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China's macroeconomic policies and spillover effects*

Julia Niemeläinen†

Abstract

This paper provides a brief overview of China's capital controls, external asset holdings and the real interest rate, and analyzes the quantitative effects of China's macroeconomic policies between 2000 and 2015, including capital controls, interest rate policy, exchange rate policy and fiscal policy, on the dynamics of China's trade balance vis-a-vis the United States and the world real interest rate. In my analysis, I take into account the demographic differences between the countries, which affect the external imbalances directly and indirectly by affecting the transmission of the macroeconomic policies. Capital controls in China remain stringent even though they have somewhat eased in 2010s, and its gross external asset holdings differ from its peer countries both in terms of the largest functional categories and by type of investment. The average interest rate spread with the US has narrowed down. According to my analysis, the macroeconomic policies overall, and mainly the undervaluation of the real exchange rate, have had a positive impact on China's trade balance. The impact of the macroeconomic policies on the real interest rate has been positive, countering the negative trend induced by demographic factors.

Keywords: capital controls, capital flows, China

JEL codes: F21, F41, F42, G28

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† Ministry of Finance of Finland (julia.niemelainen@gmail.com), orcid.org/0000-0003-2816-1327.

Non-technical summary

FOCUS

China has practiced macroeconomic policies which have distorted both its intratemporal terms of trade (i.e. the price of foreign goods in the domestic market) and intertemporal terms of trade (i.e. the real interest rate): there has been evidence of real exchange rate has undervaluation, and China's capital account restrictions have been strong. At the same time, China has run a persistent trade surplus and become a significant global net creditor. To what extent have these policies contributed to China's strong external position and the world real interest rate?

CONTRIBUTION

I build a two-country dynamic general equilibrium model describing the behaviour of Chinese policy-makers to analyze the effects of China's macroeconomic policies between 2000-2015 on the dynamics of its trade balance and the real interest rate. The paper provides a quantitative theory-based assessment of the importance of government policies on the observed external imbalances. I also provide a brief overview of China's capital controls, external asset holdings and the real interest rate.

FINDINGS

I find that the macroeconomic policies of 2000-2015 overall had a strong positive impact on the trade balance. The effects are driven by the real exchange rate policy, which has caused households to postpone consumption into the future. I also find that the macroeconomic policies had a positive impact on the international real interest rate, as they have resulted in a reduction in world aggregate savings.

1 Introduction

The rapid rise of China into a global economic superpower and the world's largest merchandise trader has created tensions between China and other large economies. These tensions come from the fact that China's trade has been persistently imbalanced, and these imbalances have been interpreted as being, at least to some extent, the result of government policies which distort both the country's intratemporal terms of trade (*i.e.* the price of foreign goods in the domestic market) and the intertemporal terms of trade (*i.e*. the real interest rate) at the expense of China's trading partners. Throughout the 2000s, China has in fact run trade and current account surpluses against the rest of the world and against its main trading partner, the United States (US).

In this paper I provide a quantitative analysis of the effects of China's macroeconomic policies between 2000-2015 on the dynamics of its trade balance and the real interest rate, and the spillover effects of these policies on the US. In particular, three macroeconomic policies are analyzed: capital controls, which allow the government to set a domestic interest rate which differs from the world interest rate (labeled as interest rate policy), undervaluation of the real exchange rate (exchange rate policy), and expansionary fiscal policy.

To quantify the impact of these policies, I build a two-country dynamic general equilibrium model embedded with the policy instruments describing the behaviour of Chinese policymakers. In particular, I assume that a consolidated Chinese government-central bank can impose capital controls, which prevent private Chinese agents from holding foreign assets, and control directly an exogenously given real exchange rate. The model also features a life-cycle structure in which households live through two different stages in life and the sizes of the cohorts vary over time. This feature serves two purposes. First, fiscal policy is non-Ricardian in the life-cycle framework, and its effects depend on the demographic structures of the economies. This is important for the quantitative analysis since the demographic structures differ considerably between China and the US. Second, the life-cycle structure allows to take into account the impact of life-cycle behaviour on households' consumption-saving choices. This is relevant given that

the current account surplus of China is driven by Chinese households' high saving rate and, as earlier literature suggests, there is a strong link between household savings and the life cycle.

The novelty of this paper is to provide a quantitative theory-based assessment of the importance of government policies on the observed external imbalances between China and the US. The paper owes to earlier theoretical literature (reviewed in section 2) on capital controls and real exchange rates and extends it into a two-country dynamic general equilibrium framework, highlighting the long-term, quantitative, dynamic effects of the policies, taking into account the notable differences in the demographic structures between the economies both as an independent driver of the capital flows and as a factor shaping the transmission of the government policies.

According to my analysis, China's macroeconomic policies between 2000 and 2015 have had a positive effect on the Chinese trade balance, driven by the real exchange rate undervaluation which has caused households to postpone consumption into the future. Fiscal policy has also had a positive impact on the Chinese trade balance, while the impact of the policy of low interest rates impact on the trade balance has been negative as it has stimulated investment and discouraged savings. The removal of capital controls, which would lead to an equalization of the domestic interest rate with the international interest rate, would have a positive effect on the Chinese trade balance, so that the trade surplus would grow. Furthermore, I find that the effect of the macroeconomic policies on the real interest rate has been positive, as they have resulted in a reduction in world aggregate savings. Demographic changes have, on the other hand, put downward pressure on the international interest rate, as they have strengthened the saving-for-retirement motive in both economies. Demographic changes have also resulted in a long-term improvement in China's trade surplus because of the relatively large increase in life expectancy in China.

The rest of the paper is organized as follows. In section 2, I discuss the studies that laid the groundwork for this work and my contribution to the literature. In Section 3 I provide a brief overview of China's capital controls and their effect on its external asset holdings and interest rate. The theoretical model is described in Section 4 and the quantitative analysis is done in Section 5. Finally, Section 6 concludes.

2 Motivation and related literature

The reasons for considering the capital controls, exchange rate manipulation, and expansionary fiscal policy as potential drivers of the trade imbalances are the following.

First, despite maintaining an open trade stance, China's restrictions on its capital account are relatively high in international comparison (see the left panel in figure 1), and free capital mobility, especially in portfolio investments, has been prevented.[1,2] Even though the liberalization of the capital account has earlier been promoted by Chinese authorities (see e.g. PBOC, 2012) and measures to allow higher capital mobility have taken place, full capital account liberalization is not expected in the near future. Capital controls have given China the possibility to exercise independent interest rate policy despite its exchange rate regime, in which the yuan has been effectively anchored to the US dollar.[3] According to World Bank data (see the right panel in figure 1), except for some years, the US real interest on average exceeded considerably the Chinese real interest rate rate since 1980s. By controlling the domestic real interest rate, the government has been able to distort the intertemporal terms of trade faced by the private sector and thereby the trade balance. As the private sector is, to a large extent, prevented from accessing the international financial market, the persistent trade surpluses have given rise to the accumulation of a sizeable foreign reserve position held by the People's Bank of China (PBOC), which constitutes the majority of China's external assets (see figure 17 in Appendix section D).

The effects of capital controls have been extensively analyzed in the literature. The welfare effects of capital controls and reserve accumulation are discussed among others by Bacchetta, Benhima and Kalantzis (2013). They show, using model in which a consolidated government-central bank is the only agent that can access the international financial market and households are borrowing constrained, that, in a fast-growing economy like China, the central bank can subsidize or tax households' borrowing and saving by

[1] The historical development of the capital control index is shown in figure 5.

[2] Foreign direct investments (FDI) have been less stringently regulated, which is reflected in a relatively large share of FDI in the foreign liabilities (figure 17 in Appendix section D). For a review of capital controls on different asset classes, see Fernández, Klein, Rebucci, Schindler, Uribe et al. (2016) (with most recent update from August 2021).

[3] Since 2016, the yuan has been classified as *de facto* anchored to a composite instead of the dollar.

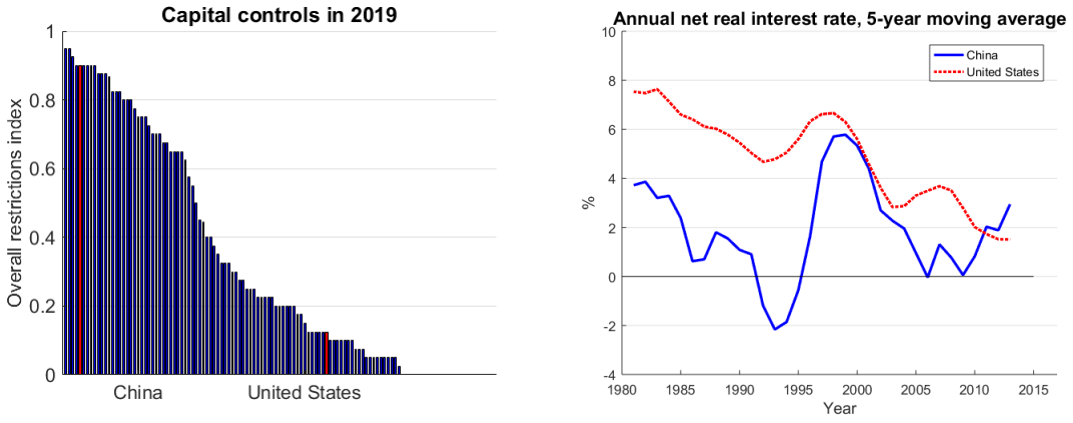

Figure 1: Left panel: capital controls index (overall restrictions index, including all asset classes). Right panel: real interest rates (lending interest rate adjusted for inflation as measured by the GDP deflator).

Notes. Sources: Fernández et al. (2016), updated in 2021 (left graph), World Bank World Development Indicators 2018 and author's calculations (right graph).

manipulating the interest rate and therefore influence the intertemporal allocation of resources in a welfare improving way. Chang, Liu and Spiegel (2015) study the welfare effects of China's macroeconomic policies with a new Keynesian DSGE model focusing on the monetary policy trade-off that sterilization of the PBOC interventions involve. Song, Storesletten and Zilibotti (2014), on the other hand, analyse the economic consequences of China's capital controls and domestic interest rate and exchange rate policies on several measures of economic performance, including the trade surplus. As in Bacchetta et al. (2013), domestic households cannot access the international financial market. In addition, a consolidated government-central bank accumulates foreign reserves and exercises interest rate and exchange rate policies. In this paper, I generalize the two-stage overlapping generations (OLG) structure used by Song et al. (2014) into a Gertler (1999) life-cycle model, which allows to take into account the impact of demographic transition and rationalizes the observed high saving propensity through population ageing.

The effects of capital controls in international context have also been analyzed by several authors with theoretical two-country models (Jeanne and Korinek, 2010, Bianchi, 2011, Costinot, Lorenzoni and Werning, 2014, Benigno, Chen, Otrok, Rebucci and Young, 2016, and Korinek, 2017). The main difference in comparison to this literature is that my approach is positive and aims at explaining the link between

observed capital controls and the dynamics in the external sector. This strand also abstracts from consideration of demographic factors.

Second, the Chinese real exchange rate is estimated to have been undervalued for an extended period of time during the 2000s and 2010s according to several sources. For instance, Goldstein and Lardy (2009) argue that the Chinese real exchange rate was undervalued by approximately 20 % from 2002 until 2008.[4] According to the IMF Series of External Sector Reports, the real effective exchange rate (henceforth, REER) appreciated since 2005, but remained slightly undervalued until 2014, after which it has been close to the level in line with the fundamentals. The period of renmimbi undervaluation coincides with the substantial increase in the current account surplus in 2006-2007. Figure 2 presents estimates of the REER undervaluation based on Goldstein and Lardy (2009) and by the IMF, and plots the bilateral real exchange rate vis-a-vis the dollar, which shows that the REER has followed closely the

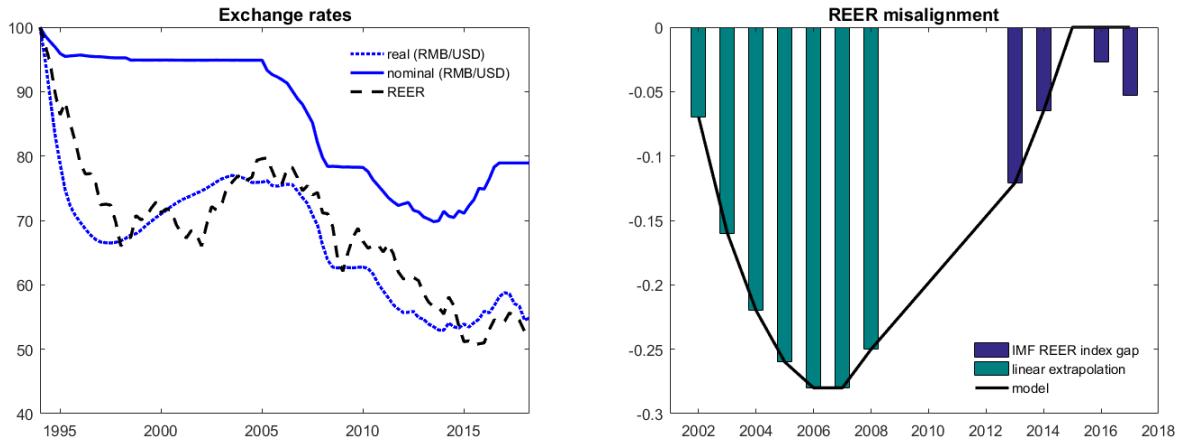

Figure 2: Left panel: nominal China / US exchange rate (solid line), real China / US exchange rate (dashed blue line), China's real effective exchange rate (dotted black line). Right panel: China REER misalignment.

Notes. All data is quarterly. Data sources: Federal Reserve Bank of St. Louis (exchange rates), OECD (inflation). the REER misalignment is based on IMF REER index gap and linear extrapolation as in Goldstein and Lardy (2009).

[4] This finding appears to be in line with several studies, even though the size of the undervaluation is debated. Goldstein (2008) summarizes the findings of 18 studies and reports that 17 of them find the REER was undervalued in the first part of the 2000s.

real RMB/USD exchange rate.

Examples of early literature on the link between terms of trade and the external balance include Harberger (1950) and Laursen and Metzler (1950), who explore the negative income effect of an adverse terms-of-trade shock on private savings. More recently, Obstfeld and Rogoff (1995) and Corsetti and Pesenti (2001) discuss the substitution effect related with terms-of-trade shocks based on two-country DSGE model. Cashin and McDermott (2003) explore the role of intertemporal and intratemporal substitution in influencing the responses to terms-of-trade shocks in a small open economy. Uribe and Schmitt-Grohé (2017) discuss the empirical evidence on terms-of-trade shock and the external sector. My contribution is to analyze quantitatively the link between the undervaluation of the real exchange rate and the external imbalances.

Third, the size of the general government has grown markedly in the 2000s in China, and government expenditures have been financed, to a growing extent, with net borrowing (see figure 3). General government total expenditures grew from approximately 17 % to over 30 % of GDP between 2000 and 2015, and the growth in government revenues has not been enough to close the fiscal deficit, especially in the latter part of 2010s.[5] The observed fiscal deficits have potential to explain China's high saving rate to the extent that they have led to an increase in private savings in anticipation of high future tax rates. At the same time, the US has also been running a persistent government budget deficit, which widened at the aftermath of the global financial crisis and has led to a substantial increase in public debt.

Finally, the demographic structures of China and the US differ significantly from each other, and demographic developments have changed the population age structures in both countries in the past decades (see the United Nation's 2017 demographic projections, figure 4). Demographic changes have been larger in China than in the US, and this asymmetry in itself can potentially explain the observed imbalances in the external sector. In addition, the demographic structure affects the transmission of public policies in the economies by altering the share of different age groups in the economy, whose marginal propensities

[5] China's true fiscal deficit is likely to be larger than what the official figures, which do not cover all debt liabilities, imply. The discrepancy between the official figures by the Chinese authorities and e.g. IMF staff estimates has increased in the 2000s (see e.g. IMF, 2010, IMF, 2016 and IMF, 2023).

Figure 3: General government total expenditures and revenues, deficit, and debt in 2001-2017.

Notes. Data source: IMF World Economic Outlook Database October 2018.

to save and consume differ from each other, and by affecting the households' discount rate.

The importance of demographic structure is illustrated in the works of Kilponen, Kinnunen and Ripatti (2006), Fujiwara and Teranishi (2008), Ferrero (2010), Carvalho, Ferrero and Nechio (2016), and Niemeläinen (2021), which all build on the Gertler (1999) framework. Fujiwara and Teranishi (2008) show that the impact of monetary policy shocks depend on the demographic structure of the economy. Ferrero (2010) and Carvalho et al. (2016) discuss the role of demographic change as a driver of the decline of the real interest rate. The main difference between my model and the others is the embedded policy instruments, which allows to account for demographic differences when analyzing the impacts of these macroeconomic policies.

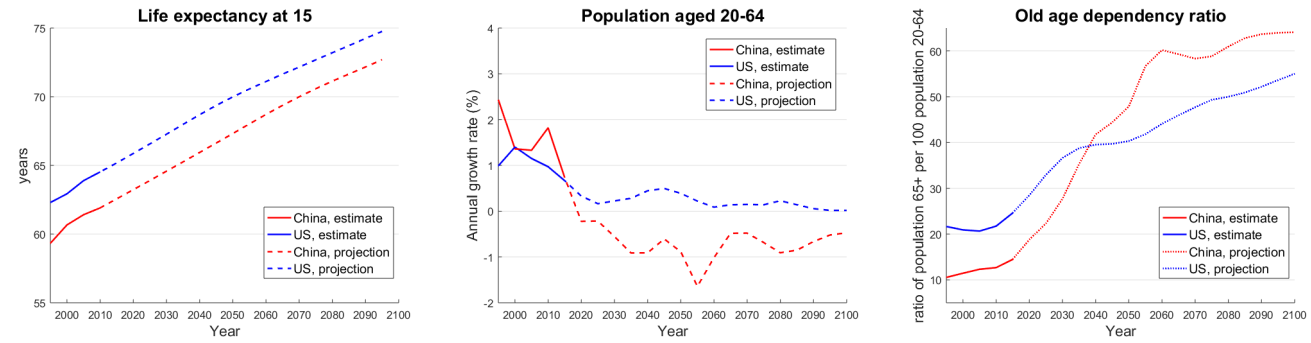

Figure 4: Historical estimates and long term projections of demographic trends in China and the US.

Notes. Source: United Nations World Population Prospects 2017. "Year" on the x-axis corresponds to a five-year period in the data; *e.g.* "1980" corresponds to an estimated value in 1980-1985.

3 A brief overview of China's capital controls and their effect on its external asset holdings and interest rate

Overall restrictions indices (plotted in left graph in figure 5) show that capital controls in China remain stringent even though they have somewhat eased in 2010s. According to Chen and Qian (2016), measures to liberalize the capital account have mainly been targeted equity and bond holdings (see the right graph in figure 5).

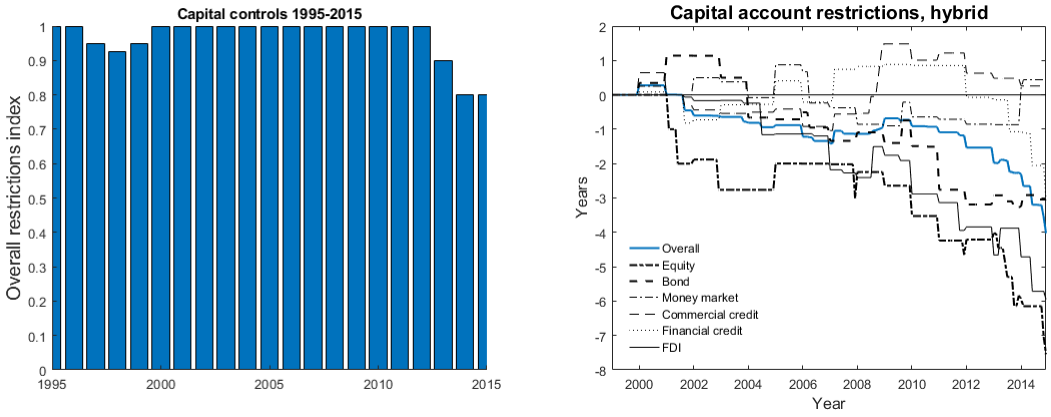

Figure 5: Left panel: Capital controls in China 1995-2015, overall restrictions index. Right panel: China's monthly financial openness index which describes the intensity of capital controls in different asset classes.

Notes. The source of the left graph is Fernández et al. (2016). The index is bound between 0 and 1, where "1" indicates full capital account closedness and "0" full openness, taking into account all asset classes and inward and outward flows. The source of the right graph is from Chen and Qian (2016) (updated in June 2021). January 1999 is set as a benchmark and assigned value 0. A policy tightening adds one unit to the score and loosening removes 1 unit from the score; a higher score therefore represents tighter controls. Chen and Qian (2016) provide both *de jure* and *hybrid* indices. The hybrid indices equal the de jure indices weighted by respective subcategory asset (flow) values relative to total asset (flow) values in China's capital account (SAFE data). The term *hybrid index* is used given that the index is based on de jure controls but it also take into account the size of the respective asset class in the financial account.

Capital controls limit the variety of financial assets that both Chinese and foreign agents can hold and therefore the portfolios of foreign assets. They also distort the return on assets and savings by preventing international arbitrage and, ultimately, the quantity of financial assets held. In what follows, I characterize

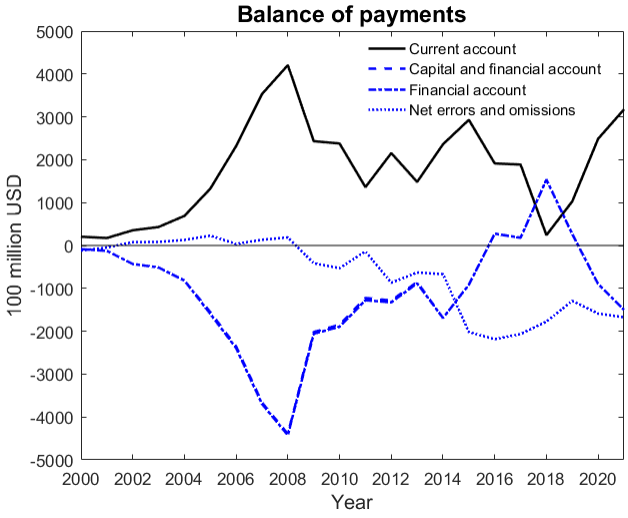

Figure 6: Balance of payments, main accounts.

Notes. Source: State Administration of Foreign Exchange, SAFE BoP.

China's external assets holdings and real return separately, and lay an overview on literature discussing the impact of capital controls on them.

To analyze the effects of capital controls on the variety of financial assets held, I first look at the composition of the portfolios of foreign assets. China's current account surplus (figure 6) indicates a systematic increase in net foreign asset (NFA) holdings through the 2000s. Even though, for most of the time, the financial account was consistently in deficit, the error term in the balance of payments has grown since the financial crises, making it more difficult to estimate the flows of foreign assets and leaving a substantial share of the current account surplus unexplained .[6]

A breakdown of China's financial account (flow data) and the net international investment position (NIIP, stock data) (right and left panel in figure 7, respectively) illustrate the substantial – but changing – role of reserve assets and the significant growth in gross financial flows overall. The accumulation of reserve assets (green dotted line, left panel) exceeded the accumulation of other assets (green dashed line) until

[6] Recent literature finds that about half of China's debt to developing countries is not picked up by "gold standard" databases (Horn, Reinhart and Trebesch, 2021) and that national accounts data leads to mismeasurement in China's NFA because of the significant role played by offshore issuance and tax havens for international capital flows (Coppola, Maggiori, Neiman and Schreger, 2021).

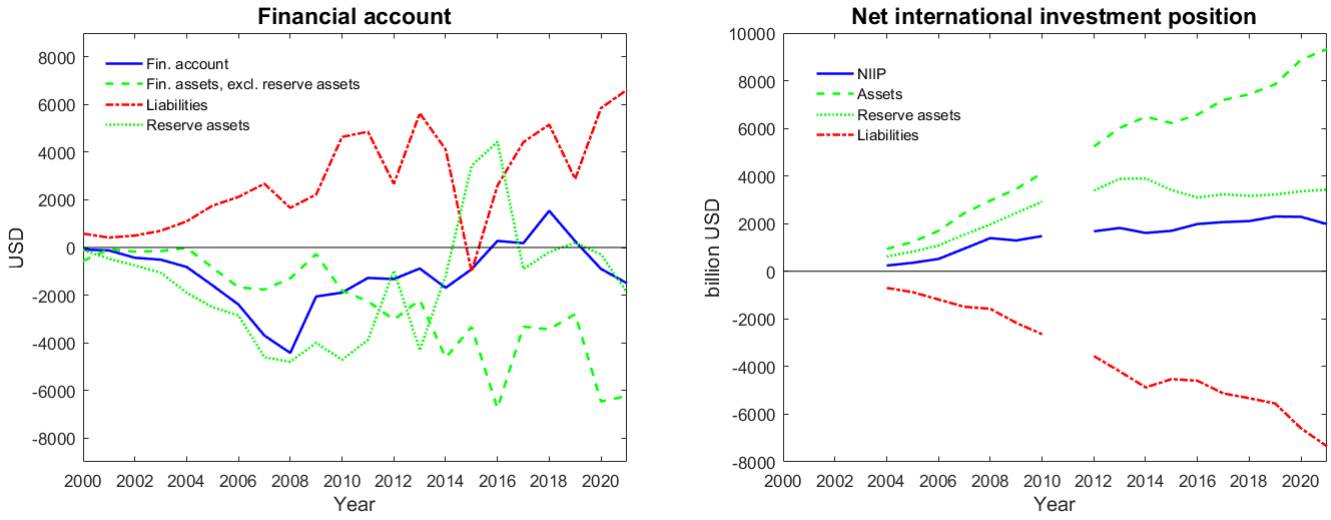

Figure 7: Left panel: Financial account flows. Right panel: NIIP (stock data).

Notes. Sources: SAFE BoP (left graph), IMF (right graph).

2012, while this trend has reverted since 2014. This shift in the composition of gross outflows, also discussed by Agarwal, Gu and Prasad (2020), is visible in the stabilization of the level of reserve assets in China's international investment statistics and in the increase of the stock of foreign assets other than reserves (right panel, figure 7). The stock of foreign liabilities has also grown. In the early 2000s, liabilities (red line) exceeded assets excluding reserve assets, resulting in a net inflow of assets. Towards the end of the 2010s, the growth in financial assets caught up with the volumes of liabilities, again, highlighting the increasing role of Chinese gross outflows other than reserve assets .[7]

The upper left panel of figure 8 shows a further breakdown of the NIIP into three functional categories: direct, portfolio, and other investments. Direct investments stand out as the main category both in assets and liabilities while, on the asset side, the importance of other assets is also large. The direction of both net FDI and net portfolio investments (plotted in figure 8, upper left panel) was towards China for most of the 2000s, and net outflows in other investments, which have consisted mainly of *currency and deposits*, *trade credit and advances*, and *loans*.[8]

[7] With a break in the trend in 2015 and 2016 during the Chinese stock market turbulence, in which the decline of gross inflows was countered by an inflow of reserve assets.

[8] In the SAFE financial account data, a positive (negative) value for assets (liabilities) represents a net decrease (increase)

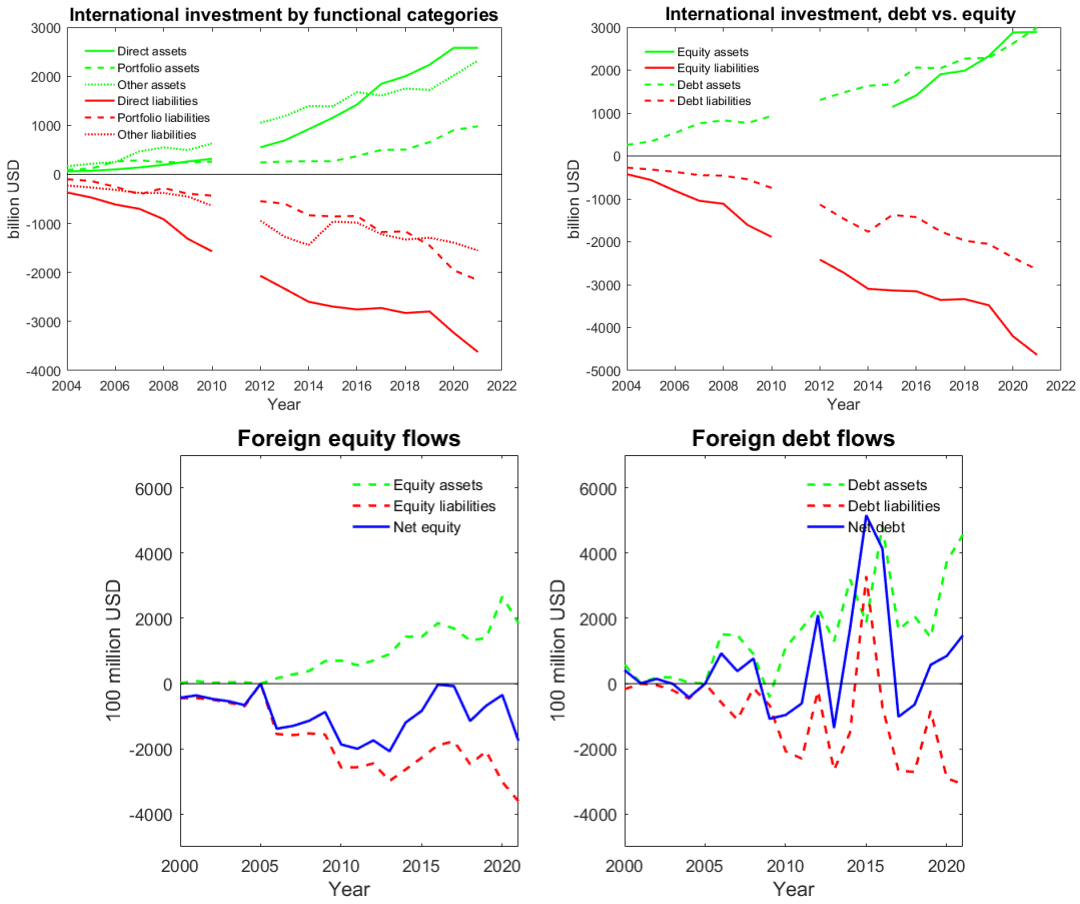

Figure 8: Left: NIIP by type of investment, gross. Centre: NIIP, equity vs. debt. Right: China's financial accounts: equity vs. debt.

Notes. Source: IMF BOP.

A different breakdown of China's financial accounts into debt and equity (including both portfolio and direct assets, see upper right panel in figure 8), shows that the gross holdings of foreign assets and liabilities are dominated by equity, mainly on the liability side but also amongst assets by the end of the sample. Direct debt assets and portfolio debt liabilities have also recently grown. Net equity flows have been negative in the 2000's, whereas net debt has been more volatile in the 2000s and 2010s, especially around 2015, but debt assets have been consistently positive and on a growing trend (lower panels in figure 8).

while a negative (positive) value represents a net increase (decrease). In the IMF data, a negative value for assets represents a net decrease.

In international comparison (see figure 19 and 20 in Appendix section E), reserves are still larger than in peer countries (Germany, Japan, Korea, and US). China's international gross assets have grown more than in these countries, in which gross assets have grown strongly in the 2000s. China's gross external assets holdings are mainly direct even though the share of portfolio investments has grown, whereas in peer group countries, portfolio holdings dominate. Its gross external assets and liabilities are predominantly in equities mainly due to large direct equity liabilities.

The opening of China's capital account has been anticipated and its effects on capital flows and return on foreign investment have been analyzed in the literature. In an empirical study, Bayoumi and Ohnsorge (2013) assess the potential impact of China's capital account liberalization and find that it would lead to a substantial increase in gross flows and net outflows from equity and bond markets, with significant effects not only in China but also on global financial markets. The finding of an increase in gross flows is also supported by Pasricha, Falagiarda, Bijsterbosch and Aizenman (2018). The analysis by He, Cheung, Zhang and Wu (2012) suggests that a liberalization would increase the importance of private sectors foreign assets and China would be able to earn higher net investment income from abroad.

Empirical evidence on the sensitivity of capital flows and financing cost/returns to recent capital account liberalization measures provide some guidance on the distortional impact of these control measures. Kitano and Zhou (2022) show that the effectiveness of the capital controls varies across asset categories, finding that controls on equity and financial credits have a significant effect on net inflows whereas controls on bond, commercial credit, and direct investment do not. Ma, Rogers and Zhou (2021) analyze the effects of the 2014 stock market liberalization (the Stock Connect) on Chinese firms and find that the measure brought about capital outflows, and lowered the funding costs and raised the stock prices of internationally connected firms relative to nonconnected ones (even though all stock prices fell).

The effects of capital controls on the assets' real return, which affect households' savings decisions and, ultimately, the current account, are the main focus of this paper. From Figures 1 and 5, one can see that the large positive differences in the real return between US and China observed at the beginning of 2000s gradually narrowed down towards the end of the sample period as capital controls become less stringent.

The theoretical model used in this paper does not consider the variety of assets holdings and their real return. However, by using the China's real return as a policy instrument, the model can be used as a laboratory to study the quantitative effects of China's macroeconomic policies on the world real interest rate and on the dynamics of China's trade balance vis-a-vis the US.

4 The model

The model economy consists of two countries populated by finitely lived agents with the Gertler (1999) life-cycle structure. In country 1 (China), a consolidated government-central bank imposes capital controls both on outflows, so that domestic private agents can invest in domestic firms or government bonds but not on foreign government bonds or firms, and on inflows, so that foreign investors cannot hold private domestic assets. The government-central bank issues domestically held debt to match the domestic asset demand given the interest rate, which is exogenously set by the government-central bank. It also collects taxes, consumes, and intervenes in the foreign exchange markets by acquiring the net income by exporters and using the proceeds to acquire foreign reserves according to its fiscal policy rule. The foreign reserves are composed solely of government bond of country 2 (US).

$$V_t^z = \left\{ \left[(C_t^z)^v (1 - l_t^z)^{1-v} \right]^\rho + \beta_{t,t+1}^z \left[E_t \left(V_{t+1} \mid z \right)^\mu \right]^{\frac{\rho}{\mu}} \right\}^{\frac{1}{\rho}}, \; z = \{w, r\} \tag{1}$$

subject to

$$C_t + \left(B_t + e_t B_{pt}^* \right) \left[1 + \frac{\Omega_b}{2} \left(\frac{B_t}{B_t + e_t B_{pt}^*} - \bar{\psi} \right)^2 \right] \leq w_t L_t + \left(R_{t-1} B_{t-1} + e_t R_{t-1}^* B_{p,t-1}^* \right) + \frac{D_t}{P_t}$$

In both economies, a representative firm produces an internationally traded good with a Cobb-Douglas production technology with labour-augmenting productivity.

4.1 Households

All households are assumed to be born as workers at the age of 20 years and face the probability $1-\omega_{t,t+1}$ to retire between periods t and $t+1$. In retirement, households die with probability $1-\gamma_{t,t+1}$. The growth rate of the number of workers is $n^{w}_{t,t+1}$ and the old age dependency ratio (ψ_t) evolves according to

$$\psi_{t+1}\left(1+n^{w}_{t,t+1}\right) = (1-\omega_{t,t+1}) + \gamma_{t,t+1}\psi_t \ , \tag{2}$$

where $\psi_t = \frac{N^r_t}{N^w_t}$ and N^r_t is the number of retirees ad N^w_t the number of workers. N_t is the size of the total population.

Retirees A retiree born in period j and retired in period i chooses consumption-saving allocation to maximize her/his expected continuation value given by

$$V^{jr}_t(i) = \underset{C^{jr,1}_t(i),C^{jr,2}_t(i),A^{jr,1}_{t+1}(i)}{max} \left\{ \left[C^{jr}_t(i)\right]^{\rho} + \beta\gamma_{t,t+1}\left[V^{jr}_{t+1}(i)\right]^{\rho} \right\}^{\frac{1}{\rho}} \ . \tag{3}$$

Households consume both domestic goods, $C^{jr,1}_t(i)$, and foreign goods, $C^{jr,2}_t(i)$, and the consumption index of a retiree is given by

$$C^{jr}_t(i) = \left\{ \left[C^{jr,1}_t(i)\right]^{\frac{\varepsilon-1}{\varepsilon}} + \left[C^{jr,2}_t(i)\right]^{\frac{\varepsilon-1}{\varepsilon}} \right\}^{\frac{\varepsilon}{\varepsilon-1}} \ , \tag{4}$$

where ε is the elasticity of substitution between domestic and foreign goods (Armington elasticity). The budget constraint of the retiree is

$$A_{t+1}^{jr}(i) = \frac{R_t^d A_t^{jr}(i)}{\gamma_{t-1,t}} - C_t^{jr,1}(i) - e_t C_t^{jr,2}(i) \ , \tag{5}$$

where R_t^d is the domestic interest rate set by the local authority, e_t is the price of the foreign good in terms of a domestic good (the real exchange rate), $e_t C_t^{jr,2}(i)$ consumption expenditures of the foreign good in local consumption units, and $A_t^{jr}(i)$ the value of financial wealth.

The first order condition with respect to asset accumulation is

$$\left\{ \left[C_t^{jr,1}(i) \right]^{\frac{\varepsilon-1}{\varepsilon}} + \left[C_t^{jr,2}(i) \right]^{\frac{\varepsilon-1}{\varepsilon}} \right\}^{\frac{\varepsilon\rho}{\varepsilon-1}-1} \left(C_t^{jr,1}(i) \right)^{\frac{\varepsilon-1}{\varepsilon}-1} = \beta \gamma_{t+1} \left[V_{t+1}^{jr}(i) \right]^{\rho-1} \frac{\partial V_{t+1}^{jr}(i)}{\partial A_{t+1}^{jr}(i)} \ , \tag{6}$$

and the first order condition with respect to foreign consumption is

$$C_t^{jr,1}(i)\, e_t^{-\varepsilon} = C_t^{jr,2}(i) \ . \tag{7}$$

The retiree's Euler equation is

$$C_{t+1}^{jr,1}(i) = C_t^{jr,1}(i) \left(\beta R_{t+1}^d \right)^{\sigma} \left(\frac{1+e_t^{1-\varepsilon}}{1+e_{t+1}^{1-\varepsilon}} \right)^{\frac{\varepsilon-\sigma}{\varepsilon-1}} \ , \tag{8}$$

and their marginal propensity to consume evolves according to

$$\varepsilon_t \pi_t = 1 - \frac{\varepsilon_t \pi_t}{\varepsilon_{t+1} \pi_{t+1}} \gamma_{t,t+1} \beta^{\sigma} (R_{t+1}^d)^{\rho\sigma} \left(\frac{1+e_t^{1-\varepsilon}}{1+e_{t+1}^{1-\varepsilon}} \right)^{\frac{1-\sigma}{\varepsilon-1}} \ . \tag{9}$$

Workers A worker born in period j chooses consumption-saving allocation to maximize her/his expected continuation value given by

$$V_t^{jw} = \max_{C_t^{jw,1}, C_t^{jw,2}, A_{t+1}^{jw}} \left\{ \left(C_t^{jw} \right)^{\rho} + \beta \left[\omega_{t+1} V_{t+1}^{jw} + (1-\omega_{t+1}) V_{t+1}^{jr} \right]^{\rho} \right\}^{\frac{1}{\rho}} , \tag{10}$$

where $C_t^{jw} = \left[\left(C_t^{jw,1} \right)^{\frac{\varepsilon-1}{\varepsilon}} + \left(C_t^{jw,2} \right)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}$, subject to the periodic budget constraint

$$A_{t+1}^{jw} = R_t^d A_t^{jw} + W_t - C_t^{jw,1} - e_t C_t^{jw,2} - T_t^{jw} . \tag{11}$$

The first order condition with respect to asset accumulation is

$$\begin{aligned} &\left[\left(C_t^{jw,1} \right)^{\frac{\varepsilon-1}{\varepsilon}} + \left(C_t^{jw,2} \right)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon\rho-\varepsilon+1}{\varepsilon-1}} \left(C_t^{jw,1} \right)^{-\frac{1}{\varepsilon}} \\ &= \beta \left[\omega_{t+1} V_{t+1}^{jw} + (1-\omega_{t+1}) V_{t+1}^{jr} \right]^{\rho-1} \left[\omega_{t+1} \frac{\partial V_{t+1}^{w}}{\partial A_{t+1}^{w}} + (1-\omega_{t+1}) \frac{\partial V_{t+1}^{rj}}{\partial A_{t+1}^{wj}} \right] , \end{aligned} \tag{12}$$

and the first order condition with respect to consumption of foreign goods is

$$C_t^{jw,1} e_t^{-\varepsilon} = C_t^{jw,2} . \tag{13}$$

The Euler equation for the worker is

$$\omega_{t+1} C_{t+1}^{jw} + (1-\omega_{t+1}) (\varepsilon_{t+1})^{\frac{\sigma}{1-\sigma}} C_{t+1}^{jr} = C_t^{jw,1} \left(\beta R_{t+1}^d \Omega_{t+1} \right)^{\sigma} \left(\frac{1+e_t^{1-\varepsilon}}{1+e_{t+1}^{1-\varepsilon}} \right)^{\frac{\varepsilon-\sigma}{\varepsilon-1}} , \tag{14}$$

and her/his marginal propensity to consume evolves according to

$$\pi_t = 1 - \frac{\pi_t}{\pi_{t+1}} \beta^{\sigma} \left(R_{t+1}^d \Omega_{t+1} \right)^{\sigma-1} \left(\frac{1+e_t^{1-\varepsilon}}{1+e_{t+1}^{1-\varepsilon}} \right)^{\frac{1-\sigma}{\varepsilon-1}} , \tag{15}$$

where $\Omega_t = \omega_{t-1,t} + (1-\omega_{t-1,t}) \varepsilon_t^{\frac{1}{1-\sigma}}$.

The workers' human wealth equals

$$H_t^{wj} = W_t - T_t^{jw} + \frac{\omega_{t+1} H_{t+1}^{jw}}{\Omega_{t+1} R_{t+1}^d} \ . \tag{16}$$

4.2 Aggregation

Because the marginal propensities to consume (equations 9 and 15) do not depend on individual characteristics, aggregate consumption expenditures by the retirees can be solved to be a fraction of aggregate financial wealth held by the retirees

$$C_t^r = \varepsilon_t \pi_t (R_t^d \lambda_t A_t) \ , \tag{17}$$

where $\lambda_t \equiv \frac{A_t^r}{A_t}$ is the share of non-human wealth held by retirees. Similarly, aggregate consumption expenditures of workers is given by

$$C_t^w = \pi_t \left[R_t^d (1 - \lambda_t) A_t + H_t^w \right] \ . \tag{18}$$

Retirees and workers consume domestic and foreign goods in the same proportion, the consumption shares of domestic and foreign goods is determined by

$$C_t^1 e_t^{-\varepsilon} = C_t^2 \ . \tag{19}$$

Given that aggregate consumption expenditures in the domestic currency are $C_t = C_t^1 + e_t C_t^2 = C_t^1 \left(1 + e_t^{1-\varepsilon}\right) = \pi_t A_t R_t^d (\varepsilon_t \lambda_t + 1 - \lambda_t) + \pi_t H_t^w$, aggregate consumption expenditure of domestic good in country 1 is given by

$$C_t^1 = \frac{\pi_t A_t R_t^d (\varepsilon_t \lambda_t + 1 - \lambda_t) + \pi_t H_t^w}{1 + e_t^{1-\varepsilon}} \tag{20}$$

and aggregate consumption expenditure of the foreign good in country 1 by

$$C_t^2 = \frac{e_t^{-\varepsilon} \left[\pi_t A_t R_t^d (\varepsilon_t \lambda_t + 1 - \lambda_t) + \pi_t H_t^w \right]}{1 + e_t^{1-\varepsilon}} \ . \tag{21}$$

Households' aggregate financial wealth is the sum of the domestic capital stock and government bonds, given by

$$A_t = K_t + B_t \ . \tag{22}$$

4.3 Consolidated government-central bank

The consolidated government-central bank issues real one-period bonds, consumes, collects taxes, and trades international assets. Because of capital controls, it is the only agent that can hold foreign assets. The government's flow budget constraint is given by

$$B_{t+1} - e_t B^*_{t+1} = R^d_t B_t - R_{w,t} e_t B^*_t + G_t - T_t \ , \tag{23}$$

where B_t is the outstanding amount of domestic government bonds, and B^*_t the outstanding value of foreign assets, $R_{w,t}$ the interest rate on foreign assets, $R_{d,t}$ the interest rate on domestic government debt, G_t government expenditures, and T_t taxes. The left-hand-side of equation (23) is the net debt of the central-bank government.[9]

In "normal times" the government-central bank follows a balanced budget rule, given by

$$T_t = \left[R^d_t - (1 + x_{t,t+1} + n_{t,t+1})\right] B_t - e_t R_{w,t} - (1 + x_{t,t+1} + n_{t,t+1}) B^*_t + G_t \ , \tag{24}$$

which keeps net government wealth constant. In the quantitative analysis I allow the government-central bank to follow a fiscal policy so that the tax-to-output ratio, $\tau_t \equiv \frac{T_t}{Y_t}$, matches an exogenously given value calibrated to match the data. Government spending is an exogenously determined fraction of the output $\bar{g_t} = \frac{G_t}{Y_t}$, also calibrated to match the data.

[9] I follow the convention by Bacchetta et al. (2013) and Chang et al. (2015), where a positive value of B^*_t indicates a net creditor position.

4.4 The external sector

The net foreign asset position in country 1 evolves according to

$$e_t B^*_{t+1} = e_t R_{t+1} B^*_t + NX_t \ , \tag{25}$$

where NX_t is the trade balance, defined as

$$NX_t \equiv Y_t - (C_t + I_t + G_t) \ , \tag{26}$$

where C_t are aggregate domestic consumption expenditures. The interest rate on internationally traded assets, $R_{W,t}$, is pinned down by the financial market clearing condition

$$B^{1,*} + B^{2,*}_t = 0 \ , \tag{27}$$

which states that the assets are in zero net supply. In country 2, by arbitrage, the international interest rate equals the domestic interest rate. However, the central bank-government in country 1 is assumed to be able to directly control the domestic interest rate so that it can differ temporarily from the international interest rate ($R^d_t \neq R_{w,t}$). This is possible because the capital controls imposed by country 1 prevent free capital mobility.

The internationally traded foreign assets are denoted in country 2 consumption units. Equations for country 2 are analogous, but they are denoted in local consumption units. The rate of exchange in country 2 is the inverse of country 1's rate of exchange, $e^*_t = \frac{1}{e_t}$.

Definition 1 (a competitive world equilibrium)

A competitive world equilibrium without policy interventions is a sequence of quantities and prices such that in each country (i) households maximize utility subject to their budget constraint, (ii) firms maximize profits subject to their technology constraints, (iii) the government chooses a path for taxes and debt, compatible with intertemporal solvency, to finance exogenous level of total

spending, and (iv) all markets clear.

4.5 Transmission channels of transitory macroeconomic policies

In the quantitative analysis, I allow country 1 to practice transitory macroeconomic policies which cause the economy to deviate temporarily from the equilibrium conditions laid out in the previous section. In this section I describe the equilibrium conditions under activist macroeconomic policies and describe the policy transmission channels by using the following decomposition of central bank - government's periodic budget constraint (equation 28):

$$\begin{aligned} e_t B^*_{t+1} &= B_{t+1} + e_t R_{w,t} B^*_t - R^d_t B_t + T_t - G_t \\ &= \underbrace{A_{t+1} - K_{t+1}}_{private\,saving\,gap} + \underbrace{e_t R_{w,t} B^*_t - R^d_t B_t + T_t - G_t}_{net\,government\,savings} . \end{aligned} \tag{28}$$

The second equality follows from the fact that the government-central bank issues domestic debt to meet the domestic asset demand at the given domestic interest rate R^d_t, and therefore domestic government debt equals the domestic private saving gap ($B_{t+1} = A_{t+1} - K_{t+1}$). The value of foreign assets thus equals the sum of the private saving gap and net government savings.

4.5.1 Exchange rate policy

The exchange rate, e_t, is exogenous, and the government of country 1 is assumed to be able to control it directly. An exchange rate policy shock (a terms-of-trade shock) is defined as a temporary under-/overvaluation of country 1's currency, and simultaneous over-/undervaluation of country 2's exchange rate e^*_t. I define the equilibrium under exchange rate policy as follows:

Definition 2 (a competitive world equilibrium under active exchange rate policy)

A competitive world equilibrium under active exchange rate policy is a sequence of quantities and prices such that given the exogenous level of exchange rate e_t for $t \in [n,m]$, $n,m \in \mathbb{N}$, in each country

(i) households maximize utility subject to their budget constraint, (ii) firms maximize profits subject to their technology constraints, (iii) the government chooses a path for taxes and debt, compatible with intertemporal solvency, to finance exogenous level of total spending, and (iv) all markets clear.

The impact of a terms-of-trade shock on private savings, A_{t+1}, is ambiguous. On one hand, the depreciation of the foreign exchange rate of country 1 lowers households' income, which impacts negatively consumption and savings (*i.e.* the Harberger-Laursen-Metzler (HLM) effect).[10] However, the negative terms-of-trade shock also induces a positive substitution effect on current savings, because it increases the relative price of current consumption in comparison to future consumption. With low elasticity of intertemporal substitution σ, the HLM effect dominates, and the impact of real exchange rate appreciation on savings is negative.

In addition to intertemporal substitution, households respond to the terms-of-trade shock by intratemporal substitution. The depreciation of the domestic exchange rate makes foreign goods more expensive in comparison to domestic goods, increasing the optimal consumption share of domestic goods and decreasing the share of foreign goods in the consumption basket, which can be seen from the optimality condition of period t ratio of foreign to domestic goods:

$$e_t^{-\varepsilon} = \frac{C_t^{jz,2}(i)}{C_t^{jz,1}(i)} \ ,$$

where $z = \{w, r\}$. With high elasticity of substitution between home and foreign goods ε, an adverse exchange rate shock shifts the consumption in the current period from the expensive foreign good to the relatively cheaper domestic good.

The relative size of σ and ε determines whether the substitution towards domestic goods or the substitution of consumption into future periods has a larger impact on the consumption of the domestics goods. The retirees' and workers' consumption expenditures of the domestic good are decreasing in e_t as long

[10] The Harberger-Laursen-Metzler effect, after Harberger (1950) and Laursen and Metzler (1950), is also known as the consumption-smoothing effect, as discussed by Cashin and McDermott (2003). For discussion on empirical evidence on the HLM effect, see Uribe and Schmitt-Grohé (2017).

as $\sigma > \varepsilon$, as then the substitution towards future periods is larger than the increase in the consumption of domestic goods.

To develop intuition for the dynamics of the real interest rate, the workers' savings can be shown, in the limiting two-period version of the model, to be a concave function of the real exchange rate (see Appendix section A). Therefore, a symmetric terms-of-trade shock has a larger impact on the savings-behaviour of the country with an overvalued real exchange rate. If $\sigma > 1$, as in the simulations in Section 5, substitution effect dominates, and the currency undervaluation leads to an increase (decline) in domestic (foreign) savings. Because the decline in savings abroad exceeds the increase in domestic savings, the impact on world aggregate financial wealth is negative, and the therefore the policy leads to an increase in the world real interest rate.

The terms-of-trade shock also has a direct impact on the external wealth held by the central bank-government. If country 1 is a net creditor, the undervaluation worsens its foreign asset position in terms of domestic consumption units. If the country follows the balanced budget rule (equation 24), fiscal policy needs to be adjusted to take the valuation effect into account. A worsening of the net external wealth calls for an increase in taxes, to keep the value of domestic consumption units constant.

4.5.2 Interest rate policy

The domestic interest rate is exogenous and the central bank-government in country 1 is assumed to directly control it. When the domestic central bank-government is not practising active interest rate policy, the domestic interest rate equals the international interest rate determined by the asset market clearing condition ($R_t^d = R_t$). Interest rate policy is defined as a transitory deviation of the domestic interest rate from the international interest rate ($R_t^d \neq R_t$). I define the competitive world equilibrium under interest rate policy as follows:

Definition 3 (a competitive world equilibrium under active interest rate policy)

A competitive world equilibrium under active interest rate policy is a sequence of quantities and prices such that given the exogenous level of the country 1 interest rate R_t^d for $t \in [n,m]$, $n,m \in \mathbb{N}$, in each country (i) households maximize utility subject to their budget constraint, (ii) firms maximize profits subject to their technology constraints, (iii) the government chooses a path for taxes and debt, compatible with intertemporal solvency, to finance exogenous level of total spending, and (iv) all markets clear.

The impact of the interest rate policy on private savings is ambiguous. On the one hand, an increase in the domestic interest rate ($R_t^d > R_t$) has a positive impact on households' savings, A_{t+1}, because the price of the present day consumption in terms of future consumption increases (substitution effect), and because the present value of lifetime wealth falls.[11] On the other hand, the policy has a positive income effect which increases households' consumption and lowers savings. With high elasticity of intertemporal substitution, the substitution effect dominates and savings are increasing in interest rate. The impact of the increase in the interest rate on investments and the capital stock is negative. The policy increases the marginal cost of capital and therefore drags down investment and output. With high elasticity of intertemporal substitution, the policy's impact on the private saving gap is unambiguosly positive, as it has a positive impact on households' savings and a negative impact on investment.

To illustrate the impact of the interest rate policy on net government saving (equation 28) can be further decomposed as follows:

$$\begin{aligned} e_t B_{t+1}^* &= A_{t+1} - K_{t+1} - R_t^d B_t + e_t R_{w,t} B_t^* + R_{w,t} B_t - R_{w,t} B_t + T_t - G_t \\ &= \underbrace{A_{t+1} - K_{t+1}}_{private\,saving\,gap} + \underbrace{R_{w,t}\,(e_t B_t^* - B_t)}_{interest\,income} - \underbrace{(R_t^d - R_{w,t})B_t}_{policy\,cost/benefit} + T_t - G_t \ . \end{aligned} \tag{29}$$

Because the interest payments on domestic bonds differs from the interest income on foreign assets, the

[11] In the workers' case, the negative wealth effect is reinforced by the presence of the additional discount factor Ω_t which captures the expected finiteness of life, and the survival probability at work, $\omega_{t,t+1}$, which captures the fact that the worker has a positive probability to lose their future work stream. This can be seen in the workers decision rule for consumption and the marginal propensity to consume (see equation 18). In retirees' case, the expected finiteness of life is mitigated by the perfect annuity market and no such reinforcement mechanism exists.

interest rate policy induces a cost or benefit to the government, depending on the sign of the interest rate spread and whether the government is a net debtor or lender. Net government savings consist of interest income/expenses on net government assets less the cost of running the interest rate policy, and tax income net of government consumption expenditures. An increase in the domestic interest rate lowers net government savings as it induces a positive policy cost, but as the government follows the balanced budget rule which keeps net government wealth constant, taxes depend positively on the domestic interest rate (see equation 24). The net effect on government savings is therefore ambiguous.

The policy increases demand for the foreign (internationally traded) bond, if the net effect on the external asset position is positive. The increasing asset demand lowers the interest rate in the international asset market, and therefore the domestic interest rate in country 2, increasing its capital stock and output.

4.5.3 Government expenditures and fiscal deficit

In "normal times", the government is assumed to follow the balanced budget rule (equation 24). In analyzing the quantitative impacts of fiscal policy, the government is allowed to deviate temporarily from the balanced budget rule and directly choose an exogenous tax rate τ_t. I also allow for transitory government expenditure shocks. I focus on the case where the tax policy $\tau_t < T_t$, since both China and the US have run budget deficits for the most years in the period of interest (2000s). I define the competitive world equilibrium under active fiscal policy as follows:

> **Definition 4 (a competitive world equilibrium under active fiscal policy)**
>
> A competitive world equilibrium under active fiscal policy is a sequence of quantities and prices such that given an exogenous level of tax-to-GDP ratio τ_t for $t \in [n,m]$, $n,m \in \mathbb{N}$, in each country (i) households maximize utility subject to their budget constraint, (ii) firms maximize profits subject to their technology constraints, (iii) the government chooses a path for taxes and debt for $t \notin [n,m]$, compatible with intertemporal solvency, to finance exogenous level of total spending, and (iv) all markets clear.

An increase in government expenditures, when financed with a balanced budget, has a negative impact on households' consumption because of a rise in tax liabilities. However, because of the expected finitude

of working time and life, households have a higher discount rate than the government, and therefore they do not fully capitalize the future tax stream associated with higher government expenditures. The decline in private consumption does not thus offset the rise in public consumption, and the net effect on national savings is negative.

Running a fiscal deficit has a direct negative impact on external asset holdings (see equation 29) through a decline in government savings, and an indirect effect through private savings. Lower taxes raise working age households' disposable income with a positive effect on current consumption. However, agents anticipate higher taxes in the future, which has a positive effect on private savings. Because they don't fully capitalize the future tax liabilities, which are postponed further into the future because of the budget deficits, the increase in private savings does not compensate for the public dissaving, and the net effect on the national savings is negative.

Households' discount rate varies with life expectancy and population growth rate so that the extent to which the government debt increases the households' wealth depends on the demographic structure of the economy. An economy with lower life expectancy and higher population growth rate has a higher discount factor, and so the impact of government expenditures and debt on private consumption is stronger.

5 Quantitative analysis

In this section I evaluate the dynamic effects of the demographic transition and macroeconomic policies (exchange rate policy, interest rate policy, and fiscal policy) between 2000 and 2015 on the external sector and the real interest rate. The quantification of the exchange rate policy is based on the estimates on the percentage deviation of the renmimbi real exchange rate from its equilibrium level by Goldstein and Lardy (2009) and by the IMF External Sector Reports (shown in figure 2). The quantification of the interest rate policy is based on the observed real interest rates in the World Bank data (figure 1), and the quantification of the government deficits on the observations on government expenditures and fiscal deficits as in the IMF World Economic Outlook database (figure 3). In Subsection 5.1 I present

the calibration of the model and the assumed paths of the exogenous variables. In Subsection 5.2, I analyze the effects of demographic change on the world real interest rate and on the trade balance, and the resulting dynamics are used as a benchmark to analyze the impacts of the macroeconomic policies in Subsection 5.3.

5.1 Calibration and exogenous variables

Table 1 reports the values of the calibrated parameters in the simulation. The calibration follows the literature so that the labour share of income α, the discount factor β, and the capital depreciation rate δ, equal the values in Gertler (1999).[12] The parameter for the intertemporal elasticity of substitution σ is set at 1.5, which is a compromise between the two strands of literature, namely models with the Gertler (1999) framework (*e.g.* Kilponen et al., 2006, Fujiwara and Teranishi, 2008, and Ferrero, 2010) in which the elasticity of intertemporal substitution takes values below unity, and the model by Song et al. (2014), a general equilibrium model with similar policy features as the ones in this paper, in which $\sigma = 2$.

Parameter		**Value**	**Source**
α	labour share of income	2/3	Gertler (1999)
β	discount factor	0.96	Gertler (1999)
δ	depreciation rate	0.1	Gertler (1999)
σ	elasticity of intertemporal substitution	1.5	Gertler (1999) - Song et al. (2014)
ε	elasticity of substitution between home and foreign goods	2	Song et al. (2014)

Table 1: Calibration

Because the results are sensitive to the value of σ, I report the main results for $\sigma = 0.5$ in section C of

[12] Because the analysis focuses on the effects of macroeconomic policies of the government, and demographic factors which affect the households, the calibration of the supply side parameters, α and δ, follows the convention in the literature, including Ferrero (2010). As regards the labor share, some studies on China (e.g. Song, Storesletten and Zilibotti, 2011) set the labor share for China at 0.5 following Bai, Hsieh and Qian (2006). However, I abstract from any differences in the values of these parameters across the countries and the analysis of cross-country or time variation of these parameters is left for future research. As regards the capital depreciation rate, the chosen is value standard across the related literature including Ferrero (2010), Song et al. (2011) and İmrohoroğlu and Zhao (2018). Furthermore, the discount factor β is calibrated as in Gertler (1999) as I am mainly interested in the workers' effective discounted factor, which is augmented by the adjustment term Ω_t and varies over time due to the country-specific demographic factors.

the Appendix. The elasticity of substitution between domestic and foreign goods ε is set at 2 as in Song et al. (2014).

The values of the exogenous variables are reported in table 2. The frequency of the data is annual. The simulation entails a permanent demographic change which takes place over 39 periods as follows. In the initial period, life expectancies in both countries match the values in the data in 2001[13], and in the final period the values in 2040. In the initial state, population growth rates equal the average growth rate (of population between ages 20-64) between the two countries in 2001, and in the final state an approximation of the value in 2040.[14] The probability of staying in the labour force is constant and calibrated to match an average retirement age of 65 years as in Auerbach and Kotlikoff (1987) and Gertler (1999). Technological growth rate is assumed to be constant and equal between the countries and matches the average in the data between 2001-2014. Government consumption is assumed to be a constant multiple of the GDP and is calibrated to match the average in the data between 2001-2017 in each country. The government-central bank in both countries is assumed to have negative net wealth (positive debt).The net government debt-to-GDP ratio of country 2 (US) is 31.5 %, which matches the observed net debt in 2001. China's net debt is assumed to be 50 % smaller in efficiency units, corresponding to 17. 5% of GDP in the initial state.[15] In the simulation with fiscal policy, the increase in government net debt is taken into account endogenously. In other simulations, the government is assumed to follow a balanced budget rule.

The deterministic simulations are performed with the extended path algorithm, which allows to introduce unanticipated changes to exogenous policy variables.

[13] In the latest (2022) revision of the UN Population Prospects, the projected life expectancy is higher for both countries but especially for China in the long run in comparison to the 2017 projection, and the old age dependency ratio is projected to rise considerably more than projected in 2017. In the model, this could potentially raise China's saving rate and increase China's trade surplus (see figure 9). However, as the simulations capture the effect of demographic change until 2040, and the largest revisions in UN data concern the very long-run (post-2040 data), the effect on the results are likely to be limited. For instance, life expectancy in 2040 increased from 65.9 to 67.5 in China (and fell from 68.9 to 67.7 in the US) when comparing the 2017 and 2022 projections, and old age dependency ratio increased from 41.8 to 44.3 in China and remained unchanged in the US. In comparison, e.g. China's projected life expectancy in 2100 rose from 72.3 to 75.4 and old age dependency ratio from 64.1 to 90.0 in China and from 55.0 to 60.1 in the US.

[14] As the average growth rate in 2040 is negative, I assume no population growth in the final steady state.

[15] Data on China's general government net debt is to my knowledge not available.

Exogenous variable		Initial state (2001)	Final state (2040)	Data source / reference
γ^1	probability to survive (China)	0.9062	0.9374	UN Population Prospects 2017
γ^2	probability to survive (US)	0.9227	0.9465	UN Population Prospects 2017
$\omega^1 = \omega^2$	probability to stay in labour force	0.9778	0.9778	Auerbach and Kotlikoff (1987), Gertler (1999)
$n^1 = n^2$	population growth rate (China, US)	1.35 %	0.00 %	UN Population Prospects 2017
$x^1 = x^2$	technology growth rate (China, US)	1.00 %	1.00 %	Penn World Table 9.0
g^1	government spending to output (China)	16.2 %	16.2 % / 30.2 %*	IMF World Economic Outlook 2018
g^2	government spending to output (US)	30.2 %	30.2 %	IMF World Economic Outlook 2018
$\frac{B^1_{t+1} - e_t B^{1,*}_{t+1}}{Y^1_t}$	government net debt to output (China)	17.5 %	(endogenous)	Estimate based on gross debt data from IMF World Economic Outlook 2018
$\frac{B^2_{t+1} - e^*_t B^{2,*}_{t+1}}{Y^2_t}$	government net debt to output (US)	35.1 %	(endogenous)	World Bank, WEO

Table 2: Exogenous variables

Notes. *Final value in the simulation with fiscal policy.

5.2 Demographic change

Over the first decades of the 21^{st} century, increase in longevity and decline in population growth rates have led to societal ageing, *i.e.* an increase in the old-age dependency ratio, both in China and the US (see figure 4). Because longevity has increased more in China and its population growth rate has declined substantially more quickly, societal ageing has been faster in China. The old age dependency ratio rose by 37 % in China (from 10.5 to 14.5), and by 14 % in the US (from 21.7 to 24.7, based on the 2017 UN Population Prospects), between 2000 and 2015. Societal ageing is projected to continue throughout the century and significantly modify the demographic structure of the Chinese population in particular, due to a projected decline in the size of the working age population.

Figure 9 shows the dynamic effects of demographic changes, which follow closely the trends in the data, on the trade balance and the real interest rate. The increase of life expectancy raises saving in

both economies and results in a fall in the real interest rate, because increasing longevity calls for higher savings to sustain the optimal income level in the lengthening retirement period. Because life expectancy increases more in China, the effect on savings of Chinese households is more pronounced, and therefore population ageing has a positive long-term effect on its trade balance.

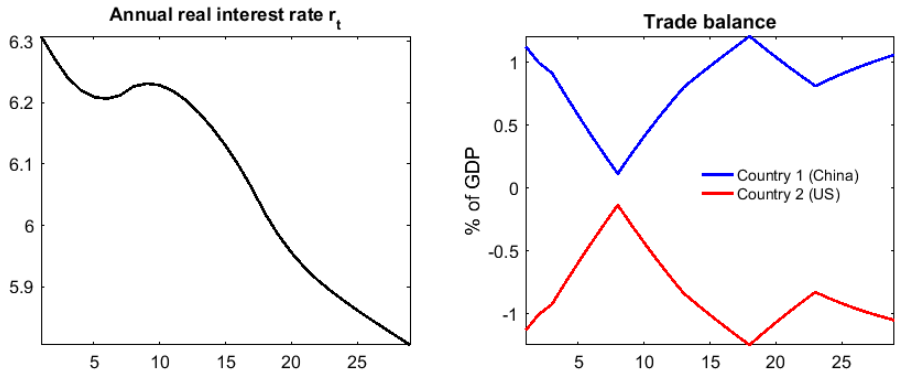

Figure 9: Impact of demographic change on the net real interest rate and the trade balance.

Notes. A permanent increase in longevity and a decline in the population growth rate result in a decline of the world real interest rate. China's trade surplus follows from the relatively large longevity growth in comparison to the US.

Furthermore, the strong fall in the population growth rate has a positive impact on the trade balance in the long run. Temporary population growth surges, including the sharp increase in working age population growth rate in China in early 2000s, result in temporary deteriorations of the Chinese trade balance, and a temporary halt in the fall of the real interest rate.

Here, the government-central bank is assumed to be passive: the domestic interest rate is equal to the international interest rate ($R_t^d = R_{w,t}$), the law of one price holds ($e_t = 1$), and the government-central bank follows the balanced budget rule (equation 24) which keeps its net wealth constant, *i.e.* acts as an intermediator between the domestic private sector and the international financial market.

5.3 Policy interventions

Despite the changes of the Chinese economy in the past decades, the government still plays a central role in economic activity as a feature of a socialist market economy. In this section I analyze to what extent the Chinese central government has affected the observed trade imbalances and the dynamics of the intertemporal terms of trade, *i.e.* the real interest rate, via three macroeconomic policies: capital controls and interest rate policy, exchange rate policy, and fiscal policy.

To analyze the impacts of the macroeconomic policies, I construct series of policy variables for the real exchange rate e_t, the real interest rate R_t^d, tax τ_t, and government expenditures g_t. The quantification of the policies is based on the following facts.

First, capital controls prevent private international capital flows to a large extent, and therefore the Chinese government has been able to control the domestic real interest rate which has, despite its convergence, stayed below the US real rate in the 2000s. Accordingly, in the quantitative analysis, the domestic interest rate R_t^d is assumed to be 50 basis points below the world interest rate in 2002, and the spread is assumed to diminish gradually so that the interest rates are equalized after 2015 ($R_t^d = 0.995 \times R_{w,t}$ for $t = 1$ and follows an AR(1) process). The initial spread of 50 basis points is based on the average interest rate spread between China and the US between 2002-2015, and the decline of the spread is based on the assumption that the capital controls are gradually removed, which leads to the equalization of the interest rates across the countries (see figure 1).

Second, for an extended period of time (between 2001 and 2014), the Chinese real exchange rate was estimated to be undervalued. In the simulation, the central bank-government manipulates the price of the foreign goods in terms of domestic goods so that the real exchange rate is undervalued for 14 periods, which corresponds to the period of renmimbi undervaluation during 2001-2014 according to Goldstein and Lardy (2009) and the IMF. The renmimbi undervaluation begins in 2002, reaches its peak in 2006-2007, and the equilibrium level is restored in 2015. Both the estimates and the policy variable, which is constructed based on the estimates, are shown in the right graph in figure 2.

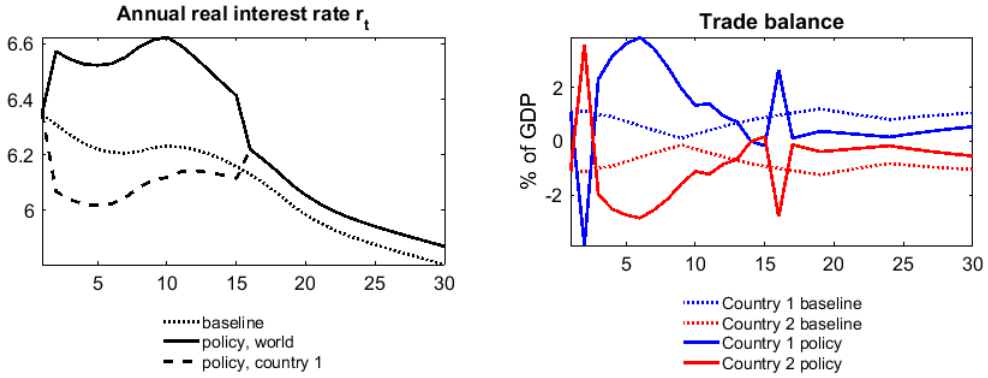

Figure 10: Impact of macroeconomic policies and demographics on the real interest rate and trade balance.

Notes. The "baseline" variables refer to the interest rate and trade balances simulated in section 5.2 with demographic change under passive policy (where $R_t^d = R_{w,t}$). The "policy" variables refer to the simulated interest rates and trade balances with demographic change and government policy interventions (where $R_t^d \neq R_{w,t}$).

Third, the quantitative analysis of fiscal policy is based on the observed changes in government expenditures between 2001 and 2015, and the fiscal deficits in the 2000s. China has experienced a large growth in both total government expenditures and revenues between 2001 and 2015 (left panel in figure 3). However, for the majority of the period, the general government has run a budget deficit. After the early 2000s, the government deficit was reduced, but has grown sharply again since 2012 with the government trying to boost economic growth with expansionary fiscal policy. In the US, the general government expenditures and revenues have remained stable at approximately 30 % of GDP in the 2000s. The general government has run a budget deficit since 2002, and due to a sharp rise in government expenditures and a decline in revenues during and after the financial crises, the deficit reached approximately 12 % of GDP and led to a substantial increase in the governments net debt. In the simulation, I use total government revenues as a share of GDP to estimate the total tax revenue of the government, and total government expenditures (which include net interest payments) to obtain an estimate of total government expenditures. To capture the effects of the budget deficits, I run a counterfactual simulation in which the government expenditures follow the dynamics in the data and the government is assumed to run a balanced budget, and compare the dynamics to the case in which the government's tax revenues follow the government revenues in the

data, which results in budget deficits in both countries, and an increase in the total government net debt.

The results of the simulation with active exchange rate, interest rate and fiscal policies are shown in figure 10, together with the results of the benchmark simulation of section 5.2 (where only demographic changes were playing a role in the transition). Overall, the policies raise the world real interest rate (black solid line) by approximately 0 to 30 basis points relative to the benchmark (black dashed line) in the short run (while the policies are active), and after a brief initial deterioration in the trade balance caused by a surge in investments, improve the trade balance of China. In the long run, they increase the interest rate by approximately 10 basis point relative to the benchmark, and worsen the trade balance of country 1 (after its return to the laissez-faire economy). The results are mainly driven by the undervaluation of the exchange rate. In what follows I analyze the impact of each individual policy in more detail.

5.3.1 Real exchange rate undervaluation

Figure 11 shows the results of exchange rate undervaluation on the model dynamics, plotted together with the benchmark policy in which the real exchange rate is at its equilibrium level.

The undervaluation of the real exchange rate in country 1 has a positive impact on the trade balance of that country in the short run and results in a large increase in the trade balance around 2006-2007 as observed in the data, which is mainly caused by a fall in aggregate consumption expenditures. Because households expect the real exchange rate to appreciate, they substitute consumption into the future and save more, and the private savings gap ($B_t = A_t - K_t$) increases. The government, which acts as an intermediator between the domestic and foreign asset markets, issues domestic debt to meet the asset demand, and invests the proceeds in international asset markets. After the equilibrium level of the real exchange rate is restored, consumption expenditures in country 1 increase, reflecting the higher level of financial wealth held by the households, with a negative impact on the trade balance. Because of the symmetry of the countries, an opposite effect takes place in country 2 as its real exchange rate appreciates.

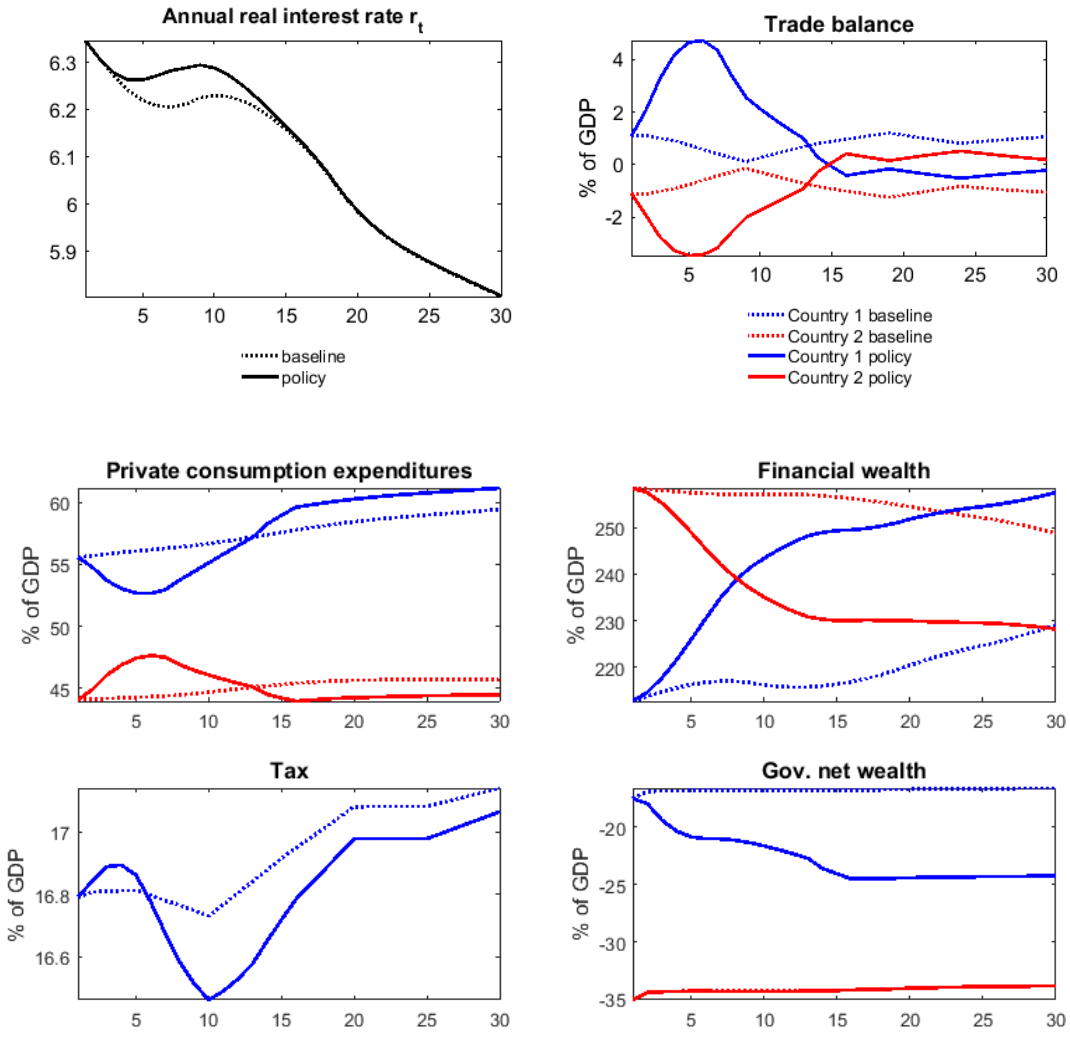

Figure 11: Impact of exchange rate policy and demographics on the economy.

Notes. Undervaluation of the exchange rate in country 1 improves the trade balance as consumption is substituted into the future.

The impact of the exchange rate policy on the world interest rate is positive due to nonlinearity of the savings function with respect to the exchange rate (as discussed in section 4.5). The reduction of savings in country 2 exceeds the increase in savings in country 1, and the decline in the world financial wealth leads to a positive effect on the world real interest rate.

5.3.2 Capital controls and interest rate policy

Figure 12 shows the results of interest rate policy on the model dynamics, together with the benchmark where the domestic and the world interest rate are equal.

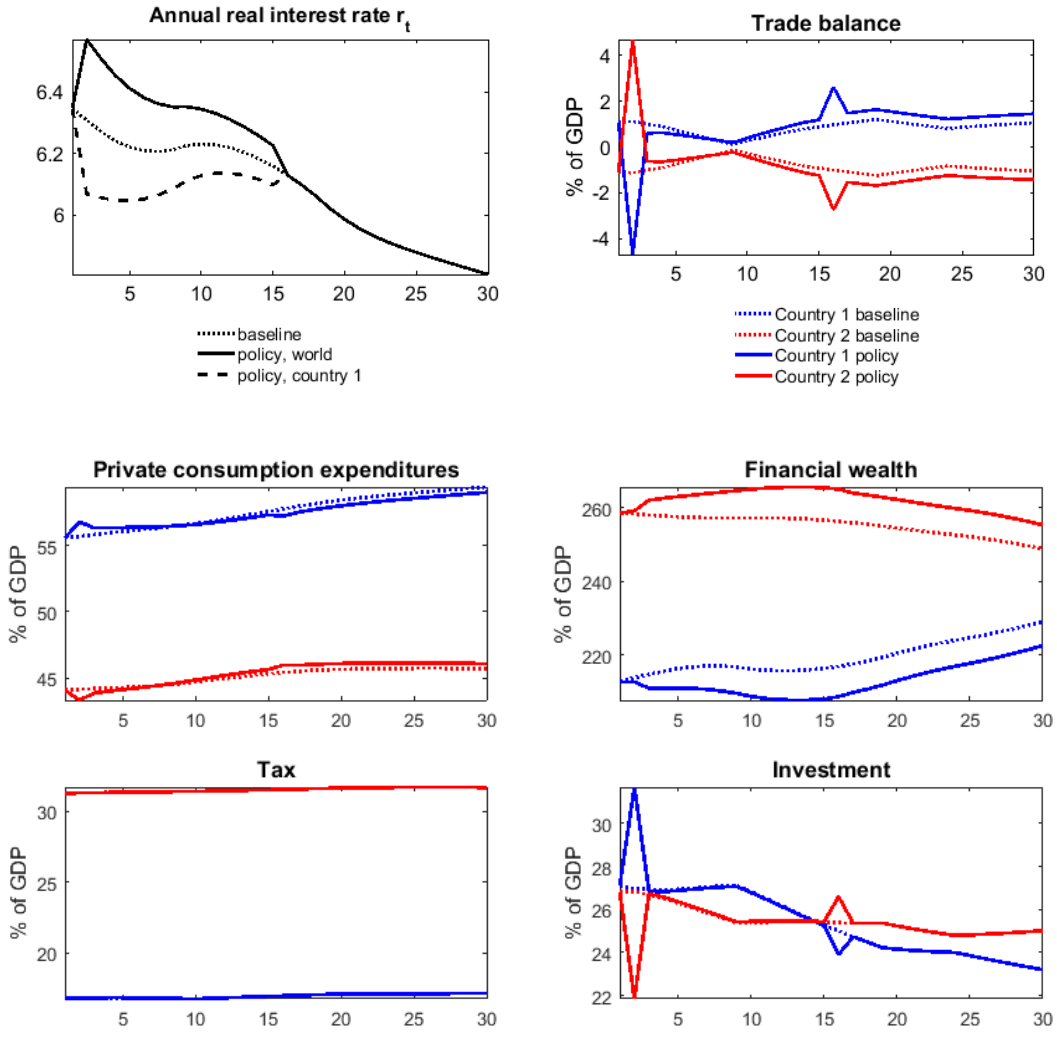

Figure 12: Impact of interest rate policy and demographics on the economy.

Notes. Low interest rate in country 1 weakens the trade balance in the short run. Gradual removal of capital controls strengthens the trade balance.

The interest rate policy affects the trade balance in country 1 negatively in the short run, relative to the benchmark. The negative trade balance effect is driven by an increase in investment, caused by

the decline in the marginal cost of capital, and by an increase in the consumption of the working age population, which is driven by the rise in wages and the present value of human wealth. The impact on the consumption of the old is negative because marginal propensities to consume out of lifetime wealth fall, as well as the level of financial wealth. In other words, the substitution effect dominates in the workers' case and the income effect in the retirees' case. However, because of the large proportion of the working age population, the net effect on consumption is positive. As there are no adjustment costs in the model, there is a large shift in investments in the periods in which the policy begins and ends, as the capital stock is instantly adjusted to the optimal level.

In the long run, the interest rate policy leads to lower level of financial wealth. After the domestic interest rate returns to the world equilibrium level, the net effect of the interest rate policy on aggregate consumption becomes negative.

As a result of the interest rate policy, the world real interest rate increases relative to the benchmark. As the policy lowers the private savings gap in country 1, and therefore its government-central banks domestic debt, it also has a negative impact on the government-central banks net foreign asset holdings. In the international financial market, lower asset demand pushes up the interest rate, which lowers investment and output and lowers consumption in country 2.

5.3.3 Government spending and budget deficits

Figure 13 shows the effects of government expenditure shocks both assuming that the government runs a balanced budget and taking into account the observed fiscal deficits, together with the benchmark simulation of section 5.2, where government expenditures are constant and both governments run a balanced budget.

The observed government expenditure fluctuations, had the government budget's been balanced (the dashed lines in figure 13), would have led to an improvement in China's and a deterioration in the US' trade balance. The increase in public consumption raises taxes and crowds out private consumption.

However, the workers' discount rate exceeds the government's discount rate (the riskless interest rate R^w_{t+1}, see equation 16) because of the anticipated finitude of working life and overall lifetime. Therefore the workers do not fully capitalize the increase in future tax liabilities, and the fall in private consumption does not fully offset the rise in government expenditures (*i.e.* increase in private saving does not fully compensate for the decline in public saving), resulting in a reduction in domestic savings, a decline in the capital stock, and an increase in the world real interest rate.

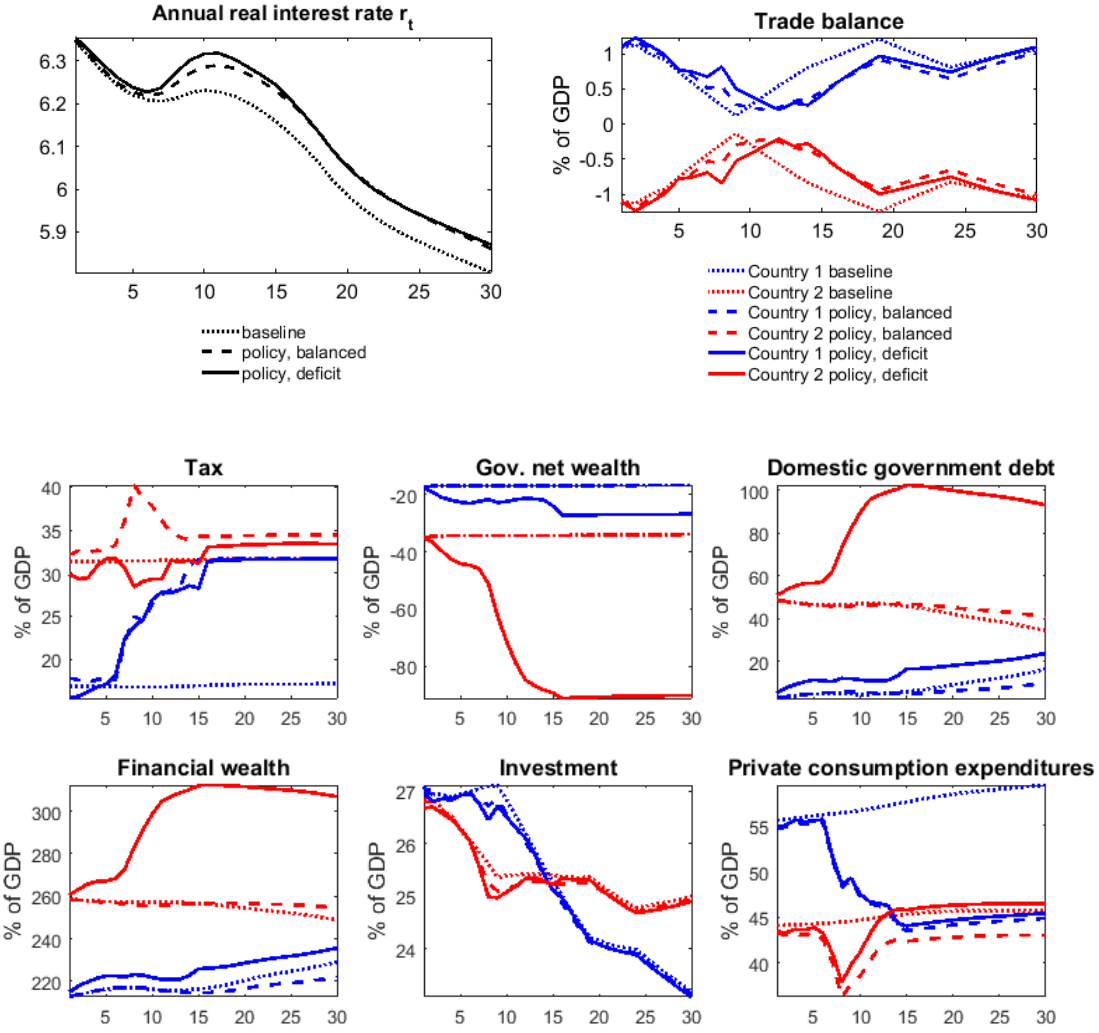

Figure 13: Impact of fiscal policy and demographics on the economy.

Notes. Increase in government expenditures and deficit has a positive effect on the real interest rate through a negative effect on aggregate savings because of the life-cycle behaviour. The trade balance improves in China, where life expectancy is lower and the population growth rate higher.

The increase in government expenditures, as it results in an increase in the world interest rate, implies an intergenerational transfer to the old, who live out of savings and interest income only. Because the discount factor of Chinese workers is lower due to lower life expectancy, the reduction in private consumption expenditures is more prounounced than in the US, resulting in a smaller decline in aggregate savings, and therefore the net effect on its trade balance is positive.

The observed fiscal deficits (solid lines in figure 13) lead to an improvement of the Chinese trade balance, and rise in the world interest rate relative to the counterfactual where the government expenditures are financed with a balanced budget. As the households' discount rate is higher than the government's, postponing tax payments further into the future raises the present value of human wealth relative to taxes timed according to a balanced budget rule. Therefore, when financed with debt, government expenditures crowd out less private consumption than with balanced budget, and the increase of private savings is smaller. As national savings are lower, the world interest rate is higher, resulting in lower investments and capital stock. The increase in life-expectancy lowers the households' discount rate and the crowding out effect of government deficit on private consumption becomes muted, and the current account effect stronger. To the contrary, an anticipated decline in the population growth rate raises the present discounted value of tax liabilities, which means that the external sector becomes less sensitive to fiscal policy (government budget deficits). The quantitative effect of observed government expenditures and deficits on the trade surplus is approximately 0.1-0.5 % of GDP, and on the interest rate, less than 10 basis point at the most.

6 Conclusions

This paper analyzes the impact of China's macroeconomic policies between 2000 and 2015 on its trade balance vis-a-vis the US and the world real interest rate. In the analysis, I take into account the direct effects of demographic factors on the external imbalances as well as the indirect effects through the impact that demographics have on the transmission of the macroeconomic policies. The paper is motivated

by the observed persistence of the external imbalances in China and the US, the central role of the public sector in the Chinese economy, and the claims that China has been able to affect both the interest rate dynamics and the trade balance by practising policies that affect both intratemporal and intertemporal terms of trade.

In order to quantify the importance of these factors, I construct a dynamic general equilibrium model embedded with features which describe the behaviour of the Chinese policymakers. The macroeconomic policies I focus on are capital controls and interest rate policy, exchange rate policy, and fiscal policy. I construct series of policy variables based on the observations that 1) the Chinese real exchange rate was undervalued between 2001 and 2014, 2) the US real interest rate has on average exceeded (but converged towards) the Chinese real rate between 2000 and 2015, and, 3) the Chinese government expenditures and budget deficits have grown in the same time period, and simulate the model to analyze the dynamics of the trade balances and the real interest rate.

According to my simulations, the macroeconomic policies of 2000-2015 overall had a strong positive impact on the trade balance and a positive impact on the international interest rate. The effects are driven by the real exchange rate policy. The demographic developments have contributed to the fall of the interest rate by approximately 50 basis points since 2001. The impact of demographic change on the trade balance has been negative in the first decade, and positive in the second decade of the century. While the impact of the exchange rate policy is qualitatively sensitive to the assumptions on the elasticity of intertemporal substitution, the impact of the demographic change and the other policies are qualitatively robust to this assumption.

The results imply that even though the macroeconomic policies of 2000-2015 have likely contributed to China's trade surpluses, their power to promote China's net exports and the accumulation of external wealth should be assessed with caution, especially that of the exchange rate policy. The fact that capital controls allow China to excercise an independent interest rate policy might constitute a disincentive for China to continue opening its capital account further amidst ongoing geoeconomic fragmentation, in addition to other considerations not discussed in this paper, even though the impact of interest rate policy

on the external balance appears to have been relatively small in the past. China's projected fast societal ageing is likely to continue to put downward pressure on the real interest rate and upward pressure on the household savings, which might call for China to implement policies such as social security reform to speed up consumption-led growth, and which are likely to fuel the global imbalances in the long run.

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Appendix

A Exchange rate and savings

The life-cycle model of this paper nests a two-period OLG model in the special case when $\omega_{t,t+1} = 0$ and $\gamma_{t,t+1} = 0 \, \forall t$. In this case, retirees consume all of their wealth, and the aggregate savings in the economy consist of workers savings only. Then, as also shown by Song et al. (2014), workers' savings are given by

$$A^w_{t+1} = (W_t - T^w_t) \left[1 - \frac{1}{1 + \beta^\sigma R^{\sigma-1}_{t+1} \left(\frac{1+e^{1-\varepsilon}_{t+1}}{1+e^{1-\varepsilon}_t} \right)^{\frac{\sigma-1}{\varepsilon-1}}} \right] \tag{30}$$

which is an increasing/decreasing function of the exchange rate e_t if $\sigma > 1/\sigma < 1$ (see figure 14). The first derivative of the savings with respect to the exchange rate is

$$\frac{\partial A^w_{t+1}}{\partial e_t} = \frac{\beta^\sigma {R_{t+1}}^{\sigma-1} (\sigma - 1) \left(\frac{1+e^{1-\varepsilon}_{t+1}}{1+e^{1-\varepsilon}_t} \right)^{\frac{\sigma-\varepsilon}{\varepsilon-1}} \frac{(1+e^{1-\varepsilon}_{t+1}) e_t^{-\varepsilon}}{(1+e^{1-\varepsilon}_t)^2}}{\left[1 + \beta^\sigma R^{\sigma-1}_{t+1} \left(\frac{1+e^{1-\varepsilon}_{t+1}}{1+e^{1-\varepsilon}_t} \right)^{\frac{\sigma-1}{\varepsilon-1}} \right]^2} (W_t - T^w_t)$$

is positive if $\sigma > 1$. Furthermore, because the savings increasing/decreasing at a diminishing rate, overvaluation of the exchange rate ($e_t < 1$) has a larger effect on savings than undervaluation of the exchange rate ($e_t > 1$).

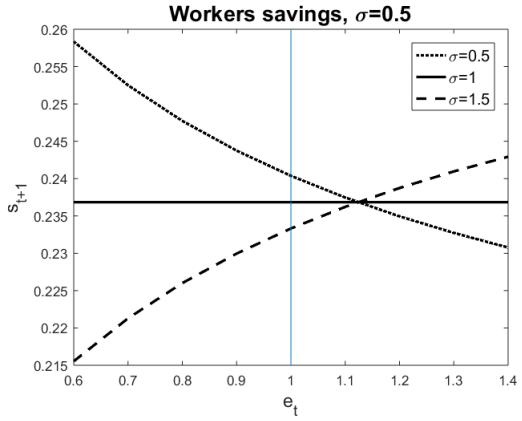

Figure 14: Workers' savings as function of the exchange rate e_t in the two-period OLG version of the model (with different elasticities of intertemporal substitution, $\sigma = 0.5$, $\sigma = 1$ and $\sigma = 1.5$).

B Capital controls and Ricardian equivalence

To develop the intuition for how the domestic interest rate policy breaks down Ricardian equivalence, consider a two-period small open endowment economy consisting of two agents: a representative household and government, which takes the international interest rate R as given, but can set a domestic interest rate R_d different from the international interest rate. Assume that the government and household have no initial wealth in period 1, and in period 2, all wealth is consumed. Assume that the household can not access external financial markets so that its only savings vehicle is the domestic government bond so that $A_{t+1} = B_{t+1}$ where A_{t+1} = household's financial wealth and B_{t+1} = domestic government bond.

In this economy, the household maximises utility, given by

$$U = C_1 + \beta C_2 \tag{31}$$

subject to the budget constraint $Y_1 - T_1 = C_1 + A_2$ in period 1 and $Y_2 - T_2 + R_2 A_2 = C_2$ in period 2. Solving the household's constrained optimization problem gives the standard Euler equation, $C_2 = \beta R C_1$, which, when combined with the budget constraints, gives the optimal consumption expenditures in periods 1 and 2, given by $C_1 = \frac{1}{1+\beta R}\left[Y_1 - T_1 + \frac{Y_2 - T_2}{R}\right]$ and $C_2 = \frac{\beta R}{1+\beta R}\left[Y_1 - T_1 + \frac{Y_2 - T_2}{R}\right]$.

The government's flow budget constraint is given by $B_{t+1} - B^*_{t+1} = R_d B_t - R B^*_t + G_t - T_t$, where B_{t+1} is the government's domestic debt and B^*_{t+1} foreign assets. The government's budget constraint is given by $B_2 - B^*_2 = G_1 - T_1$ period 1 and by $0 = R_d B_2 - R B^*_2 + G_2 - T_2 = R_d(B_2 - B^*_2) + (R_d - R)B^*_2 + G_2 - T_2$ in period 2. The government's interemporal budget constraint then solves as $T_1 + \frac{T_2}{R_d} - B^*_2\left(1 - \frac{R}{R_d}\right) = G_1 + \frac{G_2}{R_d}$.

If the government is a net external creditor, $B^*_2 > 0$, and if the domestic interest rate is below the international interest rate, $R_d < R$, the government can save at a higher rate than the households, and for a given domestic interest rate R_d, external saving by the government relaxes the budget constraint. Then, as the households internalize the government's intertemporal budget constraint, consumption in both periods depends positively on government's net external asset holdings, given by

$$C_1 = \frac{1}{1+\beta R_d}\left[Y_1 + \frac{Y_2}{R_d} - G_1 - \frac{G_2}{R_d} - B^*_2\left(1 - \frac{R}{R_d}\right)\right]$$

in period 1 and by

$$C_2 = \frac{\beta R_d}{1+\beta R_d}\left[Y_1 + \frac{Y_2}{R_d} - G_1 - \frac{G_2}{R_d} - B^*_2\left(1 - \frac{R}{R_d}\right)\right]$$

in period 2. The Ricardian equivalence in this case does not hold.

The current account is defined as $CA_t = Y_t - C_t - G_t + (R_{w,t} - 1)B^*_t = B^*_{t+1} - B^*_t$. Given the assumption of a two-period economy, the current account is given by $CA_1 = Y_1 - C_1 - G_1 = B^*_2$ in period 1 and by $CA_2 = Y_2 - C_2 - G_2 + (R-1)B^*_2 = -B^*_2$ in period 2. By substituting C_1 into period 1's current account condition, one can solve for the period 1 current account, which is given by

$$B^*_2 = \frac{\beta R_d}{1+\beta R_d - \left(1 - \frac{R}{R_d}\right)}(Y_1 - G_1) - \frac{1}{1+\beta R - \left(1 - \frac{R}{R_d}\right)}\left[\frac{Y_2}{R_d} - \frac{G_2}{R_d}\right].$$

If $R_d \neq R$, the current account differs from that under Ricardian equivalence. Specifically, a low domestic interest rate, $R_d < R$, is associated with a smaller external asset position than if $R_d = R$. This is because (even though low interest rate lowers saving) the positive wealth effect associated with pub-

lic external debt results has a positive effect on consumption, which at the optimum in period 1 equals $C_1 = \left[\frac{1}{1+\beta R_d} - \frac{\beta R_d\left(1-\frac{R}{R_d}\right)}{1+\beta R_d-\left(1-\frac{R}{R_d}\right)}\right]\left[Y_1 - G_1 + \frac{Y_2-G_2}{R_d}\right]$. Therefore, in addition to the normal interest rate channel, the capital control breaks down the Ricardian equivalence and induces a positive wealth effect on domestic households.

C Robustness of the quantitative results to elasticity of intertemporal substitution (EIS)

There is a discrepancy in the literature about the value of the elasticity of intertemporal substitution (EIS) parameter σ. Papers which study the impact of demographic change with life-cycle models, such as Gertler (1999), Fujiwara and Teranishi (2008), Ferrero (2010), and Kilponen et al. (2006), typically set the parameter value below one. Models that study the effect of terms-of-trade shocks on consumption-saving decision, including Song et al. (2014), typically have higher EIS.

Figure 15 shows the effect of demographic change with $\sigma = 1.5$ and $\sigma = 0.5$. With low value of σ, demographic change leads to a larger decline (appr. 150 basis points) of the real interest rate. However, qualitatively the result is not sensitive to this assumption, as the demographic change produces a fall in the interest rate (approximately 50 basis points) even with $\sigma = 1.5$. The simulation with low sigma which leads to a lower real interest rate, is associated with smaller gross trade balance / GDP ratios.

Figure 16 shows the effect of macroeconomic policies with $\sigma = 1.5$ and $\sigma = 0.5$. The impact of the macroeconomic policies on the world interest rate is qualitatively robust to the assumption on σ in the short run, but not in the long run. In the long run, the simulation with policies and with $\sigma = 1.5$ results in an interest rate which is approximately 0-10 basis points above the benchmark interest rate, but if $\sigma = 0.5$, the long run interest rate is approximately 30 basis points below the benchmark interest rate. This, as well as the sensitivity of the trade balance dynamics to the value of σ, are mainly due to the fact that the exchange rate policy has opposite effects with different values of σ. As discussed in section

4.5, exchange rate policy is dominated by the HLM effect when $\sigma < 1$ and by substitution effect when $\sigma > 1$. Also fiscal policy's impact on the trade balance is sensitive to the value of σ, as fiscal policy has a stronger impact with $\sigma < 1$. Then the increase of taxes does not have quite as large negative effect on private savings, and the net effect on government savings is larger. Because of the sensitivity of the results to parameter values, and because of the illustrative nature of the policy shocks, the results need to be interpreted with caution.

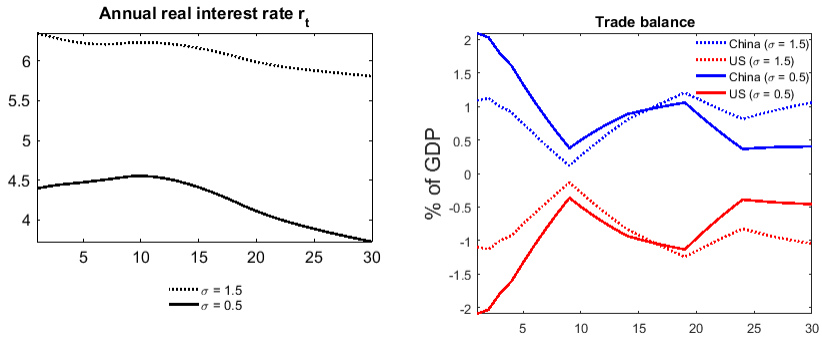

Figure 15: Impact of demographics on the real interest rate and trade balance with different elasticities of intertemporal substitution ($\sigma = 1.5$ and $\sigma = 0.5$).

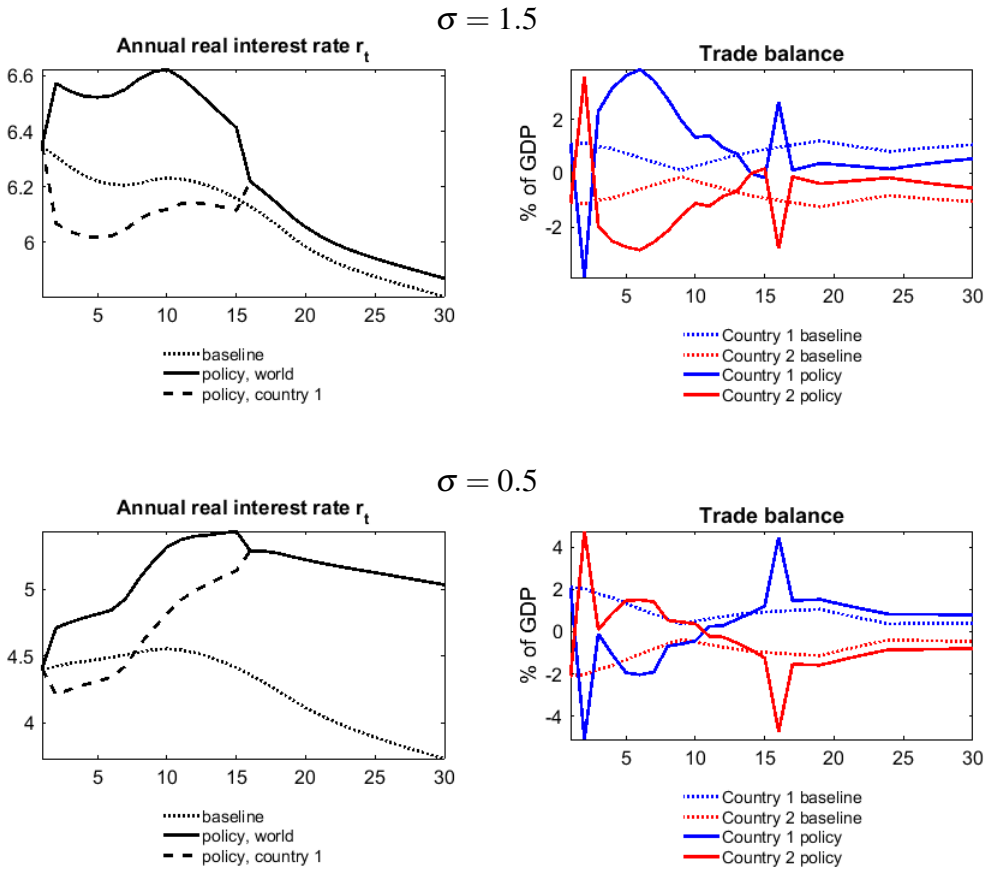

Figure 16: Impact of macroeconomic policies and demographics on the real interest rate and trade balance with different elasticities of intertemporal substitution ($\sigma = 1.5$ and $\sigma = 0.5$).

D Additional figures

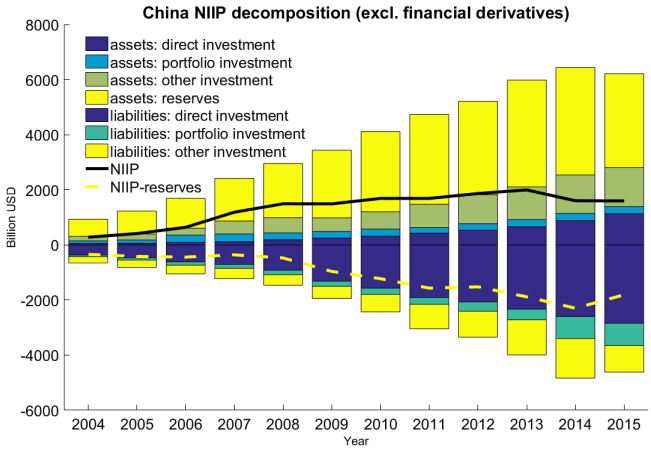

Figure 17: China's external assets and liabilities.

Notes. Source: IMF 2017.

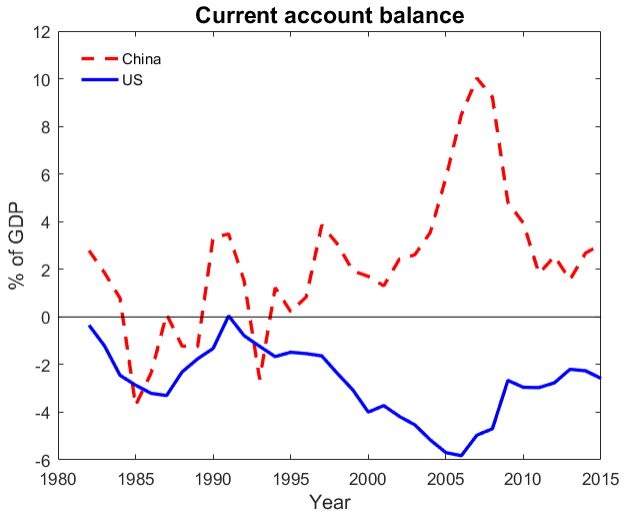

Figure 18: Current account balance of China and the United States.

Notes. Source: IMF 2018.

E International comparison

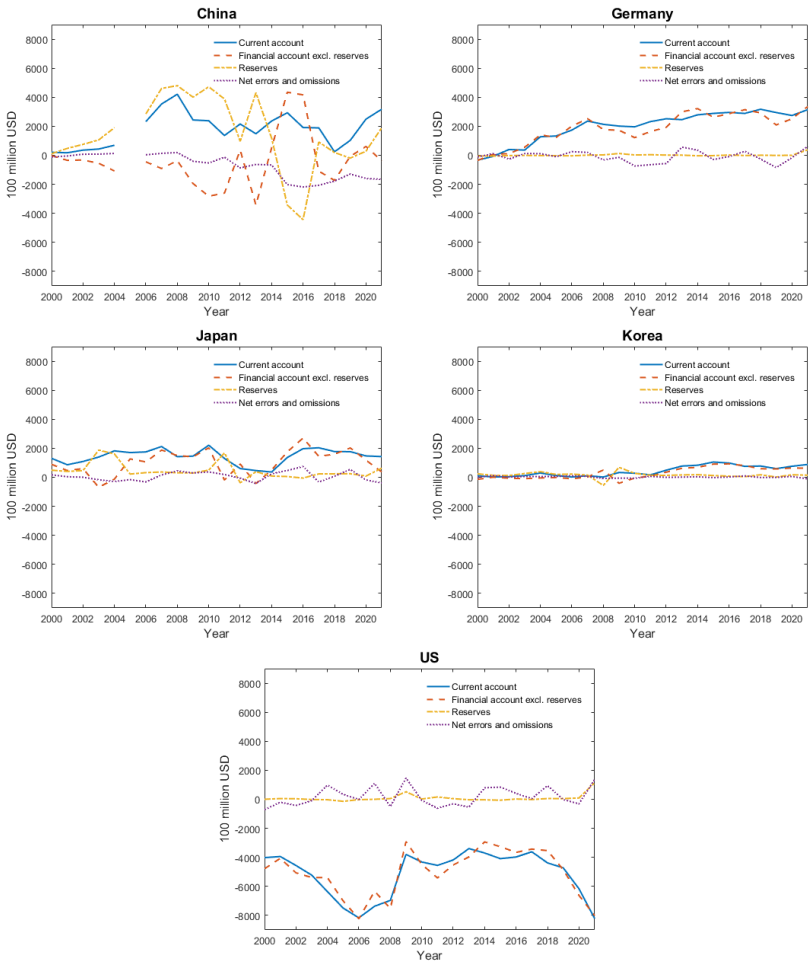

Figure 19: Country comparison, balance of payments, main accounts. China, Germany, Japan, Korea, United States.
Notes. Source: SAFE BoP.

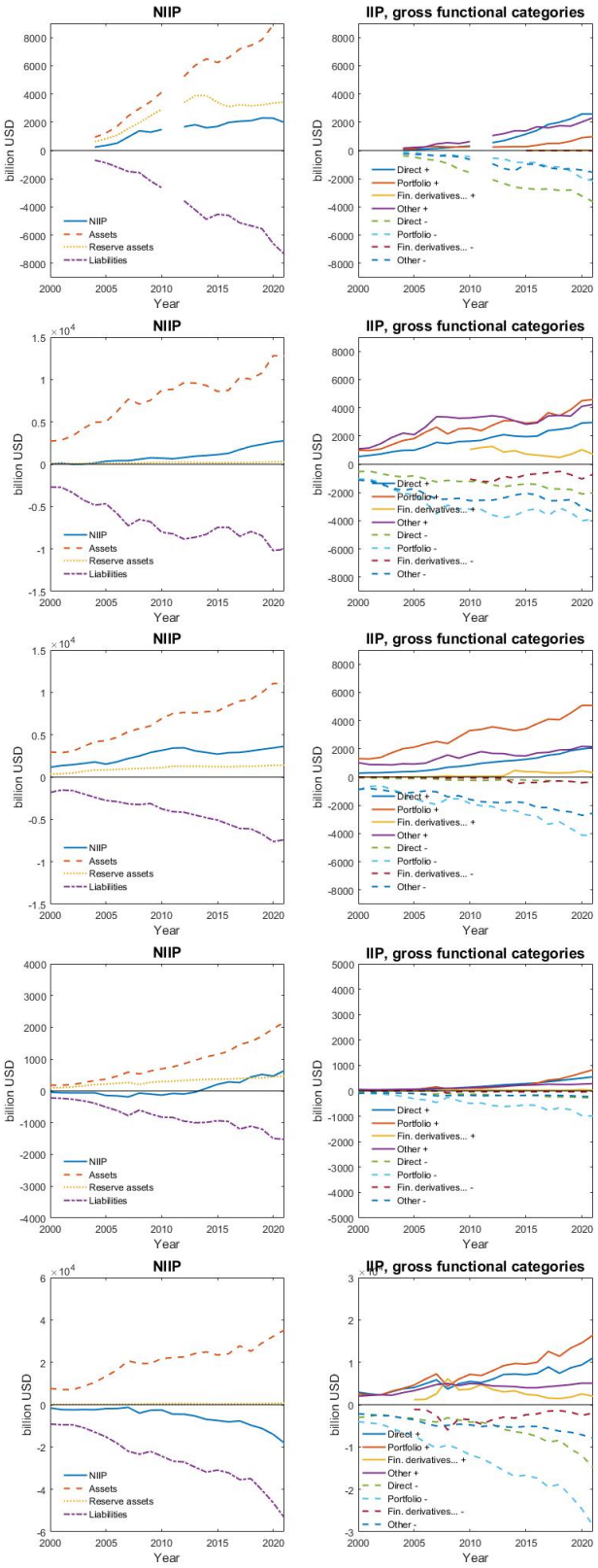

Figure 20: Country comparison, net international investment positions. China, Germany, Japan, Korea, United States.

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