_{out},t}(fdi_{out,t} - fdi_{out,t-1}). \tag{4.87}$$

Substituting equations (4.83), (4.84), (4.86) in one lagged, and (4.87) into equation (4.82), we get equation (4.53), with

$$\begin{aligned}\Omega_{f,t} \equiv Y_{f,t} + \gamma_{DIV_{rf}}E_{af,t-1} + OIP_{f,t} + TRK_{f,t} + EO_{f,t} + \Delta L_{f,t} + \Delta FDI_{in,t} + OCV_{d_f,t} \\ -I_{1_f,t}-I_{2_f,t}-I_{3,t}-W_{f,t}-r_{pf,t}(K_{1_f,t-1}-K_{2_f,t-1}+E_{af,t-1}-E_{lf,t-1}-FDI_{in,t-1}+A_{f,t-1}+Z_{f,t-1}) \\ - DIV_{pf,t} - T_{f,t} - O_{f,t} - \Delta A_{f,t} - \Delta Z_{f,t} - OCV_{b_f,t}.\end{aligned} \tag{4.88}$$

Banks:

Bank budget constraint,

$$\begin{aligned} I_{1_b,t} + W_{b,t} + r_{p,t}P_{b_{lb},t}b_{lb,t} + DIV_{pb,t} + OIP_{b,t} + T_{b,t} \\ + \Delta G_t + \Delta D_{b,t} + \Delta B_{ab,t} + \Delta L_{b,t} + \Delta IFS_{ab,t} + \Delta Z_{b,t} \\ = (1-\tau_{Lb,t})P_{y,t}y_{b,t} + r_{rb,t}D_{b,t-1} + INT_{b_{rb},t} + INT_{lb,t} + DIV_{rb,t} + O_{b,t} + EO_{b,t} \\ + \Delta H_t + \Delta D_t + \Delta B_{lb,t} + \Delta IFS_{lb,t} + \Delta A_t, \end{aligned} \tag{4.89}$$

where $I_{1_b,t}$ denotes bank fixed capital formation in value, $W_{b,t}$ denotes the wage bill paid by banks, $DIV_{pb,t}$ denotes the dividend received by banks, $OIP_{b,t}$ denotes the other income from properties paid by banks, $T_{b,t}$ denotes the income tax paid by banks, ΔG_t denotes changes in international reserves, $\Delta D_{b,t}$ denotes bank deposit savings, $\Delta B_{ab,t}$ denotes bank acquisition of bonds, $\Delta L_{b,t}$ denotes bank loan lending, $\Delta IFS_{ab,t}$ denotes bank acquisition of investment fund shares, $\Delta Z_{b,t}$ denotes bank changes of other accounts receivable/payable, $INT_{b_{rb},t}$ denotes bank interest received from bonds, $INT_{lb,t}$ denotes bank interest received from loans, $DIV_{rb,t}$ denotes the dividends received by banks, $O_{b,t}$ denotes other current transfers received by banks, $EO_{b,t}$ denotes bank errors and omissions, ΔD_t denotes total deposits received by banks, $\Delta B_{lb,t}$ denotes bank bond issuing, $\Delta IFS_{lb,t}$ denotes bank investment fund shares issuing, and ΔA_t denotes total insurance received by bank.

Bank fixed capital formation in value,

$$I_{1_b,t} = P_{k_1,t}(k_{1_b,t} - k_{1_b,t-1}) + \delta_{b,t} P_{k_1,t-1} k_{1_b,t-1} - OCV_{k_{1b},t}, \tag{4.90}$$

where $OCV_{k_{1b},t}$ denotes the other changes in value of bank fixed capital.

Bank deposit savings,

$$\Delta D_{b,t} = D_{b,t} - D_{b,t-1} - OCV_{d_b,t}, \tag{4.91}$$

where $OCV_{d_b,t}$ denotes the other changes in value of bank deposit held.

Bank bond issuing,

$$\Delta B_{lb,t} = P_{b_{lb},t}(b_{lb,t} - b_{lb,t-1}) + OCV_{b_{lb},t}, \tag{4.92}$$

where $OCV_{b_{lb},t}$ denotes the other changes in value of bank bond issued.

Substituting equations (4.90), (4.91) and (4.92) into equation (4.89), we get equation (4.62) with

$$\begin{aligned}\Omega_{b,t} \equiv\, & INT_{b_{rb},t} + INT_{b_{lb},t} + DIV_{rb,t} + O_{b,t} + EO_{b,t} \\ & + \Delta H_t + \Delta D_t + \Delta IFS_{lb,t} + \Delta A_t + OCV_{k_{1b},t} + OCV_{d_b,t} \\ & - W_{b,t} - INT_{d,t} - DIV_{pb,t} - OIP_{b,t} - T_{b,t} \\ & - \Delta G_t - \Delta B_{ab,t} - \Delta L_{b,t} - \Delta IFS_{ab,t} - \Delta Z_{b,t} - OCV_{b_{lb},t}.\end{aligned} \tag{4.93}$$

CPI and firm inventories

Figure 4.5 shows the time series of CPI inflation (left axis) and firm inventories growth (right axis). It shows a positive relationship between CPI inflation and firm inventory growth, which contradicts our expectation.

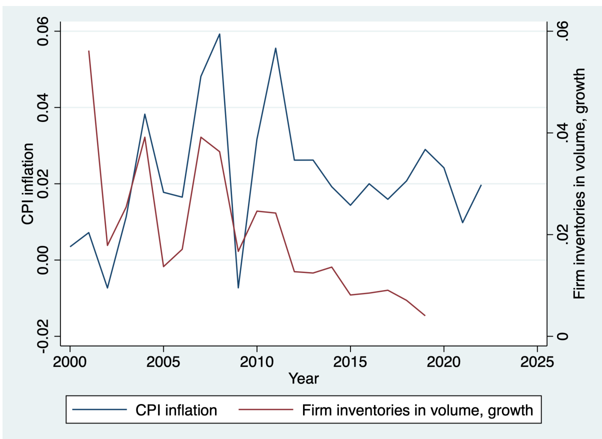


Figure 4.5: CPI inflation and firm inventories growth

We run regressions by adding firm inventories to the CPI equation. It shows a negative correlation of firm inventories to CPI in the long-run equation (equation 4.94). However, we fail to find a robust result from the short-run equation with error correction. In equation (4.95), the coefficient of firm inventories growth is not significant, with a T-statistic of -0.91. After dropping it, the coefficient of the error correction term is not significant anymore, with a T-statistic of -1.65 (equation 4.96).

Long-run regression of CPI to firm inventories,

$$\ln P_{c,t} = 0.5586_{(6.39)} \ln P_{c,t-1} - 0.0822_{(-5.06)} \ln k_{2f,t} + 0.105_{(5.17)} \ln w_t$$
$$- 0.0181_{(-2.42)} Dum_{2002} + 0.0241_{(3.23)} Dum_{2008} - 0.0237_{(-3.35)} Dum_{2009} + 0.0192_{(2.57)} Dum_{2011}, \quad (4.94)$$

where the numbers in brackets are the T-statistic, $k_{2f,t}$ denotes firm inventories in volume, and Dum_t denotes the dummy variable of year t.

Short-run regression of CPI to firm inventories,

$$\Delta \ln P_{c,t} = -0.1209_{(-0.91)} \Delta \ln k_{2f,t} + 0.2108_{(7.73)} \Delta \ln w_t - 0.792_{(-2.44)} ecm_{t-1}$$
$$- 0.0255_{(-3.56)} Dum_{2002} + 0.031_{(3.77)} Dum_{2008} - 0.0246_{(-3.53)} Dum_{2009} + 0.0203_{(2.78)} Dum_{2011}, \quad (4.95)$$

where ecm_{t-1} denotes the error correction term of the long-run equation in one lag.

Short-run regression of CPI to firm inventories without the firm inventories log-difference,

$$\Delta \ln P_{c,t} = 0.1973_{(11.66)} \Delta \ln w_t - 0.5681_{(-1.65)} ecm_{t-1}$$
$$- 0.0268_{(-3.39)} Dum_{2002} + 0.0271_{(3.04)} Dum_{2008} - 0.0254_{(-3.28)} Dum_{2009} + 0.02_{(2.48)} Dum_{2011}. \quad (4.96)$$

Table 4.3: Parameters of the New Keynesian model

Symbol	Description	Value	T-statistic
b_{f1}	Sensitivity of the growth rate of firm bond in volume per capita to the growth rate of real household consumption per capita	2.519	5.16
b_{h1}	Sensitivity of the growth rate household bonds per capita to the growth rate of interest rate receive by households	0.7981	12.59
b_{lb1}	Sensitivity of the growth rate of bank bond issued per capita to CPI inflation	3.6634	3.36
c_{h1}	Inverse of household constant relative risk aversion coefficient	3.5002	8.35
d_{b1}	Sensitivity of the growth rate of bank deposit held per capita to the growth rate of household consumption per capita	3.6807	5.76

d_{b2}	Sensitivity of the growth rate of bank deposit held per capita to the growth rate of bank rate of interest received	2.0401	4.12
d_{f1}	Short-run elasticity of firm deposit per capita to real household consumption per capita	1.2817	8.85
d_{f2}	Long-run correction parameter of firm deposit per capita	-0.027	-0.2
d_{f3}	Level of firm deposit per capita in logarithm when household consumption per capita equals 100 million rmb and the rate of interest received and paid by firms are equal	-4.2395	-23.3
d_{f4}	Long- run elasticity of firm deposit per capita to real household consumption per capita	1.4424	74.33
d_{f5}	Semi-elasticity of firm deposit per capita to the difference between the rates of interest received and paid by firms	12.73	7.42
fdi_{out1}	Short-run elasticity of outward FDI in volume per capita to real household consumption per capita	1.2856	10.07
fdi_{out2}	Long-run correction parameter of outward FDI in volume per capita	-0.4832	-3.02
fdi_{out3}	Level of outward FDI in volume per capita in logarithm when real households consumption per capita equal 100 million rmb and the price outward FDI equal CPI	9.6282	-10.22
fdi_{out4}	Long-run elasticity of outward FDI in volume per capita to real household consumption per capita	1.8155	19.14
fdi_{out5}	Elasticity of outward FDI in volume per capita to the price of inward FDI deflated by CPI	-0.4093	-2.58
h_1	Sensitivity of the growth rate of currency per capita to the growth rate of household consumption per capita	0.905	12.74
k_1	Short-run elasticity of capital productivity to total factor productivity	1.0516	7
k_2	Short-run elasticity of capital productivity to the capital cost of production	0.0661	4.66
k_3	Short-run elasticity of capital productivity to the labour cost of production	-0.516	-17.87
k_4	Long-run correction parameter of capital productivity	-0.261	-4.27
k_5	Level of capital productivity in logarithm when total factor productivity equals 1 and nominal wage equals 1 million rmb	5.076	17.68
k_6	Long-run elasticity of capital productivity to total factor productivity	1.6413	6.69
k_7	Long-run elasticity of capital productivity to nominal wage	-0.5017	-18.55
k_{b1}		0.2761	6.44
k_{h1}	Short-run elasticity of housing per capita to housing depreciation rate	-3.7492	-7.96
k_{h2}	Short-run elasticity of housing per capita to household consumption per capita	0.4446	11.85
k_{h3}	Short-run elasticity of housing per capita to real housing price per capita	-0.0855	-2.47
k_{h4}	Long-run correction parameter of housing per capita	-0.7669	-7.03
k_{h5}	Level of housing per capita in logarithm under full depreciation rate and household consumption per capita is 1 million rmb	-14.25	-3.86
k_{h6}	Long-run elasticity of housing per capita to housing depreciation rate	-5.9083	-5.67
k_{h7}	Long-run elasticity fo housing per capita to household consumption per capita	0.2603	6.06
l_{h1}	Sensitivity of the growth rate of household loans borrowed to the growth rate of household consumption	2.2536	20.74
n_1	Sensitivity of the growth rate of labour productivity to the growth rate of capital cost of production	-0.0607	-3
n_2	Sensitivity of the growth rate of labour productivity to the growth rate of labour cost of production	0.6981	28.23
p_{c1}	Sensitivity of inflation to nominal wage growth	0.2324	12.47
p_{k1}	Sensitivity of capital price growth to nominal wage growth	0.2273	4.68

p_{kh1}	Sensitivity of housing price growth to nominal wage growth	0.5921	8.47
p_{x1}	Sensitivity of export price growth to nominal wage growth	0.1004	1.94
w_1	Short-run elasticity of nominal wage to real consumption per capita	1.2768	27.08
w_2	Short-run elasticity of of nominal wage to CPI over one minus social contribution rate	-0.0119	-0.47
w_3	Long-run correction parameter of nominal	-0.2984	1.79
w_4	Stickiness of nominal wage	0.7714	19.97
w_5	Long-run elasticity of nominal wage to real consumption per capita	0.3317	6.22
w_6	Elasticity of nominal wage to employment per capita	1.2732	5.12
y_1	Elasticity of effective labour productivity to capital labour intensity	0.5674	15.58

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