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The Effects of the Saving and Banking Glut on the U.S. Economy

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Abstract. We use a quantitative equilibrium model with houses, collateralized debt and foreign borrowing to study the impact of global imbalances on the U.S. economy in the 2000s. Our results suggest that the dynamics of foreign capital flows account for between one fourth and one third of the increase in U.S. house prices and household debt that preceded the financial crisis. The key to these findings is that the model generates the sustained low level of interest rates observed over that period.

1. Introduction

Before the financial crisis of 2007-08, most observers saw the growing international imbalances in the trade of goods and assets as the main source of vulnerability for the U.S. and the world economy (e.g. Roubini and Setser, 2005, Obstfeld and Rogoff, 2007, Krugman, 2007). As shown in figure 1.1, the U.S. trade deficit had been growing since the mid 1990s, reaching 6 percent of GDP at its peak in 2006, mostly financed by emerging Asia (especially China) and the oil-exporting countries. In a very influential speech, then Fed Governor Ben Bernanke (2005) attributed these imbalances to a *"Global Saving Glut"* (SG), which he described as an excess of saving in developing countries primarily directed towards riskless assets in the United States. Given these lopsided patterns of international exchange, many feared that a sudden loss of appetite for U.S. assets by international investors might precipitate an abrupt adjustment of its current account deficit, with serious repercussions for the world economy.

Although a catastrophic financial crisis did eventually occur, its epicenter was the American housing market, rather than the international market for assets and goods. As a consequence, most of the early literature on the causes and consequences of the crisis focused on

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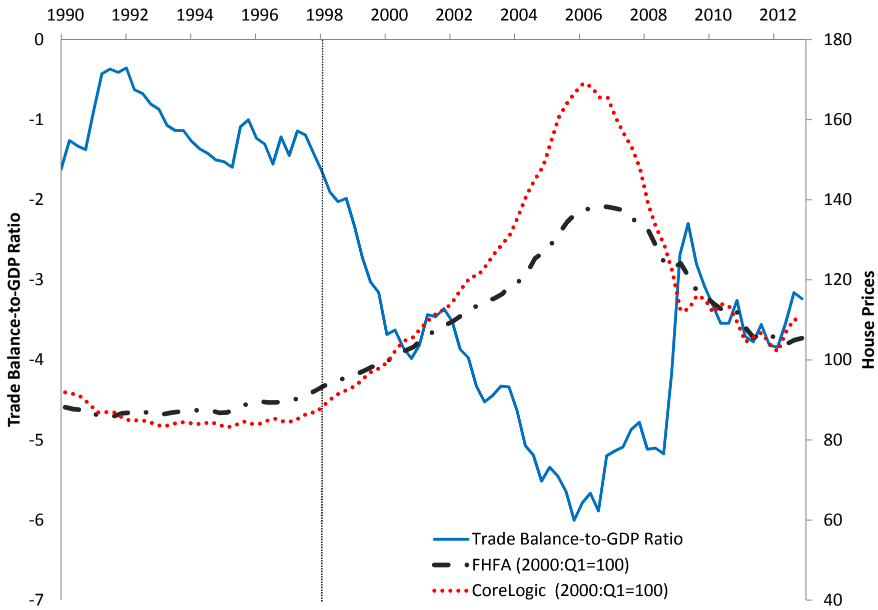

FIGURE 1.1. U.S. trade balance-to-GDP ratio (left axis) and real house prices (right axis). The two measures of house prices are the FHFA (formerly OFHEO) all transactions house price index and the CoreLogic repeated-sales index. Source: Haver.

the features of U.S. financial markets—regulation, risk-management, securitization, funding models—that contributed to the credit and housing boom of the first half of the 2000s, whose reversal was the proximate cause of the crisis.[1]

A more recent strand of literature, however, has brought back into focus the connection between the global imbalances that preceded the crisis and the credit and housing boom that precipitated it.[2] On the empirical side, this literature points to the depressing effect of capital inflows on U.S. interest rates and spreads, whose low levels contributed to the boom in mortgage debt and house prices before the crisis (Bernanke et al., 2011, Bertaut et al., 2011, Warnock and Warnock, 2009). Bertaut et al. (2011), for instance, estimate that the purchases of Treasury and Agency debt by the SG countries over the period 2003 to 2007, amounting to roughly one trillion dollars, lowered long-term interest rates in the U.S. by between 110 and 140 basis points.

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[1]See Brunnermeir (2009) for an early overview. Demyanyk and van Hemert (2011), Ashcraft and Schuermann (2008), Adrian and Shin (2010), Pozsar et al. (2010), Gorton (2009), and Mian and Sufi (2009), among many others, provide more detailed accounts of the events of the crisis and of some of the important mechanisms at play, with a special focus on subprime mortgages and their securitization. In fact, in this early phase, this sequence of events was most often described as the "subprime crisis."

[2]Obstfeld and Rogoff (2009) is one of the first papers forcefully arguing that global imbalances and the financial crisis are intimately related.

Moreover, careful detective work by Bertaut et al. (2011) in tracking the flows of capital to and from the United States has uncovered another channel through which international capital flows might have contributed to easier financial conditions in the U.S. before the crisis. Indeed these authors document that after 2003, European banks played an increasing role in the market for safe U.S. assets, especially the AAA tranches of private label asset-backed securities (ABS) that turned out to be far from riskless in the crisis. Since Europe's current account vis-a-vis the U.S. was roughly balanced, these gross positions of European banks in ABS were funded by direct borrowing in the dollar wholesale credit market. As a result, these financial institutions became an integral part of the financial intermediation sector in the U.S., in direct competition with domestic financial institutions, as also pointed out by Acharya and Schnabl (2009).

Shin (2012) refers to these gross flows from international banks into mortgage products, even in the absence of corresponding net imbalances, as the "Global Banking Glut" (BG), in juxtaposition to the Global Saving Glut associated with the U.S. current account deficit. According to his analysis, the flow of funds associated with the BG played an important role in easing financial conditions in the United States during the boom, comparable in magnitude to that of the purchases of Government debt by the SG countries.

In Shin's (2012) model of global banking, spreads are negatively related to the total amount of funds intermediated by the financial system . When risk recedes, banks expand their balance sheet and spreads fall. This motivates Shin's claim that higher total intermediation generated by European banks lowered the spreads between safe funding rates and the returns on ABS, and therefore ultimately on mortgages. Consistent with this view, Bertaut at al. (2011) estimate that the increase in the demand for ABS and similar instruments by European banks over the period 2003-2007 contributed to a decline in their yield of between 60 and 160 basis points, depending on the instruments and the methodology.[3] When the boom turned to bust, and the market for private-label ABS in which European banks were most active disappeared, the mechanism worked in reverse, contributing to the propagation of the U.S. financial crises around the world (Obstfeld, 2012, Acharya and Schnabl, 2009).

[3]These estimates represent an upper bound on the effect of the BG on U.S. rates, since they do not account for the endogenous response in the supply of ABS and similar assets. The production of these assets rose dramatically during this period, in part to satisfy the increase in demand by U.S. and foreign investors.

Despite the growing empirical evidence on the effects of net and gross capital flows on U.S. credit markets and interest rates, only a handful of papers have addressed quantitatively the impact of the global saving and banking gluts on the U.S. macroeconomy in general, and on the credit and house-price boom of the 2000s more specifically. In this paper, we tackle this question using a quantitative dynamic equilibrium model, which includes most of the ingredients of typical medium-scale DSGEs inspired by Christiano, Eichenbaum, and Evans (2005) and Smets and Wouters (2007). In addition, our model features borrowing and lending among heterogeneous households, as well as from abroad, with houses serving as collateral (Iacoviello, 2005). Therefore, in our framework house prices play a key role in determining the amount of household debt. Thanks to these features, the model is a useful laboratory to study the macroeconomic effects of the SG and BG on the U.S. economy, including their contribution to the credit and real estate boom of the 2000s.

To analyze the impact of the SG, we take the observed U.S. trade deficit, and the associated capital inflows, as exogenous: a given amount of goods and services that domestic households must consume today, received from the rest of the world in exchange for a promise of goods and services in the future. This exogenous flow of resources tilts the intertemporal consumption profile of domestic agents towards the present, which can be optimal only if interest rates decline. The rest of the adjustment in the domestic economy follows from this fall in the domestic rate of return. In brief, lower interest rates stimulate the demand for nondurable consumption, investment and housing by the lenders, who are on their Euler equation. The resulting upward pressure on house prices then relaxes the collateral constraint of the borrowers, who can thus also consume more. Finally, preferences parametrized to deliver a small wealth effect prevent this expansion in consumption from implying a sharp fall in hours worked. This chain of events is what we refer to as the Global Saving Glut channel. Quantitatively, the SG has fairly large effects on the macroeconomy. Consumption and investment increase by roughly 5% and 10% above the balanced growth path, while the effect on GDP is more muted because of the deterioration of the trade balance. Furthermore, at the peak the ratio of household debt to GDP is 8% higher, while house prices increase by 13%.

In addition to quantifying the SG's impact, we attempt to capture Shin's (2012) Global Banking Glut. We model the BG as a reduction in the spread between the interest rate paid by (mortgage) borrowers and the funding rates of the shadow banking system, which are tied in turn to the interest rate earned by savers. In our model, this spread between borrowing and lending rates reflects the market power of financial intermediaries, which channel funds to the impatient households from both the domestic patient ones and the rest of the world. More competition in this market therefore implies lower spreads. This is the channel through which the entry of European players in the intermediation market, which is at the heart of the Global Banking Glut hypothesis, affects credit conditions in the model.

This simple modeling approach captures the first order effect on macroeconomic outcomes of the entry of European banks in the American intermediation market. A reduction in spreads is also an outcome of the more sophisticated and realistic model of intermediation proposed by Shin (2012) to formalize the effects of the Global Banking Glut. Of course, that model has many more implications than ours regarding the behavior of intermediaries, but it is silent on their macroeconomic consequences.

In our simulations, the reduction in spreads due to the BG reduces the interest rate and makes houses more valuable for the borrowers, relative to nondurable goods. This shift in demand towards houses increases their price and relaxes the collateral constraint, allowing the borrowers to obtain more credit. In this case without capital inflows, the increase in credit is financed by additional lending from the domestic savers. Hence, the response of savers to the BG tends to be opposite to that of the borrowers, leading to fairly muted effects on aggregate variables. This is in contrast with the SG case, where the fall in interest rates stimulates demand by both types of households. Overall, our experiments attribute to the combined effect of the BG and SG between one fourth and one third of the increase in house prices and household debt during the years leading up to the financial crisis.

1.1. **Related literature.** Among the first papers to formally address the saving glut hypothesis were Caballero, Farhi, and Gourinchas (2008), and Mendoza, Quadrini, and Rios-Rull (2009). These influential contributions share a focus on the differences in financial market development across countries that made riskless U.S. assets a particularly appealing store of value for the excess saving in the rest of the world. In their detailed quantitative exercise, Mendoza, Quadrini, and Rios-Rull (2009) also trace the dynamic implications of global financial liberalization on international imbalances and portfolios. However, they concentrate much less then we do on the broader macroeconomic implications in the United States.

Our work is more closely related to a recent literature connecting current account deficits and foreign capital flows into the U.S. to the housing and credit booms that preceded the financial crisis. This literature is far from unanimous on the importance of this international channel for macroeconomic developments in the United States. At one extreme of this spectrum, Favilukis et al. (2012 and 2013) find virtually no effect of the foreign purchases of Government bonds on house prices and domestic credit. In their rich model, the reduction in the risk-free rate associated with the flow of international resources into the U.S. economy is offset by an increase in the risk premium on housing, due to the portfolio reallocation forced on domestic agents by the foreign purchases of safe assets.[4] In our model, on the contrary, there is no risk, and hence no meaningful portfolio choice, since agents have perfect foresight. As a consequence, our results highlight the intertemporal substitution mechanisms associated with the fall in interest rates triggered by the trade deficit. On the one hand, this stricter macroeconomic focus comes at the cost of ignoring a potentially important portfolio channel and might bias our quantitative conclusions. On the other hand, the irrelevance of portfolio choice in our model allows us to take a more comprehensive view of the saving glut, without having to worry about the composition of the capital inflows. Moreover, it enables us to calibrate the foreign impulse to the total trade deficit, rather than just to the fraction corresponding to the purchases of Treasuries, as Favilukis et al. (2012) do.

Our results are more in line with those of Adam, Kuang, and Marcet (2011), Garriga, Manuelli, and Peralta-Alva (2012), and Kiyotaki, Michaelides, and Nikolov (2011), who all find large effects of a decline in the world interest rate on house prices in small open economy models calibrated on the U.S. experience of the 2000s, despite important differences in their modeling approaches. In Adam et al. (2011), the large reaction of house prices is due to the presence of agents with subjective beliefs about these prices. In Garriga et al. (2012), the quantitative results hinge on combining lower real interest rates and looser financial conditions, while we abstract from the latter. Furthermore, unlike these papers, we model the domestic country as large, and populated by both borrowers and savers, which makes interest rates endogenous and creates interesting dynamics from the interplay of the two classes of agents. In this respect, we are closer to Kiyotaki et al. (2011), who focus on

[4]Caballero and Krishnamurty (2009) also highlight the increase in risk borne by domestic agents following the absorption of safe assets by foreigners.

the redistributive effects of changes in the world interest rate across net buyers and net sellers of houses. Finally, Ferrero (2012) also addresses the correlation between current account deficits and house prices within a two-country model, but with one representative international saver lending to one representative borrower in the U.S.

The analysis of the BG is a distinctive feature of our paper, relative to these other contributions. In this respect, we also make contact with the small-open economy business cycle literature that has emphasized the role of risk premia and spreads as an important source of business cycle fluctuations (e.g. Neumeyer and Perri 2005, Garcıa-Cicco, Pancrazi, and Uribe, 2010).

The rest of the paper proceeds as follows. Section 2 describes the model, whose calibration is presented in section 3. Section 4 presents the model's dynamics in response to three impulses: an increase in the trade deficit that captures the saving glut; a fall in the spread between borrowing and lending rates, which captures the banking glut; and a combination of the two. Section 5 concludes.

2. Model

This section presents the quantitative general equilibrium model we use to analyze the impact of the SG and BG on the U.S. economy, including their effect on the recent boom in the debt of U.S. households and in real estate prices. The model builds on Iacoviello (2005) and Campbell and Hercowitz (2009). The key assumption is that domestic households have heterogeneous desires to save, which generate borrowing and lending among them, as well as from abroad. Debt, which we often call "mortgages", is collateralized by houses, to capture the fact that mortgages represent by far the most important component of U.S. households' liabilities.

The economy is populated by four main classes of domestic agents—households, house producers, goods producers and a government. Households can borrow from each other through a financial intermediation sector composed of monopolistic investment banks and competitive commercial banks, which also collect funds from abroad.

2.1. **Households.** There are two types of households, which differ by the rate at which they discount the future. Patient households are denoted by l, since in equilibrium they are the ones saving and lending. They represent a share $1 - \psi$ of the population, and we interchangeably refer to them as the lenders or savers. Their discount factor is $\beta_l > \beta_b$, where β_b is the discount factor of the impatient borrowers. At time 0, representative household $j = b, l$ maximizes the utility function

$$E_0 \sum_{t=0}^{\infty} \beta_j^t \frac{\left(C_{j,t}^{\epsilon} H_{j,t}^{1-\epsilon} - \varphi X_{j,t} L_{j,t}^{1+\eta} \right)^{1-\sigma} - 1}{1-\sigma},$$

where

$$X_{j,t} = \left(C_{j,t}^{\epsilon} H_{j,t}^{1-\epsilon} \right)^{\mu} X_{j,t-1}^{1-\mu}.$$

In these expressions, $C_{j,t}$ denotes consumption of nondurable goods, $H_{j,t}$ is the stock of houses, and $L_{j,t}$ is hours worked. This specification of the utility function is similar to the one proposed by Jaimovich and Rebelo (2009). When $\mu = 1$, it belongs to the class of utility functions recommended by King, Plosser, and Rebelo (1988). When $\mu = 0$, these preferences resemble those of Greenwood, Hercowitz, and Huffman (1988), with no wealth effect on labor supply. The difference from Jaimovich and Rebelo (2009) is that households in this model derive utility from a Cobb-Douglas aggregator of non-durable consumption goods and housing services (assumed to be proportional to the stock of housing). The parameter ϵ denotes the share of nondurable consumption in this composite good.

The utility maximization problem is subject to the nominal flow budget constraint

$$P_t C_{j,t} + P_t^h \Xi_{j,t} + P_t I_{j,t} + R_{j,t-1} D_{j,t-1} \leq W_{j,t} L_{j,t} + R_t^k K_{j,t} + \Pi_{j,t} - P_t T_{j,t} + D_{j,t}.$$

In this expression, P_t and P_t^h are the prices of the consumption good and of houses, while R_t^k and $W_{j,t}$ are the nominal rental rates of capital and labor. The wage is indexed by j because the labor input of the borrowers is not a perfect substitute for that of the savers. $D_{j,t}$ is the amount of one period *nominal* debt (or deposits, when negative) accumulated by the end of period t, and carried into period $t+1$, with gross *nominal* interest rate $R_{j,t}$. The interest rate depends on j because the return paid by borrowers and that earned by lenders differ due to the presence of a spread in the financial intermediation sector. $\Pi_{j,t}$ is the share of profits of the intermediate firms and of investment banks accruing to each household of type j, and $T_{j,t}$ are lump-sum taxes and transfers from the government.

The stocks of houses and capital evolve according to the accumulation equations

$$H_{j,t+1} = (1 - \delta_h) H_{j,t} + \Xi_{j,t}$$

$$K_{j,t+1} = (1 - \delta_k) K_{j,t} + \left(1 - S_k\left(\frac{I_{j,t}}{I_{j,t-1}}\right)\right) I_{j,t}, \tag{2.1}$$

where $\Xi_{j,t}$ represents new houses, $I_{j,t}$ is investment in productive capital, and δ_h and δ_k are the rates of depreciation of the two stocks. The function S_k captures the presence of adjustment costs in investment, as in Christiano, Eichenbaum, and Evans (2005), and is parametrized as follows

$$S_k(x) = \zeta_k \frac{1}{2} (x - e^{\gamma})^2, \tag{2.2}$$

so that, in steady state, $S_k = S_k' = 0$ and $S_k'' = \zeta_k > 0$, where e^{γ} is the economy's growth rate along the balanced growth path, further described below. Finally, we assume that the total supply of new houses (Ξ_t) grows at the constant rate of technological progress, which corresponds to imposing infinite costs for adjusting the production of new houses. In section 4.3, we also consider a more complex specification in which new houses are produced combining land and residential investment.

2.1.1. *The borrowing limit.* Households' ability to borrow is limited by a collateral constraint, similar to Kiyotaki and Moore (1997). We model this constraint to mimic the asymmetry of mortgage contracts, as in Justiniano, Primiceri, and Tambalotti (2012). When real estate prices increase, households can refinance their loans and therefore borrow more against the higher value of the entire housing stock. When prices fall, however, the lower collateral value leads to less lending against new houses, but lenders cannot require faster repayment of the debt already outstanding.

More formally, we write the collateral constraint as

$$D_{j,t} \leq \bar{D}_{j,t} = \begin{cases} \theta P_t^h H_{j,t+1} & \text{if } P_t^h \geq P_{t-1}^h \\ (1 - \delta_h) \bar{D}_{j,t-1} + \theta P_t^h \Xi_{j,t} & \text{if } P_t^h < P_{t-1}^h. \end{cases}$$

If collateral values increase (i.e. P_t^h rises), households can borrow up to a fraction θ of the current value of their entire housing stock. This is the standard formulation of the collateral constraint, which implicitly assumes that all outstanding mortgages will be refinanced to take advantage of the new, more favorable conditions. On the contrary, if P_t^h falls, households need not repay the outstanding balance on their mortgage, over and above the repayment associated with the depreciation of the housing stock (δ_h).[5] Therefore, the new less favorable credit conditions only apply to the flow of new mortgages, collateralized by the most recent house purchases.

This asymmetry of the borrowing limit makes debt in the model very similar to an adjustable-rate mortgage, in which the interest rate changes every quarter, but the principal can only be adjusted by the borrower, either through a cash-out refinancing, or through pre-payment. Therefore, this modeling device captures an important feature of long-term mortgages over real estate cycles, namely the downward stickiness of the principal. During booms, homeowners take advantage of rising property values through refinancing, which reduces the effective duration of outstanding mortgages. During busts, on the contrary, existing homeowners cannot be forced to pay down their outstanding debt (over and above the contractual amortization), even if the value of the collateral falls.

Given their low desire to save, impatient households borrow from the patient in equilibrium. In fact, local to the steady state, they borrow up to the collateral constraint. Therefore, they choose not to hold any capital: absent the constraint, they would borrow even more, so it is clearly not optimal for them to hold any asset other than houses. For simplicity, we impose that borrowers do not accumulate capital also when the collateral constraint does not bind away from the steady state, even if it might occasionally be optimal for them to do so.

2.2. **Goods producers.** There is a continuum of intermediate firms indexed by $i \in [0,1]$, each producing a good $Y_t(i)$, and a competitive final good sector producing output Y_t according to

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{1}{1+\lambda}} di \right]^{1+\lambda}.$$

Intermediate firms, which are owned by the lenders, operate the constant-return-to scale production function

$$Y_t(i) = A_t^{1-\alpha} K_t^{\alpha}(i) \left[(\psi L_{b,t}(i))^{\nu} ((1-\psi) L_{l,t}(i))^{1-\nu} \right]^{1-\alpha} - A_t F. \tag{2.3}$$

[5] This formulation assumes that the amortization rate of the mortgage coincides with the depreciation rate of the housing stock. In Justiniano, Primiceri, and Tambalotti (2012) we also experiment with higher amortization rates, so that households build equity in their house over time, as in Campbell and Hercowitz (2009).

They rent labor (of the two types) and capital on competitive markets paying $W_{b,t}$, $W_{l,t}$ and R_t^k respectively. F represents a fixed cost of production, and is chosen to ensure that steady state profits are zero. The labor augmenting technology factor A_t grows at rate γ.

The intermediate firms operate in monopolistically competitive markets and set their price $P_t(i)$ subject to a nominal friction as in Calvo (1983). A random set of firms of measure $1-\xi_p$ optimally reset their price every period, subject to the demand for their product, while the remaining ξ_p fraction of prices do not change. In section 4.1, we describe how the presence of sticky prices amplifies the expansionary effect of the SG on labor demand and the equilibrium level of production.

2.3. **Fiscal and monetary policy.** The government collects taxes, pays transfers, consumes a fraction of final output, and sets the nominal interest rate.

We assume that government spending is a constant fraction g of final output, and that the government balances it's budget, i.e.

$$G_t = gY_t = \psi T_{b,t} + (1-\psi)\, T_{l,t}.$$

In addition, we assume that total taxes levied on borrowers represent a constant share χ of the financing needs of the government, i.e.

$$\psi T_{b,t} = \chi G_t.$$

If $\chi = 0$, the entire tax burden is on the savers, while if $\chi = \psi$ borrowers and savers pay the same amount per-capita. Therefore, we can interpret the parameter χ as capturing the extent of government redistribution. Given the presence of borrowing-constrained agents and the redistributive nature of the tax rule, Ricardian equivalence does not hold in our model. Therefore, the balanced budget assumption is not entirely innocuous, but just a simplification that allows us to abstract from the details of how the government finances its expenditures, as is the assumption of lump-sum taxes.

Monetary policy sets the short-term nominal interest rate on deposits based on the feedback rule

$$\frac{R_{l,t}}{R_l} = \max\left\{\frac{1}{R_l};\left(\frac{R_{l,t-1}}{R_l}\right)^{\rho_R}\left[\left(\frac{\left(\pi_t\cdot\pi_{t-1}\cdot\pi_{t-2}\cdot\pi_{t-3}\right)^{1/4}}{\pi}\right)^{\tau_\pi}\left(\frac{Y_t}{Y_t^*}\right)^{\tau_y}\right]^{1-\rho_R}\right\},$$

where π_t is the gross rate of inflation, π is the Central Bank's inflation target, and Y_t^* is the trend level of output that grows at the constant rate of technological progress. The parameters ρ_R, τ_π and τ_y capture the degree of inertia, and the strength of the interest rate reaction to the deviations of annual inflation from the target and of output from trend.

2.4. **Financial intermediaries.** The financial intermediation sector transfers resources to the borrowers from savers at home and in the rest of the world. The sector consists of investment banks, which do the lending, and retail banks, which collect deposits. Investment banks fund the purchase of mortgages by issuing securities, say asset-backed commercial paper, on a non-competitive wholesale credit market. Retail banks (or money market mutual funds) buy these securities using the deposits that they collect. In the process, the investment banks earn a profit in the form of a spread between the mortgage rate and their funding rate, which is equal to the retail deposit rate paid to savers.

We assume that this spread derives from market power exercised by investment banks in the wholesale funding market, for instance by creating differentiated credit products that they sell to commercial banks and money market mutual funds. The existence of this market power can be microfounded through a monopolistic competition structure as in Gerali at al.'s (2010) DSGE model of banking. Alternatively, we could assume that the spread earned by investment banks derives from the costs of intermediation that each of them sustains, as in Curdia and Woodford (2009) for instance.

In either case, what is relevant for our analysis is only that the spread falls when European banks enter the wholesale credit market, as suggested by Shin's (2012) global banking glut hypothesis. Under monopolistic competition, this compression in the markup follows naturally when new competitors enter the market. With intermediation costs, instead, spreads fall if entry reduces each bank's market footprint, and hence its volume of intermediation, under the conventional assumption that the cost is convex in the amount of funds intermediated.[6]

[6]For our purposes, this intermediation structure is equivalent to one with a third layer of intermediation, in which individual mortgages are securitized and sold to investment banks and other participants in the shadow banking system, rather than purchased directly by them. This more complex structure would be equivalent to the one presented here because the margin that is relevant for the global banking glut hypothesis that we are trying to capture is the one between wholesale funding and mortgage products, rather than the one between mortgages and mortgage-backed securities.

2.4.1. *Investment banks.* Investment banks purchase mortgages with funds they raise in the wholesale credit market, by issuing a continuum of differentiated credit instruments indexed by $n \in [0, N_t]$. Each of these instruments carries a net interest rate $r_t(n)$, while mortgages accrue net interest of $r_{b,t}$. Therefore, the profit earned from funding $D_{b,t}(n)$ dollars worth of mortgages by selling $L_t(n)$ dollars of instrument n is

$$\Pi_t(n) = r_{b,t} D_{b,t}(n) - r_t(n) L_t(n),$$

where one dollar in wholesale funding turns into one dollar in mortgages, so that $D_{b,t}(n) = L_t(n)$.

2.4.2. *Retail banks.* Retail banks collect a total amount of deposits

$$D_t = -(1-\psi) D_{l,t} + D_{f,t},$$

where $-(1-\psi) D_{l,t}$ come from the lenders and $D_{f,t}$ come from the RoW.[7] The net interest rate paid on these deposits is $r_{l,t}$, and they are invested in the securities issued by investment banks, generating total profits for the retail banking sector in the amount

$$\int_0^{N_t} r_t(n) L_t(n) dn - r_{l,t} D_t.$$

We assume that retail banks have a taste for a diversified portfolio, which implies a downward sloping demand function for each instrument issued by the investment banks, with elasticity $\varepsilon(N_t)$. For instance, under the translog specification proposed by Feenstra (2003), this elasticity would be $\varepsilon(N_t) = -(1 + \varepsilon N_t)$ (e.g. Bilbiie, Ghironi, and Melitz, 2012). As the number of instruments available on the market increases, they become closer substitutes, and the elasticity of demand increases.

2.4.3. *Equilibrium, spread and market clearing.* The taste for portfolio diversification of retail banks generates monopoly power in the wholesale credit market, which investment banks exploit by selling their securities at a discount with respect to the interest rate charged to borrowers. As a result, in the symmetric equilibrium in which all securities pay the same interest rate, we have

$$r_{b,t} = \mu(N_t) r_{l,t}, \tag{2.4}$$

[7]Recall that $D_{l,t}$ denotes debt if positive and deposits if negative. Similarly, a positive $D_{f,t}$corresponds to foreign holdings of U.S. debt.

where the spread in the borrowing over the lending rate $\mu(N_t)$ depends on the size of the market N_t. Under the translog specification, this function is $\mu_t(N_t) = 1 + (\varepsilon N_t)^{-1}$. Alternatively, if the portfolio purchased by retail banks were a CES aggregate of a discrete set of N_t instruments, we would obtain $\mu_t(N_t) = [\varepsilon(N_t - 1) + N_t] / [\varepsilon(N_t - 1)]$, as in Jaimovich and Floetotto (2008). Intuitively, both of these parametrizations imply that markups fall as the number of competitors increases. However, in our calibration we do not exploit any specific mapping between N_t and μ_t, and instead we calibrate directly the decline in spreads due to the entry of European players.

In the symmetric equilibrium, in which one dollar of deposits turns into one dollar of wholesale lending and one dollar of loans, with no deadweight loss from interest rate dispersion, market clearing implies

$$-(1-\psi) D_{l,t} + D_{f,t} = \int_0^{N_t} L_t(n)\, dn$$
$$\psi D_{b,t} = \int_0^{N_t} L_t(n)\, dn,$$

so that

$$\psi D_{b,t} + (1-\psi) D_{l,t} = D_{f,t}. \tag{2.5}$$

Moreover, the aggregate profits of the intermediation sector, which are rebated to households in period $t+1$, amount to

$$r_{l,t}(\mu(N_t) - 1) D_t.$$

2.5. **The resource constraint and the current account.** The economy's resource constraint is

$$Y_t + (\Delta D_{f,t} - r_{l,t-1} D_{f,t-1}) = \psi C_{b,t} + (1-\psi) C_{l,t} + \Xi_t P_t^h / P_t + \psi I_{l,t} + G_t, \tag{2.6}$$

where $I_{l,t}$ is the amount of per-capita investment undertaken by the lenders, who are the only households accumulating capital. This expression derives from aggregating the budget constraints of borrowers and lenders with that of the government, using the zero profit conditions of the competitive firms and of retail banks, the definition of profits for the intermediate firms and the investment banks, and the debt market clearing condition (2.5).

Equation (2.6) clarifies the role of foreign debt in our economy. The RoW holds a stock of domestic deposits equal to $D_{f,t}$, on which it earns a return $r_{l,t}$. Deposits are the only asset traded internationally, so that $D_{f,t}$ also represents the net foreign debt position of the U.S. The change in this position, $\Delta D_{f,t}$, corresponds to the current account deficit. This accumulation of deposits, net of the interest paid on the outstanding debt, $\Delta D_{f,t} - r_{l,t-1} D_{f,t-1}$, is the counterpart to the trade deficit in the financial account. Therefore, it represents an addition to the resources produced domestically, Y_t, which is available for consumption (and investment) at home.[8]

From the perspective of the U.S. economy, the willingness of the RoW to invest its excess savings in U.S. assets results in a flow of real resources today, to be returned with interest in the future. This flow of resources is the exogenous force that tilts the consumption profile of domestic agents towards the present, "forcing" them to consume more today than what their domestic production would allow.

As for the RoW, we do not model the source of their desire to lend to the U.S., but simply take as given their excess of saving with respect to investment. However, this does not imply that their desired current account surplus is insensitive to interest rates. The assumption is instead that there exists a sequence of shocks to desired saving and/or investment in the RoW, which generates the observed current account deficit at the prevailing interest rate. This view that U.S. current account deficits are driven exclusively by developments abroad is perhaps extreme, but it captures well the spirit of Bernanke's (2005) saving glut hypothesis. As such, however, it is most compelling for the period of growing international imbalances leading up to the financial crisis, but less so as a description of the retrenchment in the U.S. trade deficit that accompanied the Great Recession. This is why our quantitative experiments stop in 2006Q3, when the current account deficit reached its peak.

[8] In the data, changes in the net foreign asset position can differ from the current account due to valuation effects, which have been sizable and favorable to the U.S. in the last twenty years (e.g. Gourinchas and Rey, 2013). Capturing these effects would require a much more sophisticated model of international financial flows than the one adopted here, which should include a distinction between net and gross asset flows, and a rich menu of assets with different rates of return and realistic movements in their prices. Developing such a model is well beyond the scope of this paper.

Households	β_l	β_s	φ	η	σ	μ	ψ	ϵ	θ
	0.998	0.99	1	1	1	0.0005	0.61	0.899	0.85
Production	γ	ν	α	λ	ξ_p	δ_h	δ_k	ζ_k	
	0.005	0.525	0.3	0.2	0.65	0.003	0.025	2	
Other Param.	π	ρ_R	τ_π	τ_y	χ	g	$D_{f,0}/(4Y_0)$	$4(R_b - R_l)$	
	1.005	0.8	2.5	0.125	0.45	0.175	0.15	0.015	

TABLE 1. Parameter values.

3. Calibration

We parametrize the model so that its steady state matches some key statistics for the period of relative stability of the 1990s. Choosing a later period would be problematic, because the large swings in debt, house prices and the trade balance observed in the 2000s are likely to represent large deviations from such a steady state. The calibration is summarized in table 1 and is based on U.S. aggregate and micro data.

Time is in quarters. We set the Central Bank's inflation target (π) equal to the average gross rate of inflation (1.005, or 2% per year), and the growth rate of productivity in steady state (γ) to match average GDP growth (0.5%) during the 1990s. In steady state, $R_l = \frac{e^{\gamma}\pi}{\beta_l}$. Therefore, we choose a value of 0.998 for the lenders' discount factor (β_l), to obtain an annualized steady state nominal interest rate of 4.8%, close to the average Federal Funds Rate. For the borrowers' discount factor (β_b) we pick a value of 0.99, so that the relative impatience of the two groups is similar to that in Campbell and Hercowitz (2009) and Krusell and Smith (1998). The labor disutility parameter (φ) only affects the scale of the economy, so we normalize it to 1. We also pick a Frisch elasticity of labor supply ($1/\eta$) equal to 1. This value is a compromise between linear utility, which is typical in the Real Business Cycle literature (Hansen, 1985), and the low elasticities of labor supply usually estimated by labor economists and more common in the empirical DSGE literature. We choose the standard value of 1 for the risk aversion parameter (σ) and 0.0005 for the parameter μ, so as to minimize the strength of the wealth effect on labor supply, while still being consistent with balanced growth.

We parametrize the degree of heterogeneity between borrowers and lenders using the Survey of Consumer Finances (SCF), which is a triennial cross-sectional survey of the assets and liabilities of U.S. households. We identify the borrowers as the households that appear to be liquidity constrained, namely those with liquid assets worth less than two months of their total income. Following Kaplan and Violante (2012), we define liquid assets as the sum of money market, checking, savings and call accounts, directly held mutual funds, stocks, bonds, and T-Bills, net of credit card debt. We apply this procedure to the 1992, 1995 and 1998 SCF, and obtain an average share of borrowers equal to 61%, which directly pins down the parameter ψ. Given this split between borrowers and savers, we set the production parameter ν equal to 0.525 to roughly match their relative labor income (0.64) in the SCF. In addition, we choose the parameter controlling the progressivity of the tax/transfer system to match the ratio of hours worked by borrowers and lenders (1.08). This requires setting $\chi = 0.45$, which implies a moderate level of overall redistribution.

The share of nondurable consumption in the Cobb-Douglas aggregator of the utility function (ϵ), the depreciation of houses (δ_h) and the initial loan-to-value ratio (θ) are chosen jointly to match three targets. The first target is the real estate-to-GDP ratio, which we estimate from Flow of Funds (FF) and NIPA data as the average ratio between the market value of real estate owned by households and nonprofit organizations and GDP (1.2). The second target is the debt-to-real estate ratio, for which we use FF data on the average ratio between home mortgages and the market value of real estate (0.36). The third target is the ratio of residential investment to GDP (4%). Hitting these targets requires choosing $\delta_h = 0.003$, which is consistent with the low end of the interval for the depreciation of houses in the Fixed Asset Tables, and $\theta = 0.85$, which is in line with the cumulative loan-to-value ratio of first time home buyers estimated by Duca et al. (2011) for the 1990s.

On the production side, we follow standard practice and pick an elasticity of the production function (α) of 0.3, and a depreciation of productive capital (δ_k) of 0.025. The average net markup of intermediate firms (λ) is 20%, which is in the middle of the range of values used in the literature and the Calvo parameter (ξ_p) is 0.65, consistent with the evidence in Nakamura and Steinsson (2008). For the second derivative of the investment adjustment cost function (ζ_k) we pick a value of 2, in line with the estimates of Eberly, Rebelo, and Vincent (2012).

We fix the steady state ratio of G to Y equal to 0.175. For the monetary policy rule we choose a considerable amount of interest rate inertia ($\rho_R = 0.8$), a moderate reaction to the output gap ($\tau_y = 0.125$), and a relatively strong reaction to inflation ($\tau_\pi = 2.5$), in line with the typical empirical estimates of the Taylor rule in the post-1984 period.

We set the initial stock of foreign lending relative to annual GDP $(D_{0,f}/(4Y_0))$ equal to 15%, based on Gourinchas and Rey's (2013) estimate of the U.S. net foreign asset position in 1998.[9] Finally, we choose the annualized steady state interest rate spread between borrowing and lending rates $(4(R_b - R_l))$ by looking at the average spreads over the 1990s between the 30-year conventional mortgage rate and the 5-, 7- and 10-year constant maturity Treasury rates, which were 1.79%, 1.57% and 1.45% respectively. We choose 1.5% as a round compromise among these three numbers, since the fluctuations over time in the effective duration of conventional mortgages make it difficult to choose Treasuries of a particular maturity as the most appropriate benchmark.

As described in detail in the next section, we study the impact of the SG and BG by analyzing the response of the model's endogenous variables to changes in the forcing process $D_{f,t}/(4Y_t)$ and $4(R_{b,t} - R_{l,t})$. We compute these responses by solving the system of nonlinear difference equations given by the first order conditions of the agents' optimization problems and the market clearing conditions. The algorithm used to solve this nonlinear forward-looking model is based on Julliard, Laxton, McAdam, and Pioro (1998), but has been modified to account for the asymmetry of the borrowing constraint, and for the fact that this constraint always binds in steady state, but it is occasionally slack during the transitions.

4. Results

This section presents estimates of the effects of the BG and SG on the U.S. economy, based on the quantitative model described in sections 2 and 3. Although its open economy dimension is extremely stylized, this model is a useful laboratory to analyze how these international forces affected the U.S. economy, including the extent to which they contributed to the boom in house prices and household debt leading up to the financial crisis. In the rest of the section, we start by describing the impact of the SG and BG in isolation, and then consider their interaction.

[9] This ratio increases over the course of the model's simulations, due to the accumulation of current account deficits, as shown in figure 4.3.

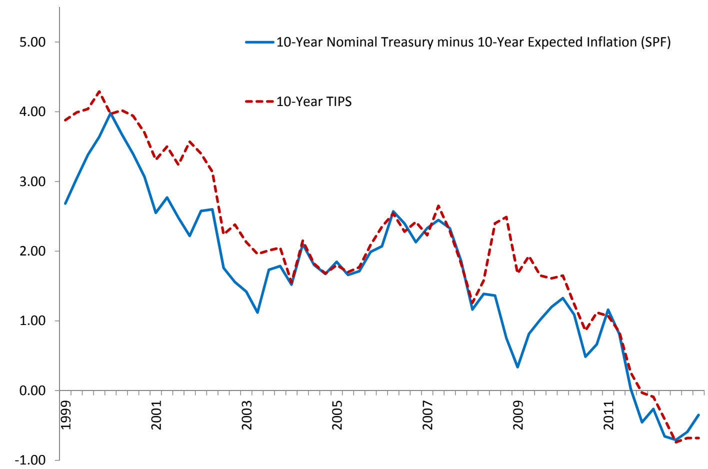

FIGURE 4.1. 10-year Treasury constant maturity rate minus expected inflation (measured as the median CPI-inflation forecast over the next 10 years from the Survey of Professional Forecasters); and continuously compounded 10-year zero-coupon yield on Treasury Inflation-Protected Securities (TIPS). Source: Haver.

4.1. **Saving glut.** Bernanke (2005) coined the phrase Global Saving Glut to suggest that the large current account deficits run by the Unites States since the 1990s were driven primarily by a high level of desired saving in some developing economies, such as Emerging-Asia and the oil exporting countries. A key motivation behind this "somewhat unconventional explanation of the high and rising U.S. current account deficit" (Bernanke, 2005) was Greenspan's (2005) so-called "conundrum," namely the puzzling fact that bond yields were falling in the mid 2000s, even in the face of a monetary policy tightening. This decline is illustrated in figure 4.1, which presents two measures of ex-ante real bond yields: the difference between the nominal yield on 10-year Treasury Notes and expected inflation from the Survey of Professional Forecasters, and the yield of 10-year Treasury Inflation-Protected Securities (TIPS). In light of this puzzle, Bernanke's (2005) key observation was that an increase in desired saving around the world could be consistent with both low interest rates globally, and with a current account deficit in the U.S., as an endogenous reaction to those low rates. Explanations of global imbalances based on domestic developments, on the contrary, such as a fall in desired saving by U.S. households, would be harder to square with these observations on both prices and quantities.

One of the stylized facts associated with the saving glut is that the capital inflows generated by the surplus countries were directed mostly towards safe assets, such as Treasuries and Agency debt, and to a lesser extent towards equity (Bernanke et al., 2011). In our model, however, this portfolio composition of the flows is irrelevant. The macroeconomic effects of net capital flows depend instead only on the size of the associated trade imbalance.

To see more clearly why the portfolio composition of these flows can be ignored, suppose that a foreign agent wishes to purchase U.S. bonds in exchange for a certain amount of goods, thereby contributing to the trade deficit. Domestic lenders—the holders of these bonds in our economy—require a reduction in interest rates to deviate from their original consumption/saving plan, as implied by their undistorted Euler equation. Since under perfect foresight all returns are known with certainty, no-arbitrage transmits this decline in rates of return equally across all assets in the economy, making the domestic lender indifferent between selling Treasuries, mortgages/MBS or shares of the capital stock to the foreign agent. Therefore, in the experiments that follow, treat the trade deficit as the forcing variable, and ignore the composition of flows, focusing instead on how the (net) amount of goods shipped from abroad affects the intertemporal consumption profile of domestic agents, and hence interest rates.

This exclusive focus on goods (as opposed to assets) may seem surprising in an economy with collateral-constrained agents. However, the presence of the savers, who can trade all assets and do not face a constraint, makes the previous simple intuition valid also in our setup. In our model, international trade is ultimately an intertemporal reshuffling of consumption profiles, with effects on the interest rate dictated by the savers' Euler equation. The presence of borrowers, however, matters both quantitatively and qualitatively. Quantitatively, the movement in interest rates engendered by trade is different than in a model without constrained agents, since borrowers can consume more only to the extent that their collateral gains value. Qualitatively, the transmission mechanism of trade deficit shocks to the domestic economy is enriched by the presence of heterogeneity among households, which also allows us to trace the implications of these shocks for debt and house prices.

The irrelevance of the portfolio composition of the foreign capital flows in our model, at least under the assumption of perfect foresight, is of course not a claim that this composition does not matter in practice. In this respect, our experiments only quantify the "first-order" effects of changes in trade flows on interest rates, and hence on the rest of the economy, ignoring the "higher-order" considerations stemming from the presence of time-varying risk, and the associated portfolio choices.

Our calculations, therefore, can be thought of as a general equilibrium version of the empirical exercises of McCarthy and Peach (2004) and Himmelberg, Mayer, and Sinai (2005), who used present value models of house prices to measure the impact of low interest rates (and other fundamentals) on real estate values in the mid 2000s. A recent and growing literature in international finance includes a role for portfolio choice in shaping the impact of international capital flows on macroeconomic outcomes (e.g. Mendoza, Quadrini, and Rios-Rull, 2009, Caballero and Krishnamurty, 2009, Tille and van Wincoop, 2010, Devereux and Sutherland, 2011, Caballero and Farhi, 2013). Extending our model along these lines is an exciting avenue for future research.

Given that the effects of the SG in our economy depend on the size of the trade deficit, rather than from the composition of capital inflows, we feed into the model a sequence for net foreign debt over GDP $\{D_{f,t}/Y_t\}_{t=1998:Q1}^{2012:Q4}$ that is consistent with the observed evolution of the trade balance. As shown in figure 4.2, the U.S. trade deficit deteriorated significantly—from approximately 1.5 to 6 percent of GDP between 1998:Q1 and 2006:Q3. We calculate the implied path of capital inflows (i.e. the sequence of ΔD_t^f) consistent with a linear approximation to the data over the period of rising deficits (dashed line in figure 4.2), given the interest payments on foreign debt implied by the model ($R_{t-1}D_{t-1}^f$), and the initial level of debt (D_t^f) observed in 1998. The solid lines in figure 4.3a and 4.3b plot the resulting time series of the U.S. net foreign debt position as a fraction of GDP (i.e. $D_t^f / (4Y_t)$), which we treat as the exogenous driver of the SG, and the associated trade balance.

As mentioned in section 2.5, the quantitative experiments illustrated below only cover the period of expanding imbalances leading up to the financial crisis, since the global saving glut hypothesis provides a much more compelling account of this period than of the retrenchment that followed.[10]

Since agents in the model are forward looking, we also need to specify their expectations regarding the future evolution of capital flows. One possibility would be to assume that they perfectly anticipated the realized path of capital flows as of 1998, following an initial surprise, but this seems implausible. Instead, we assume that they were a bit surprised at every step along the way by the deterioration of the trade balance. After each of these

[10]In a previous version of the paper we continued the experiments for both the saving and the banking glut through 2012. The results for the period of current account reversal following the crisis are roughly symmetric to those illustrated below, with some differences due to the asymmetry of the collateral constraint emphasized in section 2.1.1.

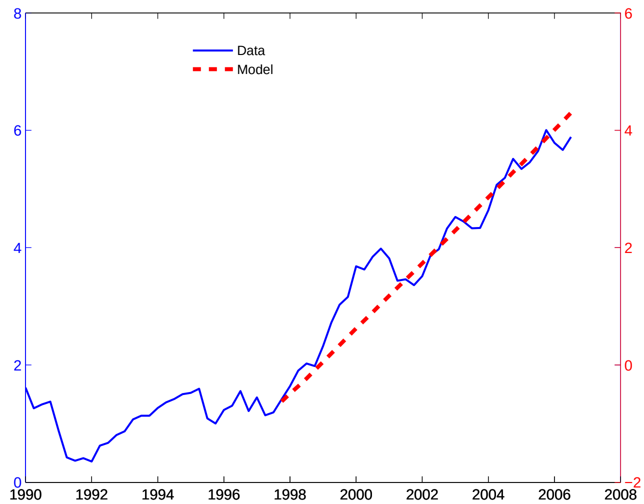

FIGURE 4.2. U.S. trade deficit-to-GDP ratio (solid, left axis) and linear approximation fed through the model (dashed, right axis). Source: Haver and authors' calculations.

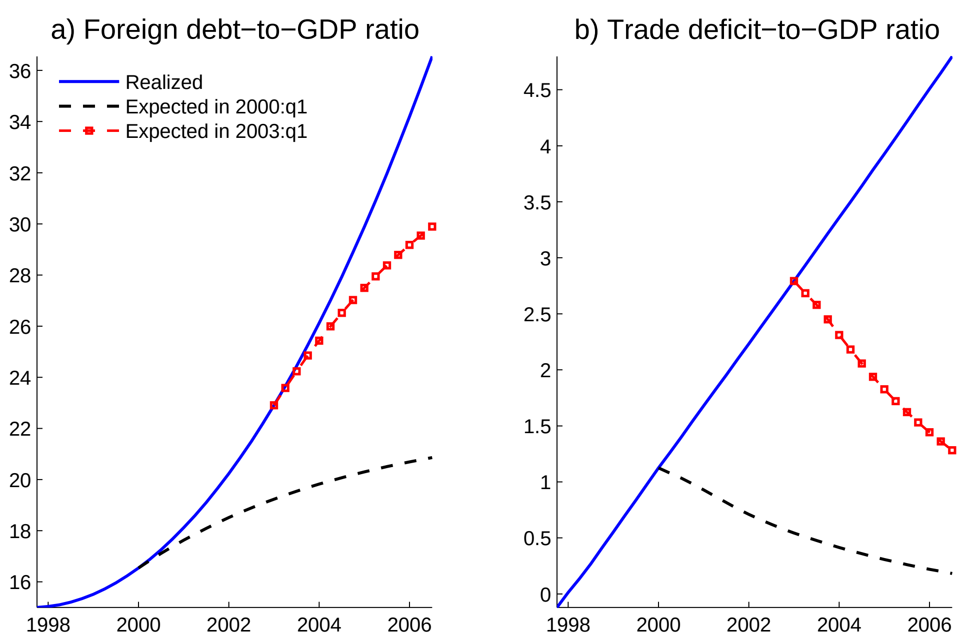

FIGURE 4.3. Realized paths in the simulation, and agents' expected paths in 2000:Q1 and 2003:Q1

surprises, they revise their expectations of the eventual size of the foreign debt-to-GDP ratio, as shown in figure 4.3a. At each point in time, these expectations on the evolution of the net foreign asset position are consistent with a gradual improvement in the trade and current account deficits (figure 4.3b), as captured by an AR(1) process for ΔD_t^f with persistence equal to 0.95. The pace of this improvement is roughly consistent with 1 to 4-quarter ahead expectations for real net exports from the Blue Chip survey, as well as with the speed of current account rebalancing implied by the model of Ferrero, Gertler, and Svensson (2010).

To illustrate the expected paths and the realized surprises in our simulation, the dashed line in figure 4.3a represents the projected path of foreign-lending-to-GDP in 2000:Q1. However, in the following quarter, capital inflows are higher than originally anticipated, as shown in figure 4.3a. In 2003:Q1, agents again forecast a gradual tapering of capital inflows, associated with a protracted improvement of the trade balance. However, as before, inflows and the trade deficit are unexpectedly higher the next quarter. Similar surprises happen every quarter of the simulation until 2006:Q3, but we omit the expected paths to avoid cluttering the figure.[11]

Figures 4.4 and 4.5 summarize the effects of the SG experiment in the calibrated model. The desire of foreign agents to purchase more U.S. assets decreases real interest rates to induce the domestic lenders—the owner of these assets—to reduce saving and increase consumption (figure 4.4a). In our calibration, the SG reduces nominal interest rates by approximately 150 basis points (figure 4.4b), which is broadly consistent with some recent empirical studies on the effect of the SG on asset returns (Bertaut at al., 2011 and Warnock and Warnock, 2009). Lower interest rates also stimulate the demand for nonresidential investment (figure 4.4c) and real estate by the domestic lenders, by making these durable goods relatively more desirable than nondurable consumption.

The resulting upward pressure on house prices relaxes the collateral constraint on the borrowers. This reduces their urge to consume in the present, as measured by the multiplier on the borrowing constraint, and makes them more willing to hold durable goods. From their Euler equation,

$$\left(\frac{1-\xi_t}{R_{b,t}}\right) = E_t \frac{\beta_b \Lambda_{b,t+1}}{\Lambda_{b,t}},$$

[11]If agents anticipate correctly the entire extent of the deterioration in the foreign debt position following an initial surprise in 1998, as under standard perfect foresight simulations, their response is almost entirely front-loaded, and implausibly large. The sequence of surprises that they experience under our simulations, aside from being more realistic, also contributes to smoothing their reaction, thus delivering a more plausible dynamic profile of the endogenous variables. In this respect, this assumption on expectations is related to the learning mechanisms explored by Adam, Kuang, and Marcet (2011) and Boz and Mendoza (2010), also in an open economy context.

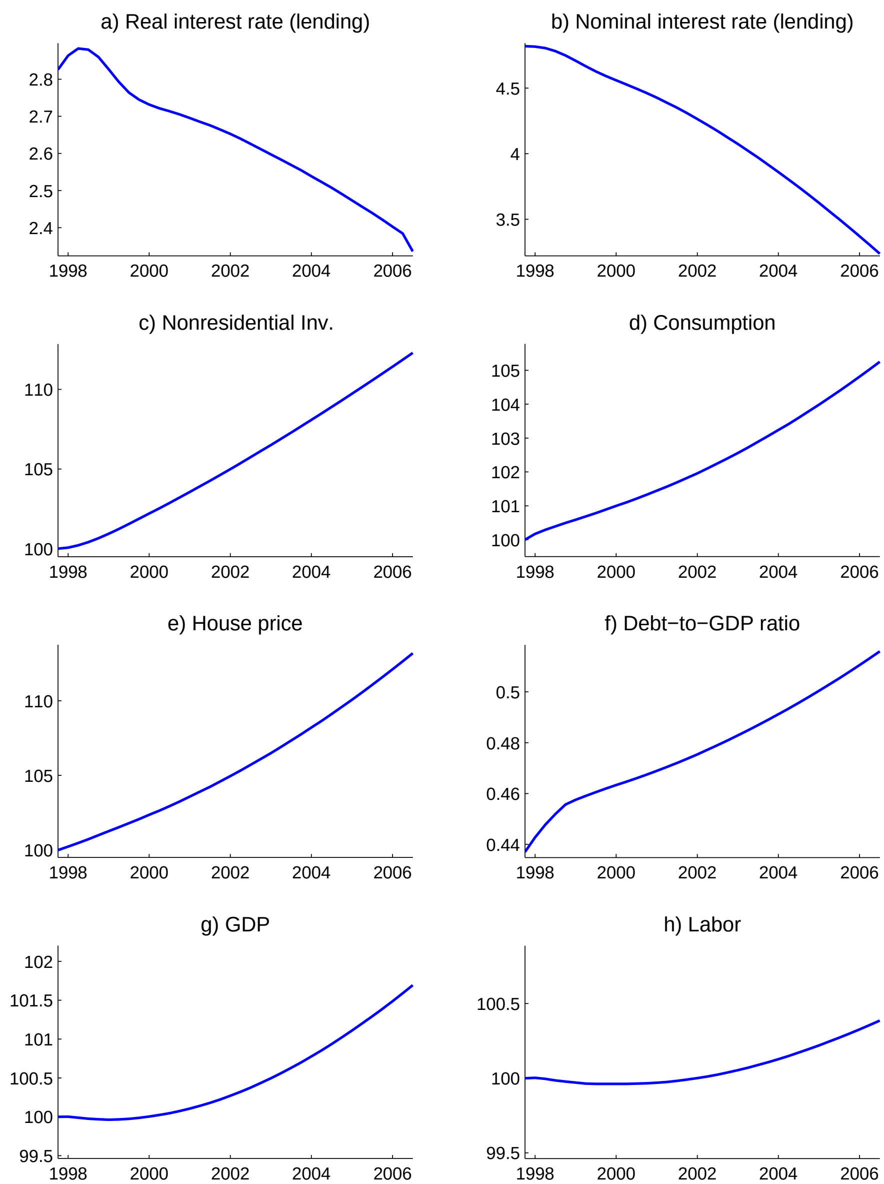

FIGURE 4.4. Saving glut experiment: aggregate variables

the fall in the multiplier ξ_t associated with the relaxation of the borrowing constraint increases the marginal valuation of future consumption vis-a-vis current consumption (the right-hand side of the expression), for any given level of the interest rate. Therefore, the borrowers' demand for houses increases more than that for nondurable consumption, and more than that of the lenders. In equilibrium, house prices rise substantially because both agents increase demand, and supply is fixed (figure 4.4e). Moreover, houses are sold by the

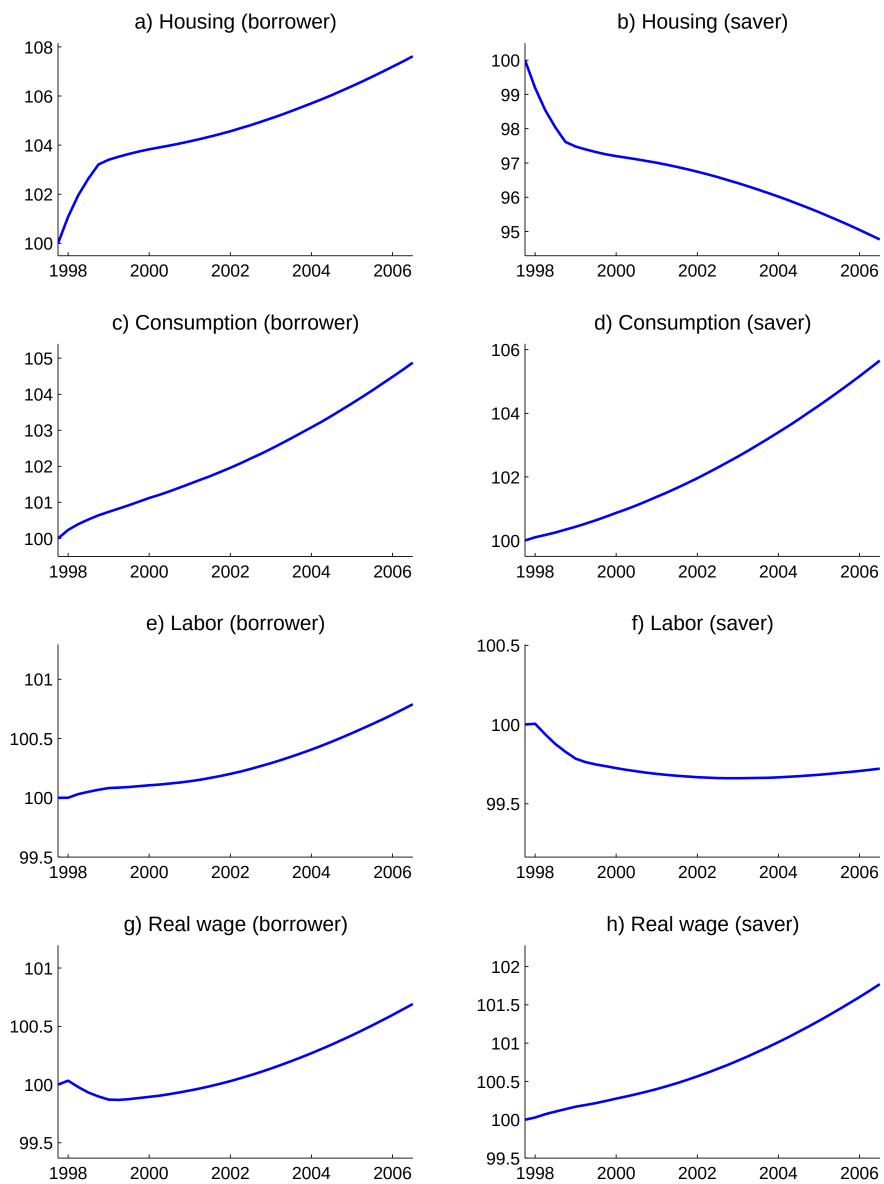

FIGURE 4.5. Saving glut experiment: borrowers and lenders

lenders to the borrowers, since their demand increases more in relative terms (figures 4.5a and 4.5b). Finally, with higher house prices, debt increases as well (figure 4.4f).

To illustrate the behavior of the housing market more clearly, consider the borrowers' first order condition with respect to the housing stock

$$P_t^h \left(1 - \xi_t \theta\right) = E_t \left[\frac{\beta_b \Lambda_{b,t+1}}{\Lambda_{b,t}} \left(MRS_{b,t+1}^{h,c} + \left(1 - \delta_h\right) P_{t+1}^h \right) \right], \tag{4.1}$$

where $MRS^{h,c}$ denotes the marginal rate of substitution between housing and consumption. Substituting for the the discount factor in equation (4.1), and recalling that there is no uncertainty about future realizations of returns under perfect foresight, we obtain

$$P_t^h = \frac{1}{1-\xi_t\theta}\frac{1-\xi_t}{R_{b,t}}\left[MRS_{b,t+1}^{h,c} + (1-\delta_h)\,P_{t+1}^h\right]. \tag{4.2}$$

This equation can be interpreted as a downward sloping demand for houses, since the MRS is decreasing in the housing stock, conditional on expectations about the future price. Comparing this expression with the equivalent one for the lenders

$$P_t^h = \frac{1}{R_{l,t}}\left[MRS_{l,t+1}^{h,c} + (1-\delta_h)\,P_{t+1}^h\right],$$

we see that, as long as $\theta < 1$, the borrowers' valuation is higher, the more they can borrow against the house (θ) and the slacker is the constraint (i.e. the lower is ξ_t).

The net positive effect on house prices from a loosening of credit conditions depends on two countervailing forces. First, a looser constraint makes an extra unit of housing less valuable as collateral, as captured by the multiplier ξ_t at the denominator of

$$\frac{1}{1-\xi_t\theta}\frac{1-\xi_t}{R_{b,t}}.$$

Second, a lower ξ_t makes borrowers effectively less impatient, increasing their valuation of future vs. current consumption, as captured by the ξ_t in the numerator. Since θ is less than one, this positive effect prevails in our model, the more so the more durable is the housing stock (i.e. the lower is δ_h).

We combine these two demand functions in figure 4.6, together with the fixed supply of houses. The demand by the borrowers is measured from left to right in the diagram, while that of the savers from right to left, for a given future price P_{t+1}^h. A fall in the interest rate shifts both schedules up, putting upward pressure on the house price.[12] For a given ξ_t, the demand of the lenders changes by more than that of the borrowers. However, the relaxation of the borrowing constraint associated with this increase in collateral values shifts the borrowers' demand further, by lowering the multiplier ξ_t. In our simulations, the borrowers' valuation increases by more, so that some houses change hands from the savers to the borrowers, as shown in the diagram.

[12]Changes in the interest rate shift and rotate the demand function at the same time.

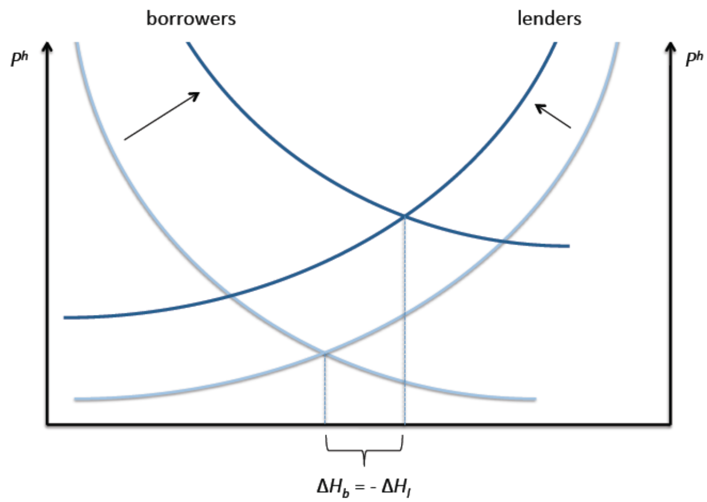

FIGURE 4.6. Housing demand by the borrowers and the lenders.

Iterating equation (4.2) forward

$$P_t^h = \sum_{s=1}^{\infty} \left(\prod_{j=1}^{s} \frac{1}{1-\xi_{t+j-1}\theta} \frac{1-\xi_{t+j-1}}{R_{b,t+j-1}} (1-\delta_h) \right) MRS_{b,t+s}^{h,c},$$

we can also see that the borrowers' valuation of housing reflects their expectations on the tightness of the constraint going forward. Therefore, the longer a loosening in the collateral constraint is expected to last, the larger the resulting shift into housing, relative to nondurable consumption.

Turning to the implications of the SG for economic activity, figure 4.4g shows that it generates an expansion through fairly standard channels. Lower interest rates boost investment and therefore the capital stock, raising the marginal product of labor and labor demand. The increase in labor demand is larger under sticky prices, because firms need to hire to satisfy the higher demand for consumption and investment goods (i.e. markups fall). With the standard King-Plosser-Rebelo preferences ($\mu = 1$), labor supply would decline due to the usual wealth effect. Under JR preferences with $\mu \approx 0$, instead, the position of the labor supply schedule depends on the housing-to-consumption ratio, rather than on the marginal utility of consumption alone. This explains why the borrowers work more, while the savers do not (figures 4.5e and 4.5f). In sum, the boom in real activity reflects the increase in the aggregate labor input and, particularly, in capital.

4.2. **Banking glut.** In contrast to the saving glut, the banking glut refers to large *gross* inflows of foreign capital from advanced economies, mostly Europe, which were matched by similar outflows, resulting in small *net* flows and minor changes in the U.S. trade balance (Shin, 2012). Compared to the portfolio allocation of the SG countries, which was concentrated in Treasury and agency debt, the composition of the European gross capital inflows was more widely spread across asset classes, with a particular concentration in private-label ABS, corporate bonds and (to a lesser extent) equity (Bernanke et al. 2011). According to the empirical literature, the higher demand for ABS and corporate bonds from European investors put downward pressure on the spreads of these securities relative to Treasuries, despite significant increases in their origination (Bertaut et al. 2011).

Consistent with this description, our model captures the BG as a gross inflow of capital into the mortgage market, which is not associated with movements in the trade balance. More specifically, we model the demand by European investment banks for structured mortgage products, and their associated issuance of credit instruments on the domestic wholesale credit market, as an increase in the competitive pressure in this market. This increase in the number of players and in the credit products they issue compresses the spread between borrowing and lending rates, as shown in equation (2.4) when N_t increases.

Direct evidence on the quantitative implications for spreads of this increased participation by European banks in the U.S. wholesale credit market is difficult to obtain, since spreads between mortgage products and funding rates move for many different reasons. Therefore, our calibration is based on the fact that the spread between mortgage rates and Treasuries of comparable maturities declined by between 50 and 150 basis points between 2003 and 2007, at the time of the surge of European funds into the market for ABS. Moreover, this spread compression was more pronounced in mortgage products directly connected with the subprime boom, which featured prominently in the portfolios of European banks.[13]

Taking this evidence as a rough guideline, our simulation assumes that in every quarter between 2003:Q1 and 2006:Q3, agents in the model are surprised with an unanticipated decline in the spread, which they expect to be permanent. Given the ambiguity surrounding the appropriate choice of a spread measure, our BG experiment assumes a gradual decline

[13]See, for instance, figures 16 and 17 in Bertaut at al. (2011). The portfolio balance model estimated by these authors suggests that the European purchases of ABS during this period lowered ABS yields by 60 basis points. Including the purchases of non-ABS corporate debt, the negative effect on yields reaches 160 basis points. However, these estimates do not account for the impact of the increase in supply of these instruments, which presumably contributed to reduce these effects on rates.

in the steady state spread by a total of 75 basis points. This number approximately corresponds to the decline in the spread between the 30-year mortgage rate and the 10-year Treasury yield reported by Bertaut et al. (2011) and Bernanke et al. (2011). We also experimented with smaller (50 basis points) and larger declines (1 percent), and found roughly proportional changes in the model's dynamics.

Our findings on the implications of the banking glut for the U.S. economy are summarized in figures 4.7 and 4.8. Faced with a lower nominal (and real) interest rate, the borrowers reallocate their demand from nondurable consumption towards houses. This shift in demand puts upward pressure on house prices, which rise by 4% during the first five years. Higher collateral values allow them to borrow more, and ultimately to increase also the consumption of nondurable goods. Moreover, the relaxation of the borrowing constraint entails an even larger decline in the effective interest rate faced by borrowers ($R_t/(1-\xi_t)$), due to the current and future expected fall in the multiplier. As a result, the borrowers' demand for housing increases substantially more than that for nondurable goods.

Absent any net injections of foreign capital, additional lending from the domestic savers to satisfy the increased borrowing by the impatient households requires an increase in the interest rate, which leads them to postpone consumption and investment. This reduction in the savers' demand almost exactly counteracts the expansion from the borrowers, resulting in a negligible overall increase in consumption and output. These offsetting effects of the responses of borrowers and savers on aggregate activity are also a feature of the closed-economy experiments in Justiniano, Primiceri, and Tambalotti (2012). As in those experiments, we also find a sizable re-allocation of houses from the borrowers to the savers.

Our simulation of the BG is subject to at least two caveats. First, empirical evidence suggests that capital inflows from the SG economies also contributed to the reduction in spreads of mortgage over Treasury yields, perhaps by substantial amounts (Bertaut et al., 2011, Warnock and Warnock, 2009). Since our model is not well equipped to capture this effect of the SG, we might be overestimating the impact of the BG relative to the SG. Second, foreign inflows were not the only factor behind the observed reduction in mortgage spreads, which is why we view the magnitude of our simulations as only suggestive of the potential effects of a compression in spreads that might be attributed to the BG channel.

4.3. **Saving and banking gluts: a quantitative perspective.** This subsection presents the results of a joint simulation of the SG and the BG. From 1998:Q1 through 2002:Q4,

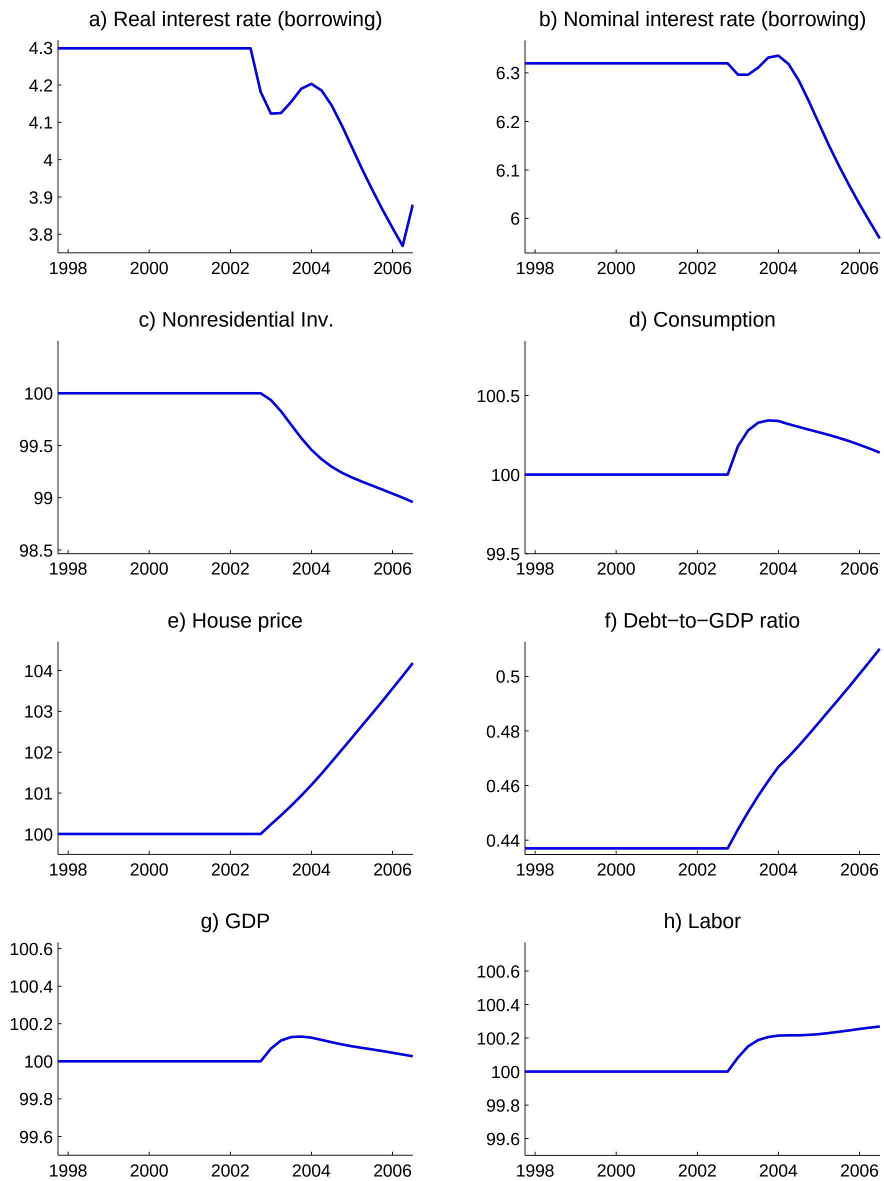

FIGURE 4.7. Banking glut: aggregate variables

only the SG is active and the transition paths are identical to those described in section 4.1. After 2003:Q1, the BG is also active. Given the focus of the previous subsections on the qualitative mechanisms at play in the model, here we concentrate on the overall quantitative impact of these international forces, with particular attention to their contribution to the housing and credit boom.

In our combined experiment, real house prices increase by 17% between 1998 and 2007 (figure 4.9e). Therefore, our results attribute between one-third and one-fourth of the

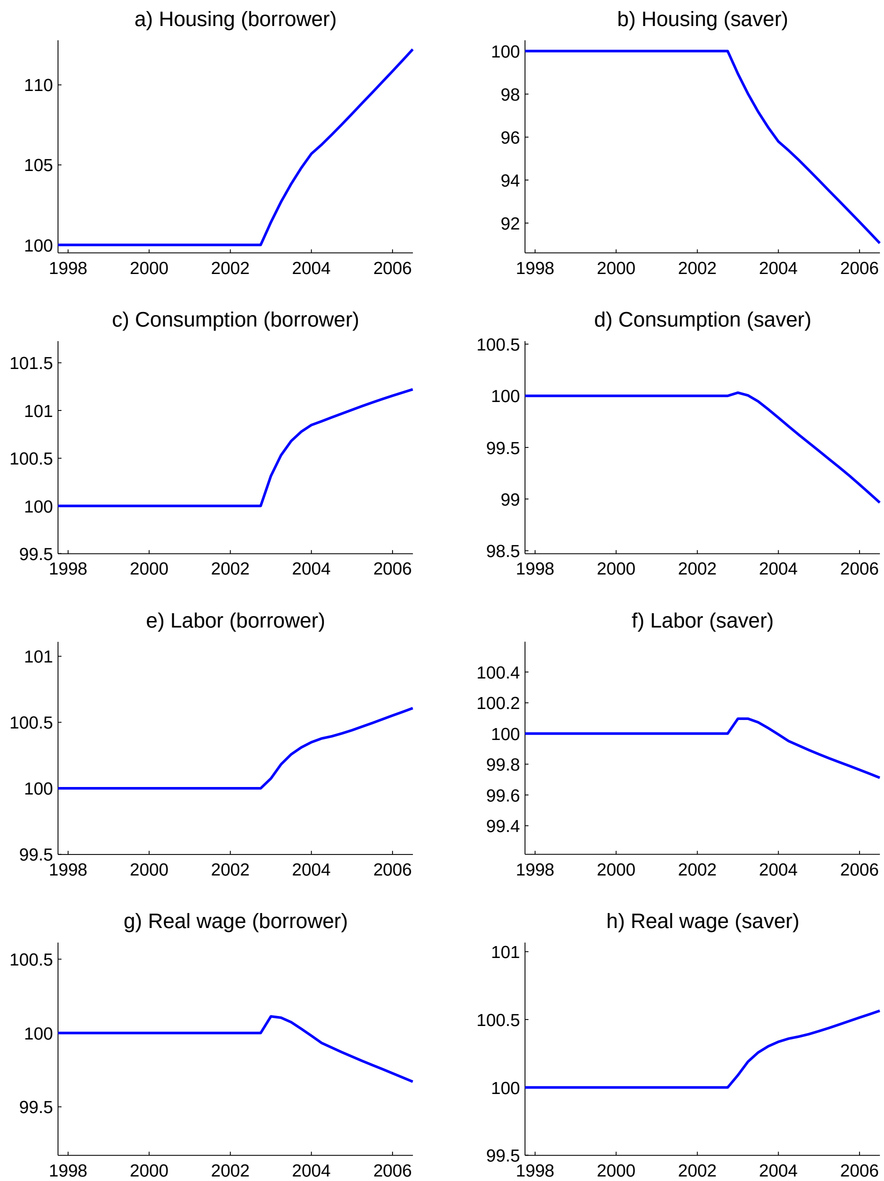

FIGURE 4.8. Banking glut: borrowers and lenders

recent house-price boom to the imbalances vis-a-vis the rest of the world. We regard the contribution of these international forces as realistic, considering that the literature has identified a host of domestic factors as important sources of the U.S. housing boom and bust and of the associated financial crisis, such as changes in the availability of credit on both the intensive and extensive margin (Mian and Sufi, 2009, Favilukis et al., 2012, Boz and Mendoza, 2010), loose monetary policy (Taylor, 2008, Ferrero, 2012), or deviations of house prices from fundamentals (Shiller, 2007).

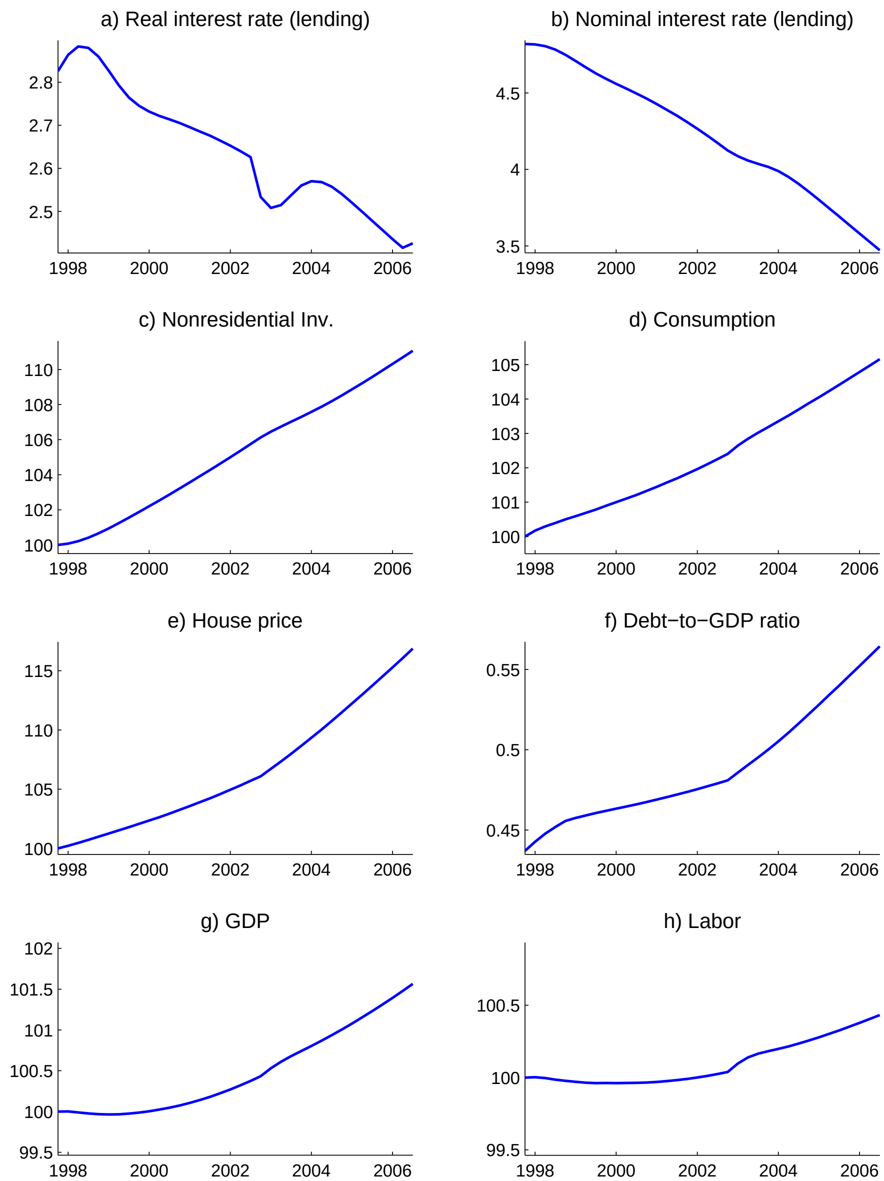

FIGURE 4.9. Saving and banking glut: aggregate variables

Our results suggest an even larger impact of the SG and the BG on the behavior of household debt. The debt-to-GDP ratio rises steadily in the joint simulation to a level of 56% (figure 4.9f), accounting for more than one-third of the observed run-up over the same period (0.44 to 0.75). With regards to the relative contributions of the BG and SG, our simulations attribute a greater quantitative role to the latter, a point reinforced by the caveats on the calibration of the size of the BG impulse raised in section 4.2.

The remaining panels in figure 4.9 plot the behavior of the real interest rate, GDP, investment and aggregate consumption in the joint experiment. As for most variables in the model, their transition paths are roughly equal to the sum of the responses in the two experiments taken in isolation.[14]The effects on activity are mostly shaped by the SG, due to the nearly offsetting responses of borrowers and savers to the BG. Investment and consumption rise considerably above trend, but the expansionary effects on GDP are more muted, due to the drag coming from the trade deficit.

Overall, the quantitative experiments illustrated above suggest that the sustained current account deficits run by the United States in the last fifteen years, and to a lesser extent the gross capital flows into mortgage-backed securities mediated by European banks, had a sizable impact on the equilibrium of the domestic economy. These flows of goods and assets reduced interest rates and spreads, and lifted nondurable consumption and house values. As a result, households' ability to borrow increased, accounting for more than one third of the observed surge in debt.

An important qualification to this conclusion is that, given the complexity of the current model, we took an extremely stylized view of international trade, as an exogenous flow of imports into the United States from the RoW, with no exports going in the opposite direction. This simplification is consistent with the two main tenets of the SG hypothesis put forth by Bernanke (2005). First, that international imbalances are best understood through the lens of the balance between desired saving and investment—the current account—rather than through that of the balance between exports and imports—the trade deficit. Second, that the main source of these imbalances since the late nineties were developments in the RoW, rather than in the U.S., and in particular the surge in desired saving in emerging Asia and the Middle East, looking for safe harbor in the United States.

4.3.1. *Robustness: supply of new houses.* Our baseline model assumes that the supply of houses expands at the rate of technological progress. This simplifying assumption is not crucial for our result that the dynamics of foreign capital flows account for between one fourth and one third of the increase in U.S. house prices and household debt. To illustrate

[14]The most notable exception is the behavior of household debt, which increases less in the combined experiment. The reason is the "zero lower bound" on the multiplier ξ_t. In the SG experiment, the collateral constraint does not bind while the trade deficit rises (from 1998:Q1 to 2006:Q3). Since the multiplier is already equal to zero, the reduction in the spread that starts in 2003:Q1 does not have an additional expansionary effect on borrowing, because the borrowers are already unconstrained.

this point, we experimented with a more complex version of the model, in which houses are produced combining a fixed factor (land) and residential investment, as in Davis and Heathcote (2005). The production of residential investment is subject to adjustment costs similar to those in equation (2.1), parameterized to approximately match the relative increase in the price and quantity of residential investment observed between 1998 and 2006. In this version of the model, house prices increase almost as much as in our simpler baseline specification (close to 14%). Meanwhile, the ratio of residential investment to GDP experiences a similar increase (roughly 17%) from its steady state level.

5. Concluding Remarks

The United States has been running large trade and current account deficits for more than twenty years. These deficits grew steadily during the 1990s and 2000s, and fell only partially following the Great Recession. We studied the quantitative effects of this massive transfer of resources from the Rest of the World to the U.S. economy, with a particular focus on its impact on the credit and real estate boom that precipitated the Great Recession.

We did so with help from a dynamic, general equilibrium model that features most of the now standard ingredients in the DSGE literature. The model also includes borrowing and lending among heterogeneous households, a non-competitive financial intermediation sector that charges a spread on borrowing rates, and a stylized foreign sector that lends resources to the domestic economy in exchange for a promise of more resources in the future. With these ingredients, we can capture two channels through which global imbalances affected the U.S. economy. The first channel is the global saving glut popularized by Bernanke (2005), which we represent as an influx of real resources in the U.S. economy calibrated to the observed sequence of trade deficits.

The second channel is Shin's (2012) global banking glut, which refers to the effect of the gross capital flows intermediated by global (mostly European) banks into the U.S. mortgage market. The evidence recently collected by Bertaut et al. (2011) suggests that these gross purchases of mortgage instruments had a significant impact on interest rates and spreads in the mortgage market, even though they were largely financed on domestic credit markets, giving rise to virtually no current account imbalance. We capture this second channel through a compression in the spread charged by financial intermediaries, associated with the increased competition in the wholesale funding market triggered by the entry of European banks.

The main finding is that the saving and banking glut together were an important contributor to some of the key macroeconomic developments in the U.S. during the 2000s, and in particular in the period preceding the financial crisis. In the calibrated model, these two forces contribute to a large boom in consumption and investment, and account for between one fourth and one third of the observed run-up in real house prices, and more than a third in that of household debt. Between the two channels, the saving glut has much larger effects, since it generates a fall in interest rates for both borrowers and savers that stimulates their demands, especially of durable goods such as houses. The compression in spreads with which we capture the banking glut, instead, elicits opposite responses between borrowers and lenders, leading to smaller effects on aggregate variables.

Our modeling strategy misses at least two potentially important dimensions of the connection between global imbalances and domestic macroeconomic developments. First, the portfolio composition of the financial flows that mirror the observed trade deficit is irrelevant in our model. This is because agents have perfect foresight, and therefore perceive no risk in the returns of the assets they hold, making them indifferent about the composition of their portfolio. The main advantage of this strategy is that it focuses on the overall macroeconomic effect of trade, without having to worry about the underlying financial flows, which can be difficult to track. The clear disadvantage is that we cannot address the important issues raised by the strong preference of the saving glut countries, and of China in particular, for safe U.S. dollar assets. These issues are the focus of Caballero, Farhi, and Gourinchas (2008) and Mendoza, Quadrini, and Rios-Rull (2009), and of a growing literature that followed them.

Second, there are no exports and imports explicitly in the model, just resources made available from the rest of the world for consumption in the U.S., and no structure on the reason why foreign agents are willing to lend those resources today. Therefore, we have nothing to say about what happens in the rest of the world, nor about the many channels through which imports, exports and the exchange rate affect domestic allocations. Nevertheless, the model provides useful insights on some of the basic mechanisms through which international imbalances affect a large economy, as well as a reasonable quantification of their aggregate effects.

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