China and global rebalancing: a two-country approach

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April 2013

Abstract

Based on simulations of an original DGE model of the US and the Chinese economies under various monetary regimes, we show that an overhaul of China's social safety net is capable of reducing global imbalances whatever the exchange-rate regime, provided international capital flows are allowed to react to expected return differentials, which requires some relaxation of capital controls. Exchange-rate flexibility would accelerate the rebalancing, but not make it larger. A monetary reform would fail to rebalance the economy unless the government simultaneously acts to curb NFA accumulation through consumption-enhancing reform or reducing its objective in terms of reserve accumulation.

1 Introduction

Since the early 2000s, China has been the center of repeated criticism by the international community concerning its contribution to global imbalances, with two main recriminations: (i) excess savings prompted by a number of market and social distortions, and (ii) a quasi fixed exchange-rate regime backed by capital controls and official reserve accumulation. Global imbalances temporary retreated during the 2007-2009 global crisis, as a consequence of the trade collapse and financial de-globalization. When the global economy started to pick up in mid-2009, it however became clear that the crisis had not wiped up the problem which was deemed to soon re-emerge (see Blanchard & Milesi-Ferretti (2010)). However China continued to resist international pressures to reform its exchange-rate regime. Instead, it committed to stimulate domestic demand through a number of structural reforms, especially the reconstruction and extension of the social safety net, while slowly moving in the direction of financial opening up and currency internationalization.

This paper aims at comparing the effectiveness of structural and monetary reforms, and the complementarity between the two, in reducing global imbalances, within a two-country, dynamic general equilibrium (DGE) model. Specifically, we compare how a more generous social safety net in China...
would be capable of curbing the current-account surplus in this country and the mirror deficit in the United States with or without a change in the monetary regime. Symmetrically, we analyze whether a monetary reform in itself could curb global imbalances without the help of structural reforms in China.

Two groups of explanations to global imbalances have been suggested in the literature (Bernanke, 2005; Dooley et al., 2003; Mendoza et al., 2007; Caballero et al., 2008): (i) macroeconomic and structural factors, such as high saving rates in emerging countries triggered by energy windfalls, deficient social safety nets, or financial under-development; low investment rates in some emerging countries following the Asian crisis; and lax monetary policy in the United States; and (ii) the international monetary system (IMS hereafter) itself, through the key role of the United States as a supplier of international reserve assets, the lack of trust in multilateral financial safety nets which has led emerging countries, especially in East Asia, to self-insure through reserve accumulation, and the success of export-oriented growth strategies that have encouraged fixed or quasi-fixed exchange-rate regimes. Contrasting with this two-pillar understanding of global imbalances, researches on rebalancing scenarios have tended to focus on real exchange-rate adjustment, especially for the United States, abstracting from the IMS (Obstfeld & Rogoff, 2005; Blanchard et al., 2005). Few studies have been devoted to the interconnection between real adjustments and monetary regimes. One exception is Blanchard and Giavazzi (2006) mentioning the needs to combine a nominal appreciation of the renminbi with a fall in China's saving rate, in order to secure internal balance while reducing the current-account surplus. Another one is Faruqee et al. (2007) who contrast the impact of a fiscal adjustment in the US depending on China's monetary regime, within a four-region DGE model.

The present paper is interested in the intertwined contribution of structural and monetary reforms to global rebalancing. While acknowledging that China has in no way been the only contributor to global imbalances, we focus on this country which represents a unique example of very high gross saving rate (50 percent of GDP on average over the 2005-2008 period according to Ma & Yi (2010)) combined with a fixed exchange-rate regime that feeds fast reserve accumulation. These features would be benign if China was still a small country. But China has become the first official reserve holder in the world, and it accounted for 62 percent of gross national savings in Asia excluding Japan in 2008 (see Prasad (2009)).

We successively cover the two lines of explanation of global imbalances, hence the two possible channels of global rebalancing. First, we study the contribution of China's aggregate saving rate. Although, as argued by Ma & Yi (2010), the unique feature of China's rising saving rate during the 2000s is that the three sectors of the economy (households, firms and the government) have simultaneously contributed to the very high saving rate, here we concentrate on the social safety net for three reasons: (i) Chamon et al. (2010) estimate that "rising income uncertainty and pension reforms can account for over half of the increase in the urban saving rate in China since the mid-1990s" (p.1). Hence, any improvement of the social safety net could be instrumental in curbing households' saving rates; (ii) consistent with the goal of "universal social security coverage for urban and rural residents by 2020" (Chinese Government, 2006), the Chinese have taken decisive actions especially concerning health insurance (see Li (2011)) and the pension system (see Herd et al., (2010)). In particular, it was decided in 2005 to reduce the share of the "individual account" in the calculation of pension benefits, thereby raising the replacement rate for urban households, and in 2009 a new rural pension program was launched with the aim to progressively extend the coverage from 10 percent of the counties at
end-2009 to 50 percent in 2012 and complete coverage by 2020. The twelve 5-year plan approved in 2011 has confirmed the extension of social security coverage as a top policy priority; (iii) reforms aiming at reducing corporate or government saving rates can be shown to have similar effects on global imbalances as social security ones, although the impact for the Chinese economy may differ (see Bénassy-Quéré et al. (2011)). After simulating rebalancing scenarios based on a reduction in Chinese households' saving rate, we turn to the second interpretation of global imbalances, based on the functioning of the international monetary system, in particular the willingness of the People's Bank of China to accumulate reserves.

We build a DGE model of two countries (China and the United States) with overlapping generations and nominal rigidities, and simulate a more generous pay-as-you go pension system in China that results in a decline of the aggregate saving rate, under different monetary regimes: the status quo (a fixed exchange rate backed by capital controls and foreign-exchange interventions), a relaxation of capital controls, and a a flexible exchange-rate regime. We then find the impact of a monetary regime change in itself, in a context of global imbalances. As in Bagnai (2009), we simulate the effect of a rebalancing shock, but unlike this author, we rely on a model where consumption, pricing and portfolio choices derive from utility maximization and account for expectations.

We find that a fall in China's saving rate would contribute to global rebalancing whatever the exchange rate regime, provided international capital flows do react to interest-rate differentials (which implies less-than-complete capital controls in China). The reason for this result is the following: with lower savings, the autarkic interest rate of China is higher, which attracts foreign investments. With low capital mobility, this effect is muted, hence there is less capital accumulation in China and the current account stays unaffected. In contrast, with high capital mobility, the higher autarkic interest rate attracts large capital inflows. The People's Bank of China (PBoC, hereafter) cannot simultaneously prevent a nominal exchange-rate appreciation and a rise in domestic prices: to prevent the former, the PBoC needs to follow the US monetary policy, which feeds domestic inflation; conversely, the PBoC can successfully avoid inflation if the currency is allowed to appreciate. In both cases, the real exchange rate appreciates and the current-account surplus is reduced.

The difference between the two exchange-rate regimes is the speed rather than the extent of the adjustment: it is quicker in a flexible regime than in a fixed one. The two regimes also differ for China, since only in a flexible regime is China able to control inflation stemming from more dynamic domestic demand (consistent with the intuition of Blanchard & Giavazzi (2006)). This feature provides strong incentive for China to move away from its fixed peg, although the advantage for the United States of such move is only transitory.

Additionally, we show that, should the United States refrain from hiking its interest rate when global savings are reduced, the need for China to float its currency would become even more acute, and the extent of the rebalancing would depend more directly on the exchange-rate regime. Finally, we find that a monetary reform in itself is unable to rebalance the Chinese economy unless it is accompanied by a shift in government policy concerning net foreign asset (NFA) accumulation, either through consumption-enhancing reforms, or through a halt to active reserve accumulation by the central bank.

1By extension, the simulation of a pension reform covers any overhaul of the social safety net that would reduce uncertainty about the ability of households to cover "big ticket" expenses (such as health care).
The remaining of the paper is organized as follows. In Section 2 presents the model. In Section 3, we simulate a pension reform in China under different monetary regimes. Section 4 studies the impact of a monetary reform in China after the latter has accumulated current-account surpluses. Section 5 concludes.

2 The model

2.1 General overview

The world is divided into two countries: the United-States (u) and China (c), that trade both goods and financial assets. Each economy is composed of households, firms, a central bank and the government. The model is quarterly.

The model is depicted in Figure 1. Each country is populated with overlapping generations of households à la Blanchard (1985) and Yaari (1965). Aggregate labor supply is \( L \). Households receive labor income, pensions and the proceeds of their previous savings (interests and dividends). Depending on their age, the flow of funds differs: as they become older, households accumulate financial wealth (hence they receive more dividends and interest payments), their labor endowment decreases (thus labor income decreases), and they receive rising transfers from the pay-as-you-go (PAYG) pension system. After paying taxes on their labor endowment, households buy domestic and foreign goods and save the remaining in the form of domestic equities, domestic bonds \( B_j \) and foreign bonds \( B_{j,j'}\) \((j,j' = c,u)\). When they die, their bequest is distributed to the surviving households through an insurance scheme. The pension system is introduced as the main policy tool that influences households aggregate savings: the higher the replacement rate, the lower the saving rate for a given real interest rate. This stylized pension system can account for any insurance scheme (e.g. health insurance) that will reduce the incentive for precautionary savings.

There are two categories of firms. Production firms hire labor \( L \) and capital \( K \) to produce goods \( Y \) that are indifferently used for consumption and investment. These goods are differentiated and sold to domestic and foreign customers under monopolistic competition. Nominal rigidities are introduced both for goods and labor through staggered contracts à la Calvo (1983). Capital firms accumulate capital \( K \) and rent it to production firms à la Calvo (1983).

The government purchases goods (public consumption) and manages the PAYG pension system which receives taxes from the households and pays transfers to the elder ones. It can issue debts \( B_g \). In China, the government also receives positive or negative transfers from the central bank (see below). The level of pensions is determined by the government budget constraint, with exogenous debt-to-GDP target and tax rate.

Finally, the central bank sets the interest rate \( R \) according to a modified Taylor rule. In the United States, the interest rate simply reacts to inflation deviations from target. In China, the rule is

\footnote{Here we do not distinguish the financial from the households sector: firms are assumed to borrow directly from domestic or foreign households.}

\footnote{Physical capital is commonly owned by firms (firm-specific capital stock) or households. However, in presence of Calvo-style price stickiness and overlapping generations, it is more convenient to assume special entities (capital firms) that accumulate physical capital, rent it to production firms and pay dividends to households (Annicchiarico et al., 2009). See also Bernanke et al. (1999) for the introduction of capital firms in presence of financial frictions.}

\footnote{Including the output gap in the monetary rule does not change the results qualitatively, although it complicates
augmented with an impact of official reserve accumulation \( FR \) on the interest rate. To (partially) sterilize its interventions, the central bank issues sterilization bonds \( Bc \). Depending on the amount of sterilization and on return differentials between foreign-exchange reserves (which yield the foreign policy rate) and sterilization bonds (which yield the Chinese policy rate), the central bank generates a positive or negative profit that is immediately transferred to the pension system, hence indirectly transferred to elder households.

In the benchmark model, there are capital controls in China: foreign investors cannot buy as many yuan-denominated assets as they would like, and Chinese investors cannot buy as many dollar-denominated assets as they would like: the uncovered interest parity does not hold. This grants the Chinese central bank some independence in the conduct of monetary policy even when the exchange rate is fixed. Alternatively, capital controls can be relaxed. In this case, a deviation from UIP triggers too large capital flows to be solely managed through foreign-exchange interventions, so the Chinese interest rate has to be kept close to the US one: China is no longer able to control domestic inflation unless the renminbi is allowed to float.

The key equations are presented in the next sub-sections, the model and its calibration being detailed in the appendix.\(^5\)

### 2.2 Households

The representative household of the cohort born at quarter \( a \), and still living at quarter \( t \), consumes \( C_{a,t} \), has a time-endowment for work of \( \bar{L}_{t-a} \) hours (which decreases over time at rate \( 1 - \gamma_g \)), and effectively works \( L_{a,t} \).\(^6\) At a given period, each previously-born household has a constant probability \( \theta_g \) to survive, and new households appear at rate \( (1 - \theta_g) \bar{N} \), where \( \bar{N} \) is the population, which thus the resolution since the model then needs to be simulated at first without nominal rigidities in order to derive potential output.

\(^5\)Robustness checks can be found in Bénassy-Quéré et al. (2011).

\(^6\)The retirement schedule and associated pension are assumed inverse, geometric functions of the remaining lifetime labor endowment of the household.
is constant. Let $0 < \beta < 1$ denote the subjective discount factor. The inter-temporal utility function of the representative household of generation $a$ at time $t$, $U_{a,t}$, is increasing in consumption and in leisure:

$$U_{a,t} = \sum_{s=0}^{\infty} (B_\beta)^s \left[ (1-\kappa) \log(C_{a,t+s}) + \kappa \log(\bar{L}_{t+s-a} - L_{a,t+s}) \right], \quad (1)$$

with $0 < \kappa < 1$.

In each country, the portfolio $A_t$ of households consists in (i) domestic equities (ii) a complete set of domestic contingent claims and (iii) foreign assets in the form of short-term bonds. Life-insurance companies à la Yaari (1965) pay a premium to alive households against the promise of inheriting their assets when they are dead. The budget constraint, first-order conditions at the cohort level, aggregate consumption and labor supply are detailed in the appendix.

The international portfolio of households consists in foreign bonds only: equities and contingent claims are assumed not to be internationally tradable.\(^7\) In a representative agent DSGE model, imperfect capital mobility or capital controls (which translate into a deviation from uncovered interest parity) is the result of an ad hoc term in the utility function, or of the introduction of taxes (or subsidies) on foreign asset holdings or capital flows.\(^8\) In the context of overlapping generations, we directly specify the demand for foreign bonds as a function of the expected return differential between foreign and domestic bonds, like in Schmitt-Grohé & Uribe (2003).\(^9\) Denoting by $B_{t,c}^{u}$ Chinese holdings of US bonds, by $B_{t,u}^{c}$ US holdings of Chinese bonds, and by $S_t$ the nominal exchange rate (the value of one dollar in yuan), we have:

$$\frac{S_t B_{t,c}^{u}}{A_c} = \frac{\gamma}{1-\gamma} \left( E_t \left\{ F_{t+1}^{c} R_t^{c} \frac{S_{t+1}}{S_t} \right\} - 1 \right) \quad (2)$$

$$\frac{B_{t,u}^{c} / S_t}{A_u} = \frac{\gamma}{1-\gamma} \left( E_t \left\{ F_{t+1}^{u} R_t^{u} \frac{S_{t}}{S_{t+1}} \right\} - 1 \right) \quad (3)$$

where $F_{t+1}^{j}$ is the nominal stochastic discount factor of country $j (=c,u)$, $R_t^{j}$ is the nominal interest rate of country $j$, $A$ is household wealth of Country $j$ ($j = c,u$) at the initial steady state, and $0 < \gamma < 1$ is a proxy for capital mobility between the two countries. If $\gamma \to 0$, the model reproduces capital controls: even when the expected excess return is high, the ability of households to hold cross-border assets is limited. On the contrary, $\gamma \to 1$ means free capital mobility, as a tiny excess return motivates large capital flows between the two countries.

Calibrating $\gamma$ between 0 and 1 will be crucial for our rebalancing simulations. In the following, given well-documented frictions (home bias), we assume that $\gamma$ may take two alternative values: $\gamma = 0.5$ (low capital mobility) or $\gamma = 0.9$ (high capital mobility). The interpretation can be grasped through

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\(^7\)The complete set of contingent claims and domestic equities are traded only among domestic households so that, when aggregating among households, these holdings net out. This assumption avoids perfect international risk-sharing. Since the stochastic discount factor will then be region-specific, it is convenient to also assume that equities are not internationally traded in order to properly define the program of the firms.

\(^8\)See Schmitt-Grohé & Uribe (2003); Farhi & Werning (2012).

\(^9\)To simplify the multi-agent portfolio decision, we assume that households delegate their portfolio choices to an asset manager.
the following relationship between the global private portfolio and the Chinese private NFA:

\[
\frac{B^{c,u} - B^{u,c}}{\text{Chinese private NFA}} = \frac{\gamma}{1 - \gamma} \left[ R^u - R^c \right] \left( A^u + A^c \right)
\]

In the low capital mobility case (\(\gamma = 0.5\)), a one percent return differential in favor of Chinese assets causes one percent of global financial wealth to flow from the US to China (which, under a fixed exchange-rate regime, can be accommodated through reserve accumulation by the PBoC). Such calibration is consistent with indirect evidence of "hot money" flowing to China, which can be proxied by the excess of reserve accumulation over the trade surplus. Over the 2000-2008 period, excess reserve accumulation in China reached USD 650 bn, or 4% of the aggregate GDP of the two countries, hence approximately 1% of their aggregate financial wealth. Given observed excess returns in China (a few percents), the numbers are consistent with the calibrated unitary elasticity. In the high capital mobility case (\(\gamma = 0.9\)), a one percent return differential causes ten percents of world financial wealth to flow (which can no longer be accommodated through reserve accumulation, unless China closely follows the US interest rate).

### 2.3 Production, investment and nominal rigidities

**Wage rigidities.** Unions are used as a way to introduce monopolistic competition and wage stickiness in the labor market. Specifically, each union is assumed to hire hours from households on a competitive market. In turn, it rents these hours to the firms on a monopolistic competition market where labor demand depends on the relative wage charged by the union with an elasticity of substitution denoted \(\epsilon_w\). Wages are sticky à la Calvo, with \(1 - \theta_w\) denoting the probability for the union to be able to reset the wage level at a given period. The first-order condition on wage setting and the derivation of aggregate-wage inflation are detailed in the appendix.

**Production and price rigidities.** The representative production firm \(i\) hires labor \(N_t(i)\) from the unions and capital \(K_t(i)\) from capital firms to produce a differentiated good along a Cobb-Douglas production function \(Y_t(i) = A_t K_t(i)^{\alpha_u} N_t(i)^{1-\alpha_u}\), where \(\alpha_u = 0.3\) and \(\alpha^c = 0.4\) to account for country differences in the labor share at the steady-state,\(^{11}\) and \(A_t\) denotes the exogenous level of total factor productivity. The good is sold under monopolistic competition. The elasticity of substitution of demand is denoted by \(\epsilon_p\). Calvo-type price stickiness is introduced so that, at each period, the representative firm is able to reset its price with a probability \(1 - \theta_p\). Factor demand, optimal price setting and aggregate inflation dynamics are derived in the appendix.

**Investment.** Capital is accumulated by specialized firms that rent it to producing firms on a competitive market. The level of capital made available by a capital firm \(k\) at the end of period \(t\) for the next production period \((K_t(k))\) depends on the capital stock at the end of period \(t-1\) and on gross

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\(^{10}\)Assuming financial wealth is around four times GDP.

\(^{11}\)According to Ma & Yi (2010), the share of labor income in GDP in 2005-2007 varies from 30 to 50 percent, depending on the province. For year 2004, Aziz & Cui (2007) find a 56 percent labor share. Accounting for a 15 percent firm markup in both countries (see below), the labor share rises to between 35 and 65 percent, which means a capital share of 0.35 to 0.65. Hence our choice of a 0.4 capital share for China is quite conservative.
investment during period \( t \) \((I_t(k))\): 
\[ K_t(k) = K_{t-1}(k)\Phi \left( \frac{I_t(k)}{K_{t-1}(k)} - \delta \right), \]
where \( \delta \) is the depreciation rate and \( \Phi \) is a non-decreasing concave function with \( \Phi(0) = \Phi'(0) = 1 \) encompassing real rigidities in capital accumulation. Although the market for physical capital is perfectly competitive, capital firms can make profit thanks to the entry barrier formed by their initial level of capital. First-order conditions on capital accumulation are derived in the appendix.

### 2.4 Central bank

**In the United States**, monetary policy is modeled through a simple interest-rate rule with persistence:

\[
\log\left( \frac{R^u_t}{R^u} \right) = \rho^u_R \log\left( \frac{R^u_{t-1}}{R^u} \right) + (1 - \rho^u_R) \alpha^u \log(\pi^u_t),
\]

(4)

where \( R^u_t \) is the nominal interest rate at time \( t \), \( R^u \) its steady-state value, \( \pi^u_t \) denotes the inflation rate, \( \alpha^u > 1 \) is the long-run reaction of the interest rate to inflation, and \( \rho^u_R \) a smoothing parameter.\(^{12}\) Note that, consistent with the Taylor rule (Taylor (1993)), the real interest rate rises whenever inflation increases. Since the model is not used to study cost-push shocks, we can safely drop the output gap from the Taylor rule (the output gap will be perfectly correlated with inflation).\(^{13}\)

In the benchmark simulations, the smoothing parameter \( \rho^u_R \) is set to 0.8. However, monetary policy may be constrained by the zero bound: if the initial policy rate is above its Taylor level due to the zero bound, then an increase in US inflation may not immediately lead to monetary tightening. To account for this possibility, we alternatively assume that, for the next eight quarters following the shock, US monetary policy follows a modified rule where the interest rate smoothing parameter \( \rho^u_R \) is set to 0.98, before switching to 0.8 as in the benchmark model.

**In China**, this simple feedback rule is augmented to account for the fixed exchange-rate regime.\(^{14}\) Specifically, the monetary rule accounts for the fact that the central bank has two instruments to maintain the peg: reserve accumulation, and the interest rate itself (see below the balance of payments). We assume that the central bank has an objective of foreign exchange reserves \( FR^* \). When actual reserves \( FR_t \) are below target, the central bank will oppose an appreciation of the yuan mainly through interventions, which corresponds to a higher interest rate; in contrast, if observed reserves are higher than the target, the central bank will refrain from intervening, and the peg will have to be defended through a lower interest rate:

\[
\log\left( \frac{R^c_t}{R^c} \right) = \rho^c_R \log\left( \frac{R^c_{t-1}}{R^c} \right) + (1 - \rho^c_R) [\alpha^c \log(\pi^c_t) - \alpha_{FR} (FR_t - FR^*)],
\]

(5)

with \( \alpha_{FR} > 0.\(;^{15}\) In the benchmark simulations, we set \( \alpha_{FR} = 0.1 \). We then test the sensitivity of our results to the central bank's behavior by setting \( \alpha_{FR} = 0.01 \) ("soft target" case).

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\(^{12}\)Interest and inflation rates are expressed as one plus the rate itself. For the sake of simplicity, it is assumed here that the inflation target is zero.

\(^{13}\)We have checked the robustness of our results when introducing the output gap in the Taylor rule.

\(^{14}\)The ability of central banks to run a fixed exchange-rate regime with partial capital mobility is discussed by Mundell (1963) and Obstfeld (1980). For empirical evidence on the sensitivity of the Chinese short-run interest rate to inflation, see Fan et al. (2011).

\(^{15}\)Note that this second term in the interest-rate rule also allows China's net foreign asset position to stabilize in the long run: the downward pressure on the interest rate when the central bank accumulates foreign-exchange reserves reduces the incentives of households to save, hence reduces the current account surplus.
In order for the central bank’s balance sheet to stabilize in the long run, we assume the cost (or benefit) from official interventions to be indirectly transferred to households through the pension system. This cost or benefit crucially depends on the sterilization of foreign-exchange interventions: with no sterilization, central bank’s earnings on its reserves are entirely transferred to the pension system; in contrast, full sterilization will reduce the transfer to the difference in interest payments between foreign-exchange reserves (asset side) and sterilization bonds (liability side). Denoting by $B_c^t < 0$ the stock of sterilization bonds and by $D_{cb}^t$ the positive or negative transfer from the central bank to the pension system, we have:

$$D_{cb}^t = S_t(FR_{t-1}^c - FR_t) + (B_c^{t-1}R_c^c - B_c^c).$$  \hspace{1cm} (6)

According to Greenwood (2008), the sterilization of official interventions in China during the 2000s was partially channeled through a rise in reserve requirements for commercial banks. Here the banking sector is not modeled, hence sterilization is performed only through the issuance of sterilization bonds that are directly (rather than indirectly) purchased by households. Following Greenwood’s evidence of a high degree of sterilization, we assume that 90 percent of foreign-exchange interventions are sterilized.$^{16}$ Denoting by $\nu_{\text{steril}} = 0.9$ the degree of sterilization, we have $B_c^c = -\nu_{\text{steril}} FR_t$.

When capital controls are relaxed, however, we consider that China is no longer able to sterilize its interventions to the same extent and subsequently set $\nu_{\text{steril}} = 0.1$.\hspace{1cm} (7)

### 2.5 Government

In each country, the government purchases public goods $G$ (an exogenous volume), sets the tax rate on labor endowments ($\tau_t$)$^{18}$ and issues domestic-currency denominated risk-free bonds, the stock of which is denoted $B_g_t$ at the end of period $t$, with a negative sign whenever the government is a debtor.

In addition, China subsidises capital (at rate $\tau_k^t$).\hspace{1cm} (8)

The debt level $B_g_t$ is set so that the debt-to-GDP ratio adjusts progressively to its target level $B_{g_{\text{target}}}$ that is exogenous:

$$B_g_t = \rho B_g_{t-1} + (1 - \rho B_g) B_{g_{\text{target}}} P_t Y_t$$  \hspace{1cm} (7)

where $P_t Y_t$ represents nominal GDP, and $\rho B_g$ is set to 0.95. We assume the public debt-to-GDP target to be lower in China (15%) than in the United States (60%).\hspace{1cm} (9)

In China under a fixed exchange-rate regime, the pension system also receives positive or negative transfers from the central bank, $D_{cb} t$. Finally, the level of pensions, $P_t$, is set so as to abide by the budget constraint set by Equation (7):

$$P_t = \tau_t W_t L_t + B_g_t + D_{cb} t - R_{t-1} B_{g_{t-1}} - PC_t G_t - \tau_k^t K_{t-1}$$  \hspace{1cm} (8)

$^{16}$This figure also corresponds to Ouyang et al. (2010) who find that almost 90% of reserve accumulation is sterilized in China.

$^{17}$In a flexible exchange-rate regime, there is no reserve accumulation, hence no sterilization and no transfer from the central bank to the pension system.

$^{18}$Taxing labor endowment rather than hours worked allows us to neglect the efficiency cost of taxation, hence to concentrate on the impact of the pension system on savings. Here, the tax has no impact on the labor market.

$^{20}$This feature aims at capturing the very high investment rate in China.

$^{20}$These figures correspond to the levels observed prior to the 2007-09 financial crisis.
2.6 Trade and the balance of payments

Domestic demand is the sum of households’ consumption and capital firms’ investment. This demand in country \( j \) \((j = c, u)\) is distributed across domestic goods \((D^j_t)\) and imported goods \((M^j_t)\) according to a Dixit-Stiglitz CES. Imports and domestic demand of China and the US write:

\[
M^c_t = \eta^c \left( \frac{S^c_t P^c_t}{P^m_t} \right)^{-\phi} (I^c_t + C^c_t + G^c_t), \quad D^c_t = (1 - \eta^c) \left( \frac{P^c_t}{P^m_t} \right)^{-\phi} (I^c_t + C^c_t + G^c_t),
\]
\[
M^u_t = \eta^u \left( \frac{P^u_t}{P^m_t} \right)^{-\phi} (I^u_t + C^u_t + G^u_t), \quad D^u_t = (1 - \eta^u) \left( \frac{P^u_t}{P^m_t} \right)^{-\phi} (I^u_t + C^u_t + G^u_t),
\]

where \( I^j_t, C^j_t, PC^j_t \) and \( P^c_t \) denote investment, consumption, the consumer price index and the producer price index for country \( j \), \( \phi > 0 \) is the elasticity of substitution and \( \eta^j > 0 \) represents trade openness.

The trade balance of China writes, in yuan:

\[
TB^c_t = P^c_t M^a_t - S^c_t P^m_t M^c_t \quad (9)
\]

By construction, the trade balance of the United States is the opposite of the trade balance of China: \( TB^u_t = -TB^c_t/S^t_c \). The balance of payments can finally be written as:

\[
[S_t(Bh^{c,a}_t + FR_t) - Bh^{c,e}_t] = [S_t(Bh^{a,a}_{t-1} + FR_{t-1})R^m_{t-1} + Bh^{a,e}_{t-1}R^c_{t-1}] + TB^c_t \quad (10)
\]

The left hand-side of the above equation is the net foreign asset position of China. The equality is obtained with either exogenous exchange rate \( S_t \) and endogenous official reserves \( FR_t \) (fixed exchange-rate regime), or exogenous reserves \( FR_t \) and endogenous exchange rate \( S_t \) (free floating regime). In the former case, reserve accumulation mechanically compensates for the sum of current account surpluses and net private capital inflows. However, when the stock of reserves exceeds the PBoC’s target, China’s interest rate declines (see 6), which reduces the needs for further reserve accumulation through lowering net private capital inflows. This setting allows the level of reserves not to grow indefinitely.

2.7 Calibration and the steady-state

The calibration of the key parameters, and the differences between the two countries, are already discussed in the previous sub-sections. In order to keep the interpretation of the results as simple as possible, with assume identical parametrization for the other equations. In particular, mark-ups are set to 15% both on the goods and on the labor market. Prices are set every three quarters and wages every four quarters, which is traditional in estimated macro-models. The depreciation rate is set to 0.02 (i.e 8% per year). Assuming similar nominal rigidities and depreciation rates may appear a strong approximation. However empirical estimates are lacking to calibrate any difference between the two countries.

This choice of similar parameters may appear controversial when it comes to demography. Note however that we are interested in changes in the generosity of China’s PAYG system rather than in the impact of the aging process itself. Therefore, and consistent with the literature, we set \( \theta_g = 0.99 \) (probability to stay alive in the next period), and \( \gamma_g = 0.985 \) (proportion of labor endowment that
remains in the next period, assuming that 2/3rds of the adult period is worked.\footnote{These parameters may appear too low from a demographic point of view, as they lead to the extinction of half of a cohort after 17.25 years, and to the retirement of half of the labor force after 11.5 years. However, when estimating the parameter $\theta_g$ in a different context (wealth effects), Castelnovo & Nisticò (2010) find $\theta_g = 0.9$, corresponding to a half-life of 1.5 years which is obviously very low. Our calibration lies in between the pure generation interpretation and the wealth effect estimation.} The full set of parameters is given in Table D.1 in Appendix, while the steady state is depicted in Table D.2. The US economy is supposed to be twice the Chinese one. The share of consumption in GDP is around 70 percent in the US but only 46 percent in China. Conversely, the share of investment is 17 percent in the US, against 37 percent in China. The real interest rate is 3.8 percent in both countries, consistent with a stable real exchange rate.

We now turn to two series of simulations of the model. In Section 3, we study the impact of a pension reform in China leading to a rise in the national saving rate, under different monetary regimes. In Section 4, we assume that China stays on a high-saving path and study the impact of a monetary reform.

### 3 Impact of a pension reform in China

The very high saving rate in China during the 2000s has attracted much attention from both policymakers and researchers. Ma & Yi (2010) note that gross national savings reached 54 percent of GDP in 2008, up from 39 percent in 1990 and 36 percent in 2000. They argue that what is special in China is the conjunction of high saving rates in the three sectors of the economy: households, corporations, and the government. Consistently, the vast literature on China's savings has investigated the three sectors of the economy.\footnote{See, e.g., Ma & Yi (2010), Guo & N'Diaye (2010), Jia et al. (2009), Horioka & Wan (2007), Feng et al. (2009), Chamon & Prasad (2010), Baker & Orsmond (2010), Cui & Azziz (2007), Chamon et al. (2010), Prasad (2009), Bayoumi et al. (2010), Huang & Wang (2010).} As already mentioned in the introduction, here we focus on the household sector.

The rise in households saving rates (as a percentage of disposable income) is generally attributed to the attrition of the social safety nets (the retreat of enterprise-based safety nets having not been taken over by the public system), together with a general rise in uncertainty due to structural change and a rising share of education expenditures falling on families. The rise in private home ownership and the 1997 pension reform (with a reduction in its generosity) have also played a role, in combination with the delayed effect of the one-child policy (and the subsequent lack of support expected for the old age). All these factors were amplified by financial underdevelopment, which has limited the access of households to bank loans as well as the diversification opportunities for their assets.

We consider an increase in the generosity of the Chinese PAYG pension system (an increase in the replacement rate corresponding to a transfer from workers to retirees of 3 percent of GDP) financed through an increase in the tax rate on labor endowment. In our overlapping-generation model, the reform induces a net transfers from future generations (that will partially bear the cost of the alive-generations' higher pensions) to alive generations (that benefit from higher future pensions but on average do not pay the full cost of it). Hence, aggregate consumption is boosted in the short run.\footnote{The reform also induces transfers across alive households since elder households benefit immediately without bearing its cost, contrasting with younger households. However, in our overlapping-generation model, this redistribution drives no change in the aggregate saving rate as the propensity to consume wealth is independent from age. The transitory}
The reform is simulated under three monetary regimes in China, successively:

**StatQuo**: A fixed exchange rate against the dollar with low capital mobility and extensive sterilization of interventions;

**CapMob**: A fixed exchange rate against the dollar with high capital mobility and limited sterilization of interventions;

**Flex**: A flexible exchange rate with high capital mobility, no interventions, hence no sterilization.

The corresponding key parameters are reported in Table 1.

<table>
<thead>
<tr>
<th>Regime</th>
<th>Exchange-rate regime</th>
<th>Capital mobility $\gamma$</th>
<th>Sterilization $\nu_{steril}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>StatQuo</td>
<td>Fix</td>
<td>0.5</td>
<td>0.9</td>
</tr>
<tr>
<td>CapMob</td>
<td>Fix</td>
<td>0.9</td>
<td>0.1</td>
</tr>
<tr>
<td>Flex</td>
<td>Flex</td>
<td>0.9</td>
<td>0</td>
</tr>
</tbody>
</table>

In autarky, the fall in aggregate savings following the shock would induce a higher real interest rate, hence lower capital accumulation. Here, to the extent that capital controls are not complete, the rise in the interest rate induces net capital inflows, so the Chinese NFA falls in the long run (Table 2). With high capital mobility (CapMob or Flex regime), the capital stock falls less in the long run than under the StatQuo regime (the net holdings of capital firms increase less). Capital mobility also increases the impact of the shock on households’ decumulation. On the whole, China’s NFA position declines more. We now turn to the dynamic reaction of both economies to the pension reform, with a standard and a constrained monetary policy in the United States, successively.

### 3.1 Chinese pension reform with standard monetary policy in the United States

The impulse-response functions are depicted in Figure 2. The upper panel shows the dynamic reaction of the Chinese economy while the bottom one reports the spillover effect on the US one. The dotted increase in aggregate consumption then comes from the fact that part of the cost of the reform will be borne by future generations.

<table>
<thead>
<tr>
<th>Regime</th>
<th>DB</th>
<th>FB</th>
<th>DB</th>
<th>FB</th>
<th>DB</th>
<th>FB</th>
</tr>
</thead>
<tbody>
<tr>
<td>StatQuo</td>
<td>4.4</td>
<td></td>
<td>4.1</td>
<td></td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>CapMob</td>
<td>0.0</td>
<td>-0.1</td>
<td>0.0</td>
<td>-0.1</td>
<td>0.0</td>
<td>-0.1</td>
</tr>
<tr>
<td>Flex</td>
<td>-5.4</td>
<td>-0.5</td>
<td>-8.8</td>
<td>-2.4</td>
<td>-8.8</td>
<td>-2.4</td>
</tr>
<tr>
<td>Nation</td>
<td>-0.9</td>
<td>-0.6</td>
<td>-4.7</td>
<td>-2.5</td>
<td>-4.7</td>
<td>-2.4</td>
</tr>
<tr>
<td>NFA</td>
<td>-1.5</td>
<td></td>
<td>-7.2</td>
<td></td>
<td>-7.1</td>
<td></td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>0.6</td>
<td></td>
<td>0.1</td>
<td></td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

Source: Author calculations.
line refers to the StatQuo regime (fixed peg, low capital mobility), the plain, gray line to the CapMob one (fixed peg, high capital mobility) and the plain, dark line to the Flex regime (free float, high capital mobility).

**Impact on the Chinese economy.** Consumption in China surges following the shock, but the extent of this surge depends on the monetary and financial regime. In the StatQuo regime, the Chinese interest rate is largely independent from the US one in the short run: it rises in reaction to higher inflation. This long-lasting increase in the interest rate mitigates the impact of the reform on consumption (+0.6 percent of GDP in the short run) and drives investment downwards (-0.2 percent of GDP). GDP and employment increase in the short run but the hike is short-lived: higher consumption induces households to reduce their labor supply ex ante, which leads to a wage increase that feeds inflation (+0.6 pp in annual terms); hence the real exchange rate appreciates and the trade balance deteriorates (-0.2 percent of GDP). The rise in China’s interest rate also attracts foreign capital inflows (and reduces incentives for China’s residents to invest abroad). Despite low capital mobility, this change in net capital flows exceeds the deterioration of China’s trade balance, so the central bank slightly increases its foreign-exchange reserves (+0.4 percent of GDP) to keep the nominal exchange rate constant. This in turn mitigates the rise in the interest rate. Due to higher inflation, the real exchange rate appreciates during the first six quarters, before falling back.

When capital controls are removed while the peg is maintained (CapMob regime), large capital inflows limit the reaction of the interest rate to the shock in the short run and raise that of consumption. Capital inflows are compensated by larger reserve accumulation (+1.1 percent of GDP). Since sterilization is limited in this regime, there are significant transfers from the central bank to the pension system, which adds to the dynamism of consumption (+0.9 percent of GDP) and inflation (+1.3 pp). The trade balance deteriorates more than in the StatQuo case (-0.4 percent of GDP), and the NFA position falls much more rapidly.

In the Flex regime (with no capital controls), the central bank no longer accumulates foreign-exchange reserves whenever there is a surge in capital inflows (or a drop in capital outflows). Rather, it allows the nominal exchange rate to appreciate. Hence, following a rise in the generosity of the Chinese pension system (and the subsequent decrease in households’ savings in China), there is both a rise in the domestic interest rate and an immediate appreciation of the renminbi. Contrasting with the previous cases, inflation slightly decreases in the short term (-0.1 pp). Consumption rises less than under the CapMob regime (but more than under the StatQuo one). Due to the sharp fall in the trade balance in the short run (-0.45 percent of GDP), GDP now falls below its baseline level, and so does employment. After six quarters, however, the trade balance is the same as under the CapMob regime, and the dynamics of the NFA position is similar in the two regimes. This is consistent with the one-off appreciation of the renminbi, contrasting with progressive appreciation through cumulated inflation differentials under a fixed peg.

If Chinese authorities’ objective function is close to that of the households, hence if it focuses on consumption, then the best regime is the CapMob one since this is the regime yielding the highest increase in consumption. Conversely, if Chinese authorities are mainly concerned with inflation, then the pension reform should be carried out under the Flex regime. Finally, if Chinese authorities consider

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24 In all simulations, employment varies like GDP, hence this graph is omitted in the Figures to save space.

25 The renminbi subsequently depreciates, consistent with the interest-rate differential and rational expectations.
employment as the main objective, as it has been the case since the mid 1990s, then our simulations suggest that the peg should be maintained while the pension reform is being implemented.

**Impact on the US economy.** The transmission of the shock to the United States comes from increased imports by Chinese households (which boosts US GDP) and from higher returns on Chinese bonds (which offers an incentive for US households to invest in China and reduces the incentive of Chinese residents to invest in the US). Since both channels are the two sides of the same coin, the transmission is magnified when capital is more mobile. In the long run, the StatQuo regime isolates the US economy from China’s interest-rate increase. This means that, already in the short run, households anticipate relatively low interest rates in the future. Accordingly, they hardly change their saving plan, and the fall in consumption is very limited in the short run. In contrast, the CapMob and the Flex regimes produce a larger pass-through from the Chinese interest rate to the US one in the long run, so households reallocate more their consumption intertemporally. Consistently, consumption decreases by a larger amount and during a longer period.

Absent the flexibility of the exchange rate, exports to China increase slowly and GDP falls slightly below potential in the short run. After two quarters, the rise in US GDP comes along with a rebalancing of the US economy since both consumption and investment fall in this country due to a higher interest rate. But only with high capital mobility is such rebalancing significant. Under a flexible regime, the immediate appreciation of the renminbi stimulates US exports and GDP in the very short run. Simultaneously, the fall in consumption is larger in the very short run than under a fixed peg, because the interest rate itself increases more rapidly. After 6-7 quarters, however, US exports, consumption and GDP are similar under the Flex and the CapMob regimes. Hence, except in the short run, a flexible exchange rate in China does not make much difference for the United States, to the extent that capital controls are removed.

3.2 Chinese pension reform with constrained monetary policy in the United States

In the above simulation, the impact of the Chinese reform on the US economy is partially channeled through the Federal Reserve’s policy rate, the increase of which lowers aggregate demand. However, the Federal Reserve may oppose such interest-rate increase if its Taylor rate is initially negative. To account for this possibility, we alternatively assume that, for the next eight quarters following the shock, US monetary policy follows a modified rule with much more inertia in the interest rate (see Section 2.4). The results are reported in Figure 3 for the same, three monetary regimes in China as previously. Since the zero-interest rate policy (ZIRP) only binds in the short and medium run, the long-run impact of the pension reform is the same as before, but the dynamics differ. Comparing Figure 3 with Figure 2, it appears clearly that the US policy rate increases much less with the ZIRP than with a Taylor rule during the first eight quarters of the simulation. Consistently, US consumption increases instead of declining during this period. The amount of rebalancing now is more dependent on China’s monetary regime, as evidenced by the evolution of China’s trade balance: under the StatQuo regime, the pension reform in China produces almost no rebalancing in the short run; and the amount

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26Potential GDP increases due to a higher saving rate that encourages labor supply.
Figure 2: Impact of a pension reform in China

**Impact on China**

- Consumption
- Investment
- Inflation
- Net foreign assets
- Real exchange rate
- Nominal interest rate
- Real GDP
- Trade balance
- Official reserves

**Impact on the US**

- GDP
- Consumption
- Nominal interest rate

Legend:

- StatQuo
- CapMob
- Flex
Figure 3: Impact of a pension reform in China with constrained monetary policy in the United-States

**Impact on China**

- Consumption
- Investment
- Inflation
- Net foreign assets
- Real exchange rate
- Nominal interest rate
- Real GDP
- Trade balance
- Official reserves

**Impact on the US**

- GDP
- Consumption
- Nominal interest rate

---

- StatQuo
- CapMob
- Flex
of rebalancing is now more than doubled if the renminbi is allowed to float, compared to the CapMob regime.

Turning to China, the main difference between Figures 2 (Taylor rule in the US) and 3 (ZIRP in the US) occurs under a fixed exchange rate, especially when capital controls are removed. In this case, Chinese monetary policy closely follows the US one. Other things equal, the increase in the Chinese interest rate is muted, which produces more inflation, a larger fall in the real interest rate, hence a higher increase in consumption and a slower decrease in investment. Consequently, the increase in real GDP is almost doubled compared with the Taylor-rule case: the policy trade-off between employment and inflation is twisted in favor of the former. Conversely, under a Flex regime, the results for China are close whether the Fed follows a Taylor rule or a ZIRP because China's monetary policy is isolated through the flexible exchange rate.

On the whole, our simulation under a ZIRP in the United States highlights the role of exchange-rate flexibility to reap the full gain of the Chinese structural reform both for China (to reduce inflationary pressures) and for the US (to rebalance its economy) when the US monetary policy is constrained, hence when no rebalancing can be achieved through an increase in the US interest rate.

4 A monetary reform in China when the economy is far from the steady-state

One limitation of the simulations presented in Section 3 is that they analyze the impact of a Chinese reform as deviations from a baseline which is a balanced steady-state. This feature hardly matches the debate on global imbalances that blames cumulated imbalances and discusses how these imbalances could unfold. Here we tackle this issue by studying the impact of a monetary reform in China when the economy is not at the steady state but rather displays large current-account surpluses.

We rely on two alternative explanations to current-account surpluses in China. In the first one, surpluses derive from a "reverse" pension reform that reduced the generosity of the system. In the second one, we assume that excess savings are driven by the behavior of the central bank that deliberately accumulated foreign exchange reserves while private capital flows were constrained (see Cová et al. (2009), Jeanne (2011)). Although we are unable to reproduce the extent of cumulated imbalances in the 2000's (since such accumulation violates inter-temporal optimization), our simulations are instructive qualitatively. We simulate two alternative "imbalance" shocks, successively: (i) a permanent fall in the replacement rate of the PAYG pension system in China, and (ii) a progressive rise in the target level of China's official reserves. In each case, the shock is performed under the StatQuo regime but after 15 quarters, the monetary regime shifts to Flex (and it subsequently keeps the level of official reserves constant).

The regime shift is assumed not to be anticipated by the markets.

\[27\] A monetary reform carried out while the economy is at the steady state would have no impact in our model, contrasting with a structural reform.

\[28\] The choice to undertake the monetary reform after 15 quarters results from the necessity to have the reform take place once the economy has already accumulated significant imbalances. It does not change the results qualitatively to select a shorter or a longer period.
Table 3: Long-run impact of the "reverse" pension reform on China's external position, in percent of GDP

<table>
<thead>
<tr>
<th>Benchmark case</th>
<th>Soft target</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>StatQuo</td>
</tr>
<tr>
<td></td>
<td>DB  FB</td>
</tr>
<tr>
<td>K-firms</td>
<td>-4.4  -4.0</td>
</tr>
<tr>
<td>Government</td>
<td>0.0   0.0</td>
</tr>
<tr>
<td>Central bank</td>
<td>-0.1  0.1</td>
</tr>
<tr>
<td>Households</td>
<td>5.4  0.5</td>
</tr>
<tr>
<td>Nation</td>
<td>0.9  0.6</td>
</tr>
<tr>
<td>NFA</td>
<td>1.5  7.0</td>
</tr>
<tr>
<td>Real exch. rate</td>
<td>-0.6  -0.1</td>
</tr>
</tbody>
</table>

Net holdings of domestic (DB) and foreign (FB) bonds, deviations from baseline. Source: Author calculations.

4.1 Pension "reverse" shock

First, we consider a reduction in the generosity of China's pension system, consistent with the 1997 pension reform that, according to Feng et al. (2009), boosted saving rates by about 6 percentage points for young households (aged 25-29) and 3 percentage points for older ones (aged 50-59) by year 1999. We assume that the replacement rate is reduced by an amount corresponding to a transfer from workers to retirees of 3 percent of GDP.\(^{29}\) The long-run impact of the shock on China's balance sheet is depicted in Table 3, depending on the monetary regime and, during the fixed exchange-rate regime, depending on whether the central bank cares about the level of official reserves (benchmark case, \(\alpha_{FR} = 0.1\)) or does not care ("soft target" case, \(\alpha_{FR} = 0.01\)). Not surprisingly, given the calibration of the shock, the results for the StatQuo, benchmark case and for the Flex regime are the same, with opposite signs, as in Table 2, i.e. with a positive shock on the generosity of the pension system: the NFA position increases in the long run, all the more that capital controls are relaxed; the real exchange rate depreciates slightly (and more so in the StatQuo regime than in the Flex regime). Additionally, Table 3 shows that the "reverse" pension shock produces more imbalances when the central bank does not care accumulating more reserves (soft target case): the NFA position of China rises more in the long run. Finally, moving from StatQuo to Flex after 15 quarters (MonRef regime) leads to more NFA accumulation in the long run than staying in the StatQuo regime (due to the relaxation of capital controls) but also more NFA accumulation than when the Flex regime is in place during the whole simulation. The latter result can be explained by large reserve accumulation before the monetary reform is carried out (thanks to capital controls, the central bank can "force" households to hold more sterilization bonds, see Table 3). Since the monetary reform does not involve selling off the reserves, the NFA position is higher in the long run than when the Flex regime is implemented from the beginning of the simulation.

We now analyze the dynamic impact of the monetary reform. The impulse-response functions are reported in Figure 4. The dotted line corresponds to the simulation with a fixed exchange rate over the entire period of simulation (StatQuo); the plain, black line assumes a flexible exchange rate (Flex);

\(^{29}\) Due to the introduction of individual account benefits, it is not easy to calculate the fall in the replacement rate involved by the 1997 reform. For simplicity, we use the same calibration as in the previous section of the paper, albeit in opposite direction.
finally, the grey line (MonRef) shows the path of the economy when switching from StatQuo to Flex after 15 quarters, our focus in the following. The restrictive pension shock leads to a fall in Chinese consumption in the short run. The interest rate decreases due to deflationary pressures. This has two consequences: (i) a rise in investment, and (ii) a net outflow of capital. Consistently, the trade balance surges and the NFA position rises. The real exchange rate of China depreciates during several quarters before appreciating towards its long run equilibrium given by Table 3. Under the fixed peg, the central bank of China initially reduces its official reserves to counter-balance the (limited) outflow of capital. After two quarters, it starts accumulating reserves to ensure the equilibrium of the balance of payment with higher trade surplus, but this accumulation is limited due to private net capital outflows.

The switch from a fixed to a flexible regime freezes official reserves at an inflated level compared to the steady state. The switch takes place while the nominal, policy interest rate is still depressed in China relative to the United States. Since the monetary change includes a relaxation of capital controls, there is a sudden outflow of private capital, and the renminbi initially depreciates further. Due to lower purchasing power, consumption declines. There is a short-run hike in inflation due to the depreciation of the exchange rate. On the whole, the regime shift triggers an increase in the trade surplus, before accompanying the economy back to its balanced path through a strong appreciation of the real exchange rate.

When the regime shift takes place, US GDP is negatively affected (because the dollar appreciates) but US consumption is boosted (due to the higher purchasing power of US households). This mirror image of China confirms the failure of the regime shift to rebalance the US economy.

The lack of rebalancing following a switch of China from a pegged regime to a flexible one arises from the combination of a depressed interest rate and the relaxation of capital controls. One reason for the fall in the interest rate is the accumulation of foreign exchange reserves above the target level of the central bank, which induces the latter to maintain the peg through a lower interest rate rather than through continued reserve accumulation. In Figure 5, we perform the same "reverse" pension shock with a switch in the monetary regime after 15 quarters. However now we assume that the central bank cares much less about the level of foreign-exchange reserves: even when reserves are above target, it is willing to accumulate more reserves ("soft target" case). Consistently, there is much more reserve accumulation before the exchange rate is freed, and the interest rate now only depends on inflation. The implication is that, when the monetary reform takes place, the interest rate is close to its steady-state level, which reduces the immediate depreciation of the yuan and the rise in the trade balance. In the long run, however, since the central bank has accumulated more reserves, China's NFA position is higher than in the benchmark case.

Reciprocally, this means that, under the StatQuo regime, the pension reform described in the previous section will produce more rebalancing if the central bank does not care reducing the level of foreign exchange reserves. This suggests that the central bank's policy regarding the level of official

30. Alternatively, we could assume that the PBoC progressively reduces its excess reserves when switching to a flexible regime. However, this would amount to piling up two shocks: a change in the monetary regime, and a portfolio shock. The results would have been less clear cut.

31. One may wonder why moving to exchange-rate flexibility while the exchange rate is undervalued leads to an immediate depreciation rather than an appreciation. The reason is the uncovered interest parity with rational expectations: the exchange rate initially jumps to a path where it then appreciates at a pace that is consistent with the interest-rate differential. Before the monetary reform takes place, the exchange-rate is undervalued compared to its long-run, equilibrium level, not compared to its short-term, market level.
reserves (independently from the decision to hold the exchange rate constant) is key to the amount of rebalancing. We come back to this point in the next sub-section. For the time being, we conclude that switching to a flexible regime (with high capital mobility) in a situation of depressed demand would put downward rather than upward pressure on the renminbi in the short run unless (i) structural reforms are simultaneously (or previously) carried out to reduce aggregate savings in China and/or (ii) the PBoC decides to sell excess reserves. Of course, this stylized result may be mitigated by the initial return differential between China and the United States. It should be reminded here that only bonds remunerated at the policy rate are traded between the two countries: in our model, then, relaxing capital controls does not induce US investors to buy high-return Chinese stocks, which may put upward pressure on the RMB. Still, the model highlights the complementarity between monetary and structural reforms to engineer a fast rebalancing of the economy.

4.2 Reserve accumulation shock

One puzzling result of the "reverse" pension reform simulation is the limited amount of reserve accumulation it produces (only 1.3 percent of GDP after 15 quarters in the "soft target" case), which does not match observed accumulation of 15 percent of GDP between 2003Q1 and 2007Q2 (15 quarters), and another 6 percent between 2007Q2 and 2010Q4 (see COFER data from the IMF). Cova et al. (2009) argue that the rise in emerging Asia's current account surplus after 2001 may be related to an increase in desired NFA. In the case of China, due to capital controls, this suggests an increase in the target level for official reserves. Here, we assume that this target increases progressively by 20 percent of GDP in 20 years. Accordingly, the interest rate rule of the Chinese central bank is shifted upward in order to be consistent with the constant exchange rate (see Equation (5)). Like in the previous exercise, China is assumed to shift to a flexible regime after 15 quarters. Here we use the benchmark parameterization of the central bank’s reaction function. The long-run impact of the shock on China’s balance sheet is reported in Table 4. In the StatQuo regime, China’s NFA position rises by 18.8 percent of GDP in the long run, and the real exchange rate appreciates by 1.9 percent. With the monetary reform, the rise in NFA is only 8.7 percent of GDP.

<table>
<thead>
<tr>
<th>StatQuo</th>
<th>MonRef</th>
</tr>
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<tbody>
<tr>
<td>K-firms</td>
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<td>NFA</td>
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</tr>
<tr>
<td>Real exchange rate</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Net holdings of domestic (DB) and Foreign (FB) bonds, deviations from baseline. Source: Author calculations.
Figure 4: Flexibilization of China’s exchange rate after a "reverse" pension reform, benchmark case

**Impact on China**

- Consumption
- Investment
- Inflation
- Net foreign assets
- Real exchange rate
- Nominal interest rate
- Real GDP
- Trade balance
- Official reserves

**Impact on the US**

- GDP
- Consumption
- Nominal interest rate

--- StatQuo  --- MonRef  --- Flex ---
Figure 5: Flexibilization of China’s exchange rate after a "reverse" pension reform, soft target

**Impact on China**

- **Consumption**
- **Investment**
- **Inflation**
- **Net foreign assets**
- **Real exchange rate**
- **Nominal interest rate**
- **Real GDP**
- **Trade balance**
- **Official reserves**

**Impact on the US**

- **GDP**
- **Consumption**
- **Nominal interest rate**

- - StatQuo — MonRef — Flex
The dynamics is displayed in Figure 6. The dotted line again represents the simulation under the StatQuo regime while the plain, gray line represents the path of the economy when switching from StatQuo to Flex after 15 quarters.\textsuperscript{32} To the extent that reserve accumulation is rationally anticipated, the real interest rate is expected to be higher in China until the level of reserves has reached its new target. As a consequence, consumption initially drops (intertemporal substitution effect). Inflation decreases in the short run, the real interest rate increases but the nominal interest rate starts by a fall to mitigate the decline in Chinese inflation. Despite the fixed nominal exchange rate, the real exchange rate depreciates. Due to nominal rigidities, the depreciation is spread over several quarters. The Chinese economy progressively accumulates trade surpluses (1.2 percent of GDP in the short run, 1.7 percent after two years), hence assets on the US economy in the form of official reserves. Symmetrically, consumption increases in the US thanks to a lower expected level of real interest rate in the medium run, whereas GDP is lowered as domestic demand shifts in favor of imported goods.

After two years, the real exchange rate appreciates through a recovery of inflation in China. Then, a monetary reform that encompasses the relaxation of capital controls, a shift to a flexible exchange rate regime and a freeze of official reserves at their inflated, current value of 11.2 percent of GDP induces an immediate appreciation of the renminbi back to its baseline value, and a rebalancing of the economy as consumption increases in China while falling in the US. The trade balance falls by 1.5 percent of GDP on impact.

This last simulation suggests that a complete reversal of the Chinese monetary strategy could be powerful to curb global imbalances, provided it corresponds to a halt in China’s government strategy to increase the NFA position of the country through reserve accumulation and capital controls.

5 Conclusion

We have constructed a two-country model to study different scenarios of global rebalancing depending on (i) structural reforms decided in China, (ii) the monetary regime of China, (iii) the constraints on monetary policy in the United States and (iv) the initial level and origin of cumulated imbalances. Our simulations suggest that, if monetary policy follows a standard, Taylor rule in the United States, then a structural reform in China that reduces aggregate savings is a powerful driver of global rebalancing, provided there is some relaxation of capital controls. A flexibilization of the renminbi can accelerate the rebalancing but has only a minor effect on its extent. For China, switching to a flexible exchange-rate regime during the reform raises a clear trade-off between inflation (which would be stabilized with a flexible regime) and employment (which would suffer).

Now, if the US monetary policy is constrained by the zero bound of the interest rate, then a move to a flexible exchange-rate regime in China has more impact on the amount of the rebalancing. In this case, the Federal Reserve refrains from hiking its interest rate when global savings are reduced: the rebalancing can only come from a depreciation of the dollar against the renminbi, hence from a more flexible exchange-rate regime in China. The US ZIRP also modifies the policy trade-off in China since removing capital controls while keeping a fixed peg on the dollar would amount to adopting the US ZIRP, hence let Chinese inflation develop without control.

\textsuperscript{\textsuperscript{32}}The Flex regime is not represented here because it does not involve reserve accumulation. In the case of official reserves, the plain, dark line represents the reserve target.
Figure 6: Flexibilization of China’s exchange rate after a reserve accumulation shock

Impact on China

- Consumption
- Investment
- Inflation
- Net foreign assets
- Real exchange rate
- Nominal interest rate
- Real GDP
- Trade balance
- Official reserves

Impact on the US

- GDP
- Consumption
- Nominal interest rate

Official reserves: dark line represents the evolution of the target.
We then account for cumulated imbalances. Specifically, we perform the reverse exercise where an initial reduction in the generosity of China’s pension system (as with the 1997 reform) raises the saving rate of households, triggering net foreign asset accumulation under a fixed peg, before the renminbi is eventually allowed to float. To the extent that the switch from a peg to a float is accompanied by a relaxation of capital controls but not by structural reforms reducing the saving rate, and assuming that China’s official reserves are frozen at their observed level when switching to the floating regime (not sold out), then the regime shift involves downward pressure on the renminbi, which delays rather than accelerating the rebalancing. The reason is the large outflow of private capital involved by the conjunction of a low policy rate in China (related to excess savings) and the relaxation of capital controls.

Alternatively, if China’s current-account surpluses are the result not of depressed consumption but of a rise in the official reserve target, then the move to a flexible regime (with frozen reserves) does produce the desired rebalancing features, with immediate appreciation of the exchange rate and subsequent reduction in the trade surplus.

On the whole, our analysis suggests that what is key in the success of the rebalancing is not the monetary reform in itself, but the accompanying shift in the government strategy concerning NFA accumulation: on the one hand, a pension reform in China that would reduce households’ savings would be successful in curbing the current-account surplus whatever the monetary regime, although capital mobility would help and exchange-rate flexibility would accelerate the process; on the other hand, a monetary reform could fail to rebalance the economy unless the government simultaneously acts to curb NFA accumulation through consumption-enhancing reforms or a reduction in its objective in terms of reserve accumulation.

**Bibliography**


Appendix

A Households' program

A.1 Households at the cohort level

Here we describe the household behavior in China. Similar equations apply to the United States, with adapted subscripts and inverse exchange rate.

In China, the inter-temporal budget constraint of a household born at time \(a\) and still living at time \(t\) writes:

\[
P_C^e C_{a,t}^e + \mathcal{A}_{a,t}^c = W_t^e L_{a,t}^e - \tau_t^e W_t^e L_{t-a} + \Omega_a^c + \mathcal{P}_{a,t},\]

where \(P_C^e\) denotes the consumption price index, \(\mathcal{A}_{a,t}^c\) is the end-of-period \(t\) asset holding, \(W_t^e L_{a,t}^e - \tau_t^e W_t^e L_{t-a}\) is the after-tax wage income.\(^{33}\) \(\Omega_a^c\) represents beginning-of-period \(t\) financial wealth, and \(\mathcal{P}_{a,t}\) is the pension received from the government during period \(t\).

Different types of assets enter the composition of the Chinese household's portfolio at the cohort level: (i) a complete set of contingent assets traded among alive domestic households, (ii) domestic equities and (iii) dollar-denominated bonds. When aggregating across households (considering the household sector instead of each individual household), holdings of contingent claims reduce to a net holding a yuan-denominated risk-free bonds. Similarly, holdings of domestic equities reduce to a claim on current and future profits of firms. Still, the detailed description of asset holdings at the cohort level is necessary since it is at this level that on among households and a proper definition of the program of firms and unions require first order conditions at to be derived.

The representative household of the cohort born at date \(a\) holds a share \(Z_{a,t}^{c}(f)\) of each domestic firm \(f\) \((f\) being either a production or a capital firm), a complete set of contingent claims in yuan \((B_{a,t+1}^{c,e})\) and risk-free nominal bonds in dollar \((B_{a,t}^{c,n})\). The value of his/her portfolio \(\mathcal{A}_{a,t}^c\) at the end of period \(t\) writes:

\[
\mathcal{A}_{a,t}^c = \mathbb{E}_t \left\{ \mathcal{F}_{t+1} B_{a,t+1}^{c,e} \right\} + S_t B_{a,t}^{c,n} + \int_f Q_{t+1}(f) Z_{a,t}^{c}(f) df
\]

where \(Q_{t+1}(f)\) is the end-of-period nominal equity price of firm \(f\), \(\mathbb{E}_t\) is the exchange rate and \(\mathcal{F}_{t+1}\) is the price at \(t\) of a contingent claim providing one yuan when the corresponding state of nature occurs at \(t+1\) (we assume that there are as many contingent claims as possible states of nature at \(t+1\)). Each item of the portfolio has its specific return, depending on the state of nature at \(t+1\), which is revealed at the beginning of \(t+1\). Hence the return of the portfolio depends on its composition \((B_{a,t+1}^{c,e}, B_{a,t}^{c,n}\) and \(Z_{a,t}^{c}(f)\)). Additionally, surviving households inherit the portfolio of deceased ones via their life-insurance contracts, which raises the portfolio return by a factor \(1/\theta_g\). At the beginning of period \(t+1\), after the state of nature has been revealed and the different returns have been received, financial wealth writes:

\[
\Omega_{a,t+1}^c = \begin{cases} 
\frac{1}{\theta_g} \left( B_{a,t+1}^{c,e} + S_{t+1} R_t^f B_{a,t}^{c,n} + \int_f Q_{t+1}(f) + D_{t+1}(f)) Z_{a,t}^{c}(f) df \right) & \text{if } a \leq t \\
0 & \text{if } a = t+1 
\end{cases}
\]

where \(D_{t+1}(f)\) is the dividend at \(t+1\) paid by the Chinese firm \(f\).

Each household decides his level of consumption, labor supply and asset holdings so as to maximize his intertemporal utility (1) under the budget constraint (11). The optimality conditions implied by the household program are the following:

\(^{33}\)In order to disentangle the redistributive from the allocation effect of labor taxation, we assume that the government is able to tax time endowment \(L_{t-a}\) rather than labor supply \(L_{a,t}^e\).
Consumption smoothing

\[ F_{t+1}^c = \beta \frac{PC_{t+1}^c}{PC_{t+1}^c + 1} \]

Labor supply

\[ L_{a,t} = L_{a-t} - \kappa C_{a,t-1} \]

Firm’s stock price

\[ Q_t(f) = E_t \{ F_{t+1}^c (D_{t+1}(f) + Q_{t+1}^c(f)) \} \]

Euler equation at the cohort level

\[ E_t \{ F_{t+1}^c R_{t}^c \} = 1 \]

where \( MRS_t \) denotes the marginal rate of substitution between consumption and leisure. It can be shown that, at the cohort level, consumption is a linear function of total wealth, i.e., of the sum of financial wealth \((\Omega_{a,t}^c)\) and human wealth \(HW_{a,t}^c\) (the future stream of labor and pension income) that can be recursively defined by

\[ HW_{a,t}^c = \left[ \frac{W_t^c L_{a,t} - \tau_t^c W_t^c L_{1-a} + PC_{a,t}}{1 - \kappa} \right] + \theta_y E_t \{ F_{t+1}^c HW_{a,t+1}^c \} \]

### A.2 Aggregation

The aggregate household behavior is described by two main relations: (i) aggregate labor supply and (ii) aggregate consumption. The former is easily derived through direct aggregation of cohort-specific labor supplies and is similar to the representative-agent case. The latter is proportional to total wealth, i.e., human wealth, \(HW^c\), (discounted sum of future net of tax labor income and pensions of already alive households), plus financial wealth, \(\Omega^c\), (the market value of equities and bonds).

\[ L_c^t = \frac{C_c^t}{1 - \kappa} \]

\[ PC_c^t C_c^t = \theta_y \left( HW_t^c + \Omega_t^c \right) \]

To evaluate the nominal stochastic discount factor, \(F_t^c\), we introduce a new variable, the relative consumption of the young \(rcy_t^c\), that is specific to overlapping-generation models. One then has:

\[ F_t^c = \frac{\theta_y \beta}{1 - (1 - \theta_y)rcy_t^c} \frac{PC_{t-1}^c C_{t-1}}{PC_c^t C_c^t}, \]

where

\[ rcy_t^c = \frac{HW_t^c + \Omega_t^c}{HW_t^c + \Omega_t^c} \]

Lastly, in order to keep a single convention for yuan-denominated and dollar-denominated risk-free bond definitions, aggregate yuan-denominated bond holdings at the end of period \(t\) write \(B_{tt+1}^c = (1 - \theta_y) \sum_{a \leq t} F_{t+1} B_{a,t+1}^c\) and the domestic bond value at the beginning of period \(t+1\) is given by \(R_t^c B_t^c\).

### B Unions and firms

The behaviors described in this subsection do not involve any international transaction or price. Therefore, we skip the country superscript. \(F_t^{t+s}\) denotes the stochastic discount factor between \(t\) and \(t+s\) (while \(F_t^c\) denotes the stochastic discount factor between \(t-s\) and \(t\)).

#### B.1 Unions and wage setting

The representative union that has the opportunity to reset its wage at period \(t\) chooses \(W_t^*\) so as to maximize the following objective function:

\[ E_t \sum_{s=0}^{\infty} (\theta_y \theta_w)^s F_t^{t+s} (W_t^* - MRS_{t+s} PC_{t+s}) \left( \frac{W_t^*}{W_{t+s}} \right)^{-\tau_w} L_{t+s} \]
The union will then receive $W_t^*$ from the firms and pay $MRS_{t+s}PC_{t+s}$ to the households at each period $t + s$ before it can again reset the wage. The first-order condition of the program defined by Equation (19) is:

$$W_t^* = \frac{\epsilon_w}{1 - \epsilon_w} \frac{X_t^w}{Z_t^w} W_t,$$

where

$$X_t^w = \mathbb{E}_t \left\{ \sum_{s=0}^{\infty} (\theta g_{w})^s F_{t}^{t+s} \left( \frac{W_t}{W_{t+s}} \right)^{-1-\epsilon_w} PC_{t+s} MRS_{t+s} L_{t+s} \right\},$$

and

$$Z_t^w = \mathbb{E}_t \left\{ \sum_{s=0}^{\infty} (\theta g_{w})^s F_{t}^{t+s} \left( \frac{W_t}{W_{t+s}} \right)^{-\epsilon_w} L_{t+s} \right\}.$$

**B.2 Producing firms and price setting**

Letting $W_t$ and $r_k_t$ denote the nominal wage and the rent cost of capital, respectively, the marginal cost $MC_t$ writes

$$MC_t = \frac{1}{\lambda_t} \left( \frac{1}{\alpha} \right)^{\alpha} \left( \frac{1}{1 - \alpha} \right)^{1-\alpha} r_k_t W_t^{1-\alpha}. \quad (20)$$

A producing firm that resets its price at period $t$ will choose $P_t^*$ that maximizes the expected discounted sum of future dividends in states of nature where the firm does not reset again its price:

$$\mathbb{E}_t \left\{ \sum_{s=0}^{\infty} \theta_p^s F_{t_s}^{t+s} D_{t|t+s} \right\}, \quad \text{with} \quad D_{t|t+s} = [P_t^* - MC_{t+s}] \left( \frac{P_t^*}{P_{t+s}} \right)^{-\epsilon_p} Y_{t+s},$$

where $Y_{t+s}$ and $P_{t+s}$ denote aggregate demand and the aggregate production-price level at time $t+s$, respectively. The first-order condition is:

$$P_t^* = \frac{\epsilon_p}{1 - \epsilon_p} \frac{X_t^p}{Z_t^p} P_t,$$

where

$$X_t^p = \mathbb{E}_t \left\{ \sum_{s=0}^{\infty} (\theta g_{p})^s F_{t}^{t+s} \left( \frac{P_t}{P_{t+s}} \right)^{-1-\epsilon_p} MC_{t+s} Y_{t+s} \right\},$$

and

$$Z_t^p = \mathbb{E}_t \left\{ \sum_{s=0}^{\infty} (\theta g_{p})^s F_{t}^{t+s} \left( \frac{P_t}{P_{t+s}} \right)^{-\epsilon_p} L_{t+s} \right\}.$$

**B.3 Capital firms and accumulation**

The representative capital firm chooses its investment level $I_t$ in order to maximize its market value, equal to the expected discounted sum of future dividends, taking as given the rental price of capital $r_k$ and the price of investment $P_t$. Let $D_t = (r_k_t + \pi_k_t)K_{t-1} - P_tI_t$ be the dividend of the capital firm. The firm maximizes:

$$Q_t = \mathbb{E}_t \left\{ \sum_{s=0}^{\infty} F_{t}^{t+s} D_{t+s} \right\}, \quad (21)$$

under the capital accumulation process:

$$K_{t+s} = K_{t+s-1} \Phi \left( \frac{I_{t+s}}{K_{t+s-1}} - \delta \right).$$
The first-order condition is:
\[ \frac{P_{it}}{\Phi(I_t + \frac{1}{K_t})} = \mathbb{E}_t \left\{ \tau R_{t+1} + \frac{P_{it+1}}{\Phi(I_{t+1} + \frac{1}{K_{t+1}})} \left( \Phi \left( I_{t+1} + \frac{1}{K_t} \right) - \frac{I_{t+1}}{K_t} \Phi' \left( I_{t+1} + \frac{1}{K_t} \right) \right) \right\} . \]

C Market equilibria

Goods markets:
\[ Y_c^t = D_c^t + M_c^t \quad \text{and} \quad Y_u^t = D_u^t + M_u^t \]

Bonds markets:
\[ B_{h_c}^t + B_{h_u}^t + B_g^t + B_{g_c}^t = 0 \quad \text{and} \quad B_{h_u}^{ar} + B_{h_c}^{ar} + B_g^{ar} + FR_t = 0 \]

D Calibration of the model and the steady-state

<table>
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<tr>
<th>Name</th>
<th>Description</th>
<th>China</th>
<th>US</th>
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<td>( \theta_g )</td>
<td>Probability to survive</td>
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<td>( \gamma_g )</td>
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<td>( \kappa )</td>
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<td>( \epsilon_{p} )</td>
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<td>( \alpha_{\pi} )</td>
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<td>( \alpha_{FR} )</td>
<td>Official reserves parameter in the Chinese augmented Taylor rule</td>
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<tr>
<td>( \nu_{steril} )</td>
<td>Degree of sterilization</td>
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<td>( \phi )</td>
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\(^a\)0.99 if constrained monetary policy in the United States.
\(^b\)0.007 with a "soft" official reserves target in China.
\(^c\)0.1 in the CapMob regime and 0.9 in the StatQuo regime.
\(^d\)0.5 in the StatQuo regime, 0.9 in the CapMob and the Flex Regime.
Table D.2: Steady-state

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<td>Public expenditure (% of GDP)</td>
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