The Recent Boom Bust Cycle:

The Relative Contribution of Capital Flows, Credit Supply and Asset Bubbles

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Abstract

We use an estimated open economy DSGE model with financial frictions for the US and the RoW, to evaluate various competing explanations about the recent boom bust cycle. We find in particular that the savings glut hypothesis is insufficient for explaining all aspects of the boom in the US. Also, relatively strong TFP growth and expansionary monetary policy are not able to explain fully the volatility of corporate and in particular residential investment. We identify bubbles in the stock and housing market as crucial. Concerning the downturn in 2008/09, the fall in house prices and residential investment only plays a minor role. Mortgage defaults have more explanatory power, especially in a specification of the model with a segregated equity market. Finally, the bursting of the stock market bubble was at least as important in this recession as in 2001. Because of various negative shocks hitting the economy at the same time in 2008/09 and continued positive technology growth, not only the real interest rate declined but inflation fell rapidly and left insufficient room for monetary policy to play a similar stabilising role as in previous recessions.

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The views expressed in this paper are those of the authors and should not be attributed to the European Commission.
Introduction

In the last 15 years, the world economy went through two boom bust cycles, characterized by financial market “malfunctioning”. Both cycles are strongly related to stock and housing price cycles. While the so called 'dot com bubble' had relatively benign macroeconomic consequences and only resulted in a mild recession, the crisis of 2008/09 following the housing boom is much deeper and will enter modern economic history as the “great contraction”. It drove both monetary and fiscal policy to its limits and is causing a fundamental reevaluation of contemporaneous macroeconomic thinking as incorporated in DSGE models, which are based on the assumption of efficient financial markets and the absence of serious agency problems (see Gali and Gertler (2007)). These models have been criticized in recent years for being useless in diagnosing bubbles in real time and suffering from insufficient “amplification mechanisms” to trace the severity of the current recession (see, for example Krugman (2009)).

In our analysis we will concentrate on the most recent boom bust cycle, starting at the beginning of 2000. The US can be seen as having played a central role both as an absorber of world savings but also as a major source of financial innovations. Also, the bulk of financial losses so far have originated in the US. Therefore we are looking at a world economy consisting of the US and the RoW.

Various competing explanations have been given for the boom. Some commentators regard financial innovation in the US mortgage market and the expansion of sub prime lending as a major source of the boom. As documented by Mayer et al. (2009), the share of non prime mortgages in total mortgages rose from about 10% to more than 30% from 2003 to 2005. The so called savings glut hypothesis, as first spelled out by Ben Bernanke in two influential speeches (2004, 2005) provides an alternative explanation for increased indebtedness of US households and also potentially explains why real interest rates have been low over that
period. Bernanke argued that in reaction to the results of the 1997/1998 crisis Asian developing countries strongly increased their supply of savings. This trend was reinforced by an increased flow of capital from newly enriched commodity exporters. The resulting 'global savings glut' led to severe adjustments in several developed economies, in particular in the US, "fuelling large appreciations in stock markets and in the value of the dollar" (Bernanke, 2005). The increased borrowing from the developing countries had also the effect of inducing these countries to run large external surpluses, which was offset by the emergence of large current account deficits in the developed world, and especially in the US.

As the 'global savings glut' theory, the 'flight to safety' hypothesis also sees the global imbalances of the first half of the 2000s being a consequence of the Asian crisis. However, unlike the former, its validity does not require a large outward shift in the supply of savings in the period immediately following the crisis. Instead, according to the 'flight to safety' hypothesis, the global imbalances were an outcome of a shift in demand for foreign assets in developing countries in that period. The primary reason for such a shift could be the loss of confidence in domestic stock markets in countries (mainly in developing Asia) that experienced a rapid build-up of the bubble in the 90s followed by an abrupt bust in 1997-1998.¹

Shiller (2007, 2008) and Laibson et al (2009) regard subprime lending, the savings glut or the flight to safety hypothesis as insufficient explanations for the US housing boom and blame the presence of a housing bubble as a major driver of demand growth in the US which has led to elevated house and stock prices and an increase in leverage of households and financial institutions.

¹ Several authors (Caballero, Fahri and Gouranichis 2006, 2008a, 2008b) constructed small general equilibrium models roughly consistent with this story.
The current recession is characterised by strong declines in asset prices and financial sector losses. Here, the question arises how the corrections in financial and housing markets could have led to such dramatic declines in GDP as observed in 2009. As noted by Bean (2010), for example, a fall in house prices constitutes a wealth effect for the household sector, however, given standard estimates about the marginal elasticity of consumption out of wealth, even combining the loss from housing wealth and the financial sector losses (3.4 trio) could not explain the shortfall of aggregate demand and especially the composition of the decline, namely a strong fall of residential investment, followed by a very significant decline in corporate investment and a rather mild decline of private consumption. Also the response of employment and wages (in the US) is hard to explain by the standard macro model. The standard macro explanation goes as follows: a reduction in wealth leads to a decline in consumption. This causes a decline of real interest rates and a reduction of wages. These two effects would stimulate corporate investment and reduce productivity. Also Iachoviello (2010) notes that in the standard model, financial market losses are largely of a redistributive nature between borrowers and lenders within the (combined) household and banking sector and it would be difficult to generate large adverse aggregate effects in the standard macro model.

In this paper, we will address the two issues raised above, namely what is the relative contribution of the various hypotheses put forward for explaining the boom in the US and second the issue of amplification mechanisms operating in the current recession. Our model has some special features which make it suitable to discuss the issues raised above, namely residential investment, credit constraints as introduced by Kiyotaki and Moore (1997) and limited capital market participation.

Given the prominent role of residential investment and innovations in mortgage lending we model housing investment explicitly and allow for collateral constraints. This should both
help us in quantifying the extent in which financial innovations have contributed to the boom but also shed light on the effects of a possible credit crunch in mortgage lending. Linking the US economy to the RoW should help us in tracing savings and portfolio/risk premia shocks. For addressing amplification effects, we draw on the recent macro/finance literature which emphasizes balance sheet constraints (see, for example Krishnamurthy (2009) for a recent survey) both in the non financial and the banking sector. This requires a further disaggregation of the household sector. We distinguish between (risk averse) savers, investors/equity owners and debtors. We assume that a fraction of households own the corporate sector, which undertakes all production and banking activities. Equity owners receive funds from savers in the form of deposits and (unsecured) corporate bonds. The supply of corporate bonds is subject to a collateral constraint, while deposits are risk free. Debtor households take out mortgage loans from banks in order to finance residential investment. They are also subject to a collateral constraint which ties borrowing to the value of their housing stock.

Our model is similar to Iachoviello (2010), but there are the following differences: First, we disaggregate the household sector differently. Iachoviello distinguishes between savers, credit constrained households, entrepreneurs (also credit constrained), and bankers. We neglect credit constrained entrepreneurs but look at an aggregate corporate sector. The reason is partly empirical and partly conceptual. Loans provided by US banks are mostly mortgage loans, while the business sector is financing itself largely via the stock market and corporate bonds.2 Also, we find it easier to analyse the adjustment and recapitalization of US banks as a capital allocation decision of investors who allocate funds optimally between production and banking within an integrated corporate stock market.

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2 The US flow of fund data suggest that only about 20% of all loans are (non mortgage) loans to US firms (see also De Fiore and Uhlig (2005)). This constitutes only a small fraction of the total value of US firms.
Second, Iachoviello only considers amplification arising from a (mortgage) loan default shock, while we also look at amplification effects arising from a decline in house prices. Third, our analysis covers both the boom period and the bust. Fourth, we allow for international repercussions, since we allow shocks to spread internationally via trade and financial linkages. Fifth, our analysis is based on an estimated model over the period 1995Q1 to 2009Q4, which allows us to systematically identify and quantify relevant shocks.

This paper is structured as follows. The next section discusses the major stylized facts of the recent boom and bust period. Section two provides a model description. It also explains our estimation strategy. Section three uses IRFs from the estimated model in order to analyse qualitatively how certain shocks, associated with alternative hypotheses, are capable to match with the stylized facts. Section four conducts a shock decomposition exercise in order to quantify the empirical relevance of certain hypotheses. The last section concludes.

1. The stylized facts of recent US booms and busts

Our discussion will mainly concentrate on the last boom bust cycle, but since some shocks (in particular the savings glut) started before the last boom, the figures presented below start in 1995. Showing two boom bust episodes also reveals the specific nature of the two cyclical episodes.

As shown by Figure 1, the US trade balance started to decline since the mid 90s, reaching a trough at the end of 2007. The composition of domestic demand has shown different developments over the two previous cycles. The 1995-2002 boom is clearly characterised by strong increase in corporate investment, while the second boom (starting after 2002) shows a strong increase in residential investment and a recovery of corporate investment. It is also noticeable that investment shares stayed significantly above pre 1995 levels. The second

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3 This and all the other figures and tables referred to in the text are in the Appendix D.
boom was also preceded by an increase in the share of private consumption. The great contraction has been led by a collapse of residential investment, followed by a strong decline in corporate investment.

Figures 2 and 3 show the evolution of US and RoW real short term interest rates and the real exchange rate. As can be seen on Figure 2, RoW real rates have been converging to US rates from above and reaching US levels at around 2002. This period was also accompanied by a real appreciation of the dollar. Between 2002 and 2005 an interest rate differential opened up again with US interest rates falling to extremely low levels. Over this period we see depreciation of the dollar.

2. The Model

We consider the US as an open economy, which produces goods which are imperfect substitutes to goods produced in the RoW. Households engage in international financial markets and there is perfect international capital mobility. We distinguish between three types of households, savers, investors/equity holders and debtors. The saver households do not engage directly in investment decisions (except residential investment) but save in the form of deposits, (and corporate bonds). Consequently they earn interest income from financial assets and receive net wages. The investors own the bank and non financial corporate sector and make corporate investment and loan supply decisions. Loans are supplied to households to finance residential investment, while corporate investment is financed via the stock (and the bond) market. In order to distinguish between borrowers and savers in the household sector, we distinguish households by the rate of time preference. Savers with a low rate of time preference supply funds to investors, while households with a high rate of time preference

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4 In order to keep the model description as simple as possible, we do not discuss real and nominal frictions associated with adjustment costs for labour, capital (residential, equipment and structures), capacity, prices and wages. These adjustment rigidities are important for fitting the model to time series observations and are therefore included in the estimated model. An appendix to this paper lists the adjustment cost specifications and a table in the appendix gives the estimated parameters.
receive loans from investors/banks. Mortgage loans supplied to creditors and bonds supplied to equity owners are subject to a collateral constraint. There is a monetary authority, following rules based stabilisation policies. Behavioural and technological relationships can be subject to autocorrelated shocks denoted by $Z^k_t$, where $k$ stands for the type of shock. The logarithm of $Z^k_t$ will generally be autocorrelated with autocorrelation coefficient $\rho^k$ and innovation $\varepsilon^k_t$.

2.1 Corporate Sector

The non financial corporate sector produces wholesale output with a Cobb Douglas production function which uses capital $K_t$ and labour $N_t$ as inputs

$$Y_t = K_t^{1-\alpha} N_t^\alpha Z^\alpha_t, \quad \text{with} \quad N_t = \left[ \int_0^1 N_i^{\theta-1} di \right]^{\theta-1}/\theta.$$  

where $N_t$ is a CES aggregate of labour supplied by individual households $i$. The parameter $\theta > 1$ determines the degree of substitutability among different types of labour. There is an economy wide technology shock $Y_t$ and an investment specific technology shock $J_t$ affecting current investment vintages. The banking sector transforms deposits $D_t$ into loans $L_t$, respecting a regulatory constraint which makes it costly for the bank if deposits exceed a fraction $\Gamma$ of total loans. The corporate sector issues shares at price $q_t$, and the number of outstanding shares is denoted by $S_{t-1}$ and pays dividends to share holders at rate $\text{div}_t$.

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5 Lower cases denote logarithms, i.e. $z_t = \log(Z_t)$. Lower cases are also used for ratios and rates. In particular we define $p^j_t = P^j_t / P_t$ as the relative price of good j w. r. t. final output. In order to economise on notation, US variables are without superscript while we use the superscript W for variables relating to the RoW.

6 Without loss of generality, we assume the number of shares to be fixed.
Dividends are equal to the cash flow of the corporate sector. The cash flow of the corporate sector is also subject to a default shock $DEF_{t-1}$ on matured loans to debtors\(^7\).

$$div_t S_{t-1} = (Y_t - w_t N_t) - p_t^j J_t + (1 + r_{t-1}^J) L_{t-1} - (1 - s) DEF_{t-1} - (1 + r_{t-1}^J) D_t - L_t + D_t - \phi(D_t - \Gamma L_t)^2 + q_t \Delta S_t$$

We assume that US banks have signed insurance contracts with RoW households which allows them to shift a fraction $S$ of loan defaults abroad\(^8\). The corporate sector makes decisions which maximises the present discounted value of dividends and it applies the stochastic discount factor of equity owners

$$Max V_0 = E_0 \sum_{t=0}^{\infty} \prod_{j=0}^{t} \left(1 + r_{t+j}^E\right) [div_{t+j} S_{t-1,j}]$$

(3)

$$- E_0 \sum \lambda_t \beta^t \left[K_t - J_t Z_t^j - (1 - \delta) K_{t-1}\right]$$

The first order condition for physical capital is given by

(4)  

$$p_t^j = Y_{K,t} + E_t \frac{(1 - \delta)}{(1 + r_t^E)} p_t^j \frac{Z_t^j}{Z_{t+1}^j}$$

And the first order condition for bank capital is given by

(5)  

$$(1 - \Gamma) = \frac{(1 + r_t^E) - (1 + r_t^J) \Gamma}{(1 + r_t^E)}$$

The corporate sector applies the same stochastic discount factor to financial and non financial sector capital. The value of the corporate sector is equal to the share price times the number of outstanding shares ($V_t = q_t S_{t-1}$) and the return on equity is made up of dividends plus capital gains. The required rate of return on equity is given by

\(^7\) First order conditions would not change if we would formulate separate maximisation problems for banks and non financial corporations. What is important is the joint ownership.

\(^8\) We assume that insurance premia for mortgage loans have been of a negligible size before the crisis. This assumption seems not inconsistent with the high ratings of mortgage backed securities.
\[ (1 + r_t^E) = \frac{\text{div}_t + E_t q_{t+1}}{q_t} \]

And we define a stochastic discount rate for the corporate sector \( d_t^E = 1/(1 + r_t^E) \).

### 2.2 Households:

The household sector consists of a continuum of households \( h \in [0,1] \). A fraction \( s^r \) of all households are savers and indexed by \( r \). \( s^c \) households are credit constrained (debtors) and indexed by \( c \) and there is a fraction \( s^e \) of equity owners. The period utility functions have identical functional forms for all household types \(^9\) and are specified as a nested constant elasticity of substitution (CES) aggregate of consumption \( (C_t^h) \) and housing services \( (H_t^h) \) and separable in deposits \( D_t^h \) and leisure \( (s^h - N_t^h) \). We also allow for habit persistence in consumption. For each household type \( h \in \{r, c, e\} \) the temporal utility is given by

\[
U^h (C_t^h, H_t^h, D_t^h, 1 - N_t^h) = \left\{ \frac{\text{CES}^h (C_t^h, H_t^h)^{\sigma^h}}{1 - \sigma^h} \right\} + \mathcal{G}^{D,h} D_t^{h,1-v} + \mathcal{G}^{N,h} (s^h - N_t^h)^{\nu^h}
\]

And

\[
\text{CES}^h (C_t^h, H_t^h) = \left[ \frac{1}{s^h} \left( C_t^h - h^h C_{i-1}^h \right) \sigma^h - 1 + \frac{1}{s^h} H_t^h \sigma^h - 1 \right]^{\sigma^h}
\]

Only savers and debtors supply differentiated labour services to unions which maximise a joint utility function for each type of labour \( i \). It is assumed that types of labour are distributed equally over the two household types. Nominal rigidity in wage setting is introduced by assuming that the household faces adjustment costs for changing wages. These adjustment costs are borne by the household.

\(^9\) Preference parameters can be different across household types.
2.2.1 Savers

Savers provide deposits $D_t$ to the banking system and hold bonds $B_t^D = B_t^D + B_t^F$ which is the sum of bonds to the domestic corporate sector $B_t^D$ and net foreign assets $B_t^F$. They also own the stock of land ($Land_t$) and they use a CES technology

$$J_t^H = \left( \frac{1}{s_L} J_t^{Land} \right)^{\sigma_L - 1} \left( \frac{1}{s_L} J_t^{Const} \right)^{\sigma_C - 1}$$

to combine land and final goods for the production of new houses $J_t^H$. The Lagrangian of this maximisation problem is

$$\text{Max} \quad V_r^t = E_0 \sum_{r=0}^{\infty} \beta^r U_r^t (C_t^r, s^r - N_t^r, H_t^r, D_t^r)$$

$$- E_0 \sum_{r=0}^{\infty} \lambda_r^t \beta^r \left( p_t^C \right) + p_t^H \left( J_t^{H,r} + J_t^{Const} + B_t^r + D_t^r - (1 + r_{t-1}) B_{t-1}^r \right)$$

$$- (1 + r_{t-1}^D) D_{t-1}^r - w_i N_t^r - p_t^L J_t^{land} - p_t^H J_t^{H,r} + T_t^r$$

$$- E_0 \sum_{r=0}^{\infty} \lambda_r^t \xi_\tau^t \beta^r \left( H_t^r - J_t^{H,r} - (1 + \delta^H) H_{t-1}^r \right)$$

$$- E_0 \sum_{r=0}^{\infty} \lambda_r^t \xi_\tau^t \beta^r \left( Land_t + J_t^{land} - (1 + g^t_{land}) Land_{t-1} \right)$$

The budget constraint is written in real terms with all prices expressed relative to final output ($P$). Investment is a composite of domestic and foreign goods. The consumption and housing investment decision are determined by the following FOC's

Consumption:

$$U_{C,t}^r = E_t (1 + r_t) \frac{p_t^C}{p_{t+1}^C} \beta^r U_{C,t+1}^r$$

Define the discount factor $d_t^r = \frac{1}{(1 + r_t)} = E_t \left( \frac{U_{C,t+1}^r \beta^r}{U_{C,t}^r} \frac{p_t^C}{p_{t+1}^C} \right)$
Deposits:

\[
\frac{U_{D,t}}{U_{C,t} / p_t} = d_t (1 + r_t^D)
\]

Residential investment

\[
p_t^{H} = \frac{U_{H,t}}{U_{C,t} / p_t} + E_t \left( d_t p_{t+1}^H (1 - \delta^H) \right)
\]

Land prices

\[
p_t^{Land} = E_t \left( d_t p_{t+1}^{Land} (1 + g^{Land}) \right)
\]

The first order conditions determine a savings schedule where the ratio between current and future expected consumption is as negative function of the real interest rate. For constant prices and interest rates residential capital and consumption grow at equal rates. The elasticity of substitution between \( C \) and \( H \) determines how strongly the demand for consumption and housing reacts to relative price changes. Finally residential investment is a negative function of opportunity costs which consist of the nominal interest rate minus capital gains from expected increases in house prices. With deposits in the utility function we capture the fact that deposits apart from providing interest income they also provide liquidity services to the household. Land constitutes an asset for the household and arbitrage requires a return equal to the risk free rate.

2.2.2 Debtors

Debtor households differ from saver households in two respects. First they have a higher rate of time preference \((\beta^c < \beta^r)\) and they face a collateral constraint on their borrowing \( L_t \). Banks impose a loan to value ratio \( \chi_t^c = \chi_t^c + z_t^c \). The Lagrangian of this maximisation problem is given by

\[
12
\]
\[
\begin{align*}
\text{Max} & \quad V_0^c = E_0 \sum_{t=0}^{\infty} \beta^t U^c (C_t^c, 1 - N_t^c, H_t^c) \\
& - E_0 \sum_{t=0}^{\infty} \lambda_t^c \beta^t \left( p_t^c (C_t^c + p_t^H J_t^H c - L_t + (1 + r_t^L) L_t) - w_t N_t^c + T_t^c - DEF_{t-1} \right) \\
& - E_0 \sum_{t=0}^{\infty} \lambda_t^c \psi_t \beta^t \left( H_t^c - J_t^H c - (1 - \delta^H) H_{t-1}^c \right) \\
& - E_0 \sum_{t=0}^{\infty} \lambda_t^c \psi_t \beta^t \left( (1 + r_t^L) L_t - \chi_t^c p_t^H H_t^c \right)
\end{align*}
\]

Consumption

\[
U_{C,j}^c = E_t \frac{(1 + r_t^L) \beta^c p_t^c}{(1 - (1 + r_t^L) \psi_t)} p_{t+1}^c U_{C,j+1}^c
\]

Define the discount factor \( d_t^c = \frac{(1 - (1 + r_t^L) \psi_t)}{(1 + r_t^L)} = E_t \frac{U_{C,j+1}^c \beta^c p_t^c}{U_{C,j}^c p_{t+1}^c} \)

Residential investment

\[
p_t^H = \frac{U_{H,t}^c}{U_{C,j}^c / p_t^c (1 - \psi_t (1 - \delta^H) \chi_t^c)} + E_t \frac{(1 - \delta^H)}{(1 - \psi_t (1 - \delta^H) \chi_t^c)} p_{t+1}^H
\]

Both consumption and residential investment are affected by the collateral constraint. A tightening of the constraint induces debtors to shift consumption from current to future periods and to reduce residential investment by increasing shadow capital costs by \( \psi_t (1 - \chi_t^c) \). A high loan to value ratio reduces the impact of credit tightening on residential investment, since in this case an increase in the capital stock makes investment valuable for the household by increasing its borrowing capacity.

2.2.3 Equity owner

Equity owners receive income (distributed profits) from dividends paid by financial and non-financial corporations and they can borrow from saver households in the form of unsecured bonds. Given moral hazard, savers impose a collateral constraint \( \chi_t^c \) which restricts bond
holdings not to exceed a certain share of the value of corporate equity. They maximise an intertemporal utility function\textsuperscript{10} subject to a budget and a collateral constraint

\begin{equation}
\begin{aligned}
\max V^E_0 &= E_0 \sum_{t=0}^{\infty} \beta^t U^e (C_t^e) - E_0 \sum \lambda_t \beta^t \left[ q_t S_t - B^D_t - (d_{t+1} + q_t)S_{t+1} + (1 + r_t) B^D_{t-1} - p_t C^e_t \right] \\
&- E_0 \sum \lambda_t \psi^e \beta^t \left[ B^D_t - \chi^e_t q_t S_{t-1} \right]
\end{aligned}
\end{equation}

Optimisation yields the following (inverse of the) stochastic discount factor for corporate investment

\begin{equation}
E_t \frac{U^e_{C,t} P^e_t}{U^e_{C,t+1} P^e_{t+1} \beta^e} (1 - \chi^e_t) + (1 + r_t) \chi^e_t = (1 + r^E_t)
\end{equation}

We consider two extreme cases for the loan to value ratio \( \chi^e_t \). For \( \chi^e_t = 1 \), equity owners have zero net worth and the savers own the corporate sector and correspondingly their stochastic discount factor is applied in the corporate sector. There is full participation of savers in capital markets and they fully diversify asset holdings across \( D \) and \( S \). In the other extreme case \( \chi^e_t = 0 \), savers only provide funds to the corporate sector in the form of deposits, i.e. there limited participation in the capital market and equity owners are credit constrained. In our analysis we will concentrate on these two extreme cases.

\textbf{2.2.4 Wage setting}

A trade union is maximising a joint utility function for each type of labour \( i \) where it is assumed that types of labour are distributed equally over constrained and unconstrained households with their respective population weights. The trade union sets wages by maximising a weighted average of the utility functions of these households. The wage rule is

\textsuperscript{10} We assume that equity owners do not engage in housing investment, deposit demand and labour supply.
obtained by equating a weighted average of the marginal utility of leisure to a weighted average of the marginal utility of consumption times the real wage of these two household types, adjusted for a wage mark up

\[
\frac{S^c U^{c}_{s^c - N^c, t} + S^r U^{r}_{s^r - N^r, t}}{S^c U^{c}_{c, t} + S^r U^{r}_{c, t}} = \frac{W_t}{P^c_t} \eta_t
\]

where \( \eta_t \) is the wage mark up factor, with wage mark ups fluctuating around \( 1/\theta \) which is the inverse of the elasticity of substitution between different varieties of labour services. The trade union sets the consumption wage as a mark up over the reservation wage. The reservation wage is the ratio of the marginal utility of leisure to the marginal utility of consumption. This is a natural measure of the reservation wage. If this ratio is equal to the consumption wage, the household is indifferent between supplying an additional unit of labour and spending the additional income on consumption and not increasing labour supply.

### 2.3 Retail sector

There is a retail sector which buys wholesale goods and diversifies them. Retailers sell these differentiated goods in a monopolistically competitive market. Retailers only face quadratic price adjustment costs (see appendix). This introduces nominal rigidities in this economy and in a symmetric equilibrium, inflation dynamics is given by a standard New Keynesian Phillips curve

\[
\pi_t = \beta E_t \pi_{t+1} + 1/ \gamma \rho MC^{WS}_t / P_t
\]
2.4 Monetary Policy

We assume that monetary policy is partly rules based and partly discretionary. The CB sets interest rates according to a Taylor rule and responds to annual consumer price inflation and the annual growth rate of output

\[ i_t = r^M_{log} i_{t-1} + (1 - r_{log}^M) r^E W + r^T_\pi \left( \pi_i + r^C_{t-2} + r^T_{t-3} - 4 r^T_\pi \right) + \tau_M \left( g_\pi + g_\tau_{t-1} + g_\tau_{t-2} + g_\tau_{t-3} - 4 g_\tau \right) / 4 + z^M_t \]  

(22)

The term \( z^M_t \) indicates discretionary deviations from the Taylor rule.

2.5 The RoW, trade and the current account

Output in the RoW is produced with labour only and production is subject to permanent shocks to technology. Households receive income from production and they can save in the form of RoW and dollar denominated bonds \( B_t^F \). They maximise an intertemporal utility function which yields the following decision rule for consumption

\[ U_{CW,t} = E_t \left( (1 + r_t^W) \frac{P_t^W}{P_{T+1}} B_t^W U_{CW,t+1} \right) \]  

(23)

Their discount factor is subject to stochastic shock \( \beta^W_t = \beta^W Z^W_t \). A savings glut in the RoW is represented by a negative shock to \( Z^W_t \). The portfolio allocation decision yields the following interest parity condition, where \( rer_t \) is the real exchange rate

\[ (1 + r_t) = (1 + r_t^W) Z^F_t r_{er_t} \]  

(24)

And we assume there is a stochastic risk premium \( Z^F_t r_{er_t} \) between US and RoW assets. An increase in the demand for US assets (flight to safety) would be indicated by a fall in \( Z^F_t r_{er_t} \).
In order to facilitate aggregation we assume that households and firms in the US and the RoW have identical CES preferences

$$A^i = \left[ (1 - s^M - Z^M) \frac{1}{\sigma^W} A^{d^i} \frac{\sigma^W - 1}{\sigma^W} + (s^M + Z^M) \frac{1}{\sigma^W} A^{f^i} \frac{\sigma^W - 1}{\sigma^W} \right]^{(\sigma^M - 1)}$$

across goods used for consumption, and investment $A^i \in \{C^i, I^i \}$. The share parameter $s^M$ can be subject to a shock $Z^M$ and $A^{d^i}$ and $A^{f^i}$ are indexes of demand across the continuum of differentiated goods produced respectively in the domestic economy and the RoW. We assume producer pricing for US imports and exports. Finally a share $s$ of defaults occurring in the US are born by RoW households. The stock of net foreign assets is thus given by

$$B_t^F = (1 + r_{t-1})B_{t-1}^F + X_t - rer_t M_t + sDEF_{t-1}$$

Where imports and exports are defined as $M_t = C_t^{US, f} + J_t^{US, f}$, and $X_t = C_t^{W, f} + J_t^{W, f}$.

Firms set prices as a mark up over marginal cost which are approximated by the output gap of the RoW. Price setting is subject to a random cost shock $z_t^{\gamma W}$

$$\pi_t^W = E_t \left( (\beta^W \pi_{t+1}^W - \pi_t^W) + 1/ \gamma_p^W \text{ygap}_t^W - z_t^{\eta W} \right)$$

The Taylor rule in RoW is similar as for the US:

$$i_t^W = \tau_{lag}^W i_{t-1}^W + (1 - \tau_{lag}^W) [r_t^{EQ} + \pi_t^W + \tau_{\pi}^W \left( \pi_t^W + \pi_{t-1}^W + \pi_{t-2}^W + \pi_{t-3}^W - 4 \pi_t^W \right) / 4 + \tau_{\pi}^W (gy_{t-1}^W + gy_{t-2}^W + gy_{t-3}^W - 4 gy_t^W) / 4] + z_t^{\pi W}$$

where $z_t^{\pi W}$ is a shock to the RoW Taylor rule.

2.6 Equilibrium
Equilibrium in our model economy is an allocation, a price system and monetary policies in the US and the RoW such that households maximise utility, and the following market clearing conditions hold for final US and RoW goods:

\[(29) \quad Y_{t}^{US} = C_{t}^{US,d} + J_{t}^{US,d} + J_{t}^{Constr,US} + X_{t}, \]

\[(30) \quad Y_{t}^{W} = C_{t}^{W,d} + M_{t}, \]

In addition markets for residential investment, labour, loans, deposits, equity and internationally traded bonds clear.

2.6 Bubbles

For implementing bubble processes for house and stock prices we follow Bernanke and Gertler (1999). Consider the arbitrage equation for the stock price, which determines the stock price in period as being equal to the current dividend plus the expected capital gain, discounted with the factor \(d_{t}^{E}\)

\[(40) \quad q_{t} = div_{t} + E_{t}d_{t}^{E}q_{t+1} \]

We assume that besides \(div_{t}\), there is a non-fundamental shock \(x_{t}\) which also influences the current price. And we assume that \(x_{t}\) follows the "near rational" bubble process\(^{11}\)

\[(41) \quad x_{t+1} = \begin{cases} \frac{a}{prob} \frac{x_{t}}{d_{t}^{E}} + e_{t} & \text{with probability} \ prob \\ 0 & \text{with probability} (1 - prob) \end{cases} \]

with \(a < d_{t}^{E}\). The expected value of \(x_{t}\) is

---

\(^{11}\) We confine ourselves to near rational bubbles for technical reasons (see next footnote). By deviating from a rational bubble we implicitly allow for the presence of noise trading which is not eliminated by rational speculators.
\( E_t x_{t+1} = a x_t / d_t^E \)

Now we can define the market price \( q_t^M \) for the respective asset

\( q_t^M = q_t + x_t \),

which follows the process

\( (1 - (1 - a)) \frac{x_t}{q_t} q_t^M = d_t^E (div_t + E_t q_{t+1}^M) \)

In the presence of bubbles the expected return of the asset differs from the fundamental return by the presence of a positive or negative premium. The asset price including the bubble obeys the asset price equation with a declining risk premium and the risk premium is defined as

\( Z_t^v = -(1 - a) \frac{x_t}{q_t} \frac{q_t^M}{q_t} \)

and \( x_t \) rises before the bubble bursts and vanishes afterwards. Similarly we implement a near rational bubble process for house and land prices.

### 2.7. Estimation

The model is estimated on quarterly data for US over the period 1995Q1 to 2009Q4. In this section we first discuss the Bayesian estimation. The appendix C contains a detailed discussion of data and the empirical fit of the model.

In Table 1 we show prior distributions and posterior estimations of our structural parameters. We estimate the population share of equity owners \( s^e \). The share of debtors \( s^r \) is then equal to \( \bar{s}^r / (1 - s^e) \) where \( \bar{s}^r \) is fixed to 0.6. Debtor households are those households which account

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12 This restriction allows us to introduce a stationary non fundamental shock into the model.
for about 10% of mortgage borrowing belonging to the subprime segment of the US mortgage market. Concerning consumption, we fix the intertemporal elasticity of substitution to one and estimate habit persistence to be 0.72. The substitution elasticity for housing services (\( \sigma_H \)) is estimated at 0.49. The adjustment cost parameters for housing are substantially larger compared to the corresponding parameters for corporate investment. This appears plausible given the nature of the two investment activities. The estimated persistence in nominal interest rate setting (\( \tau^{M}_{Log} \)) is at 0.87. The estimated fiscal response parameters are counter-cyclical. The share of forward-looking behaviour in price indexation is higher than expected, and ranges between 0.79 and 0.9.

3. **Impulse responses**

This section discusses how certain shocks which have played a role in discussions about the recent boom bust episode can account for the stylised facts of the most recent cycle. These are the large capital flows to the US because of increased savings in the RoW (\( Z_{cw} \)) or a shift in preferences in favour of US assets (\( Z_{fr} \)), IT related positive shocks to US technology (\( Z_{iy}, Z_{ij} \)), expansionary monetary policy in the Greenspan era (\( Z_{im} \)), asset price bubbles in the stock (\( Z_{is} \)) and housing market (\( Z_{ih} \)), excessive bank lending associated with the fast increase of the subprime mortgage market (\( Z_{ix} \)) and financial market losses associated with defaulting mortgage loans (\( DEF_{t-1} \))\(^{13}\). The solid lines give results for the model with zero bond financing of the corporate sector and the dotted lines give results of the model with no separation between savers and equity owners. We will concentrate on the first specification and discuss the second specification only in the case of significant differences.

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\(^{13}\) As, for example, argued by Gorton (2010) the fall in house prices is strongly linked to defaults in the US mortgage market due to the specific nature of subprime lending, therefore the default and the house price bubble shock are not strictly independent.
1. Labour augmenting technical progress (Figure 4)

Consistent with the unit root properties of macro aggregates, we model labour augmenting technical progress as a random walk. This implies that technology shocks have permanent level effects and result in increases in all domestic demand components which are in line with GDP. This shock therefore does not allow to match the distinctive features of the recent US boom, concerning the composition of domestic demand. Also it does not explain the fall in the trade balance and the fall of real interest rates.

2. Investment specific technical progress (Figure 5)

An increase in the efficiency of new capital vintages shifts demand to corporate investment while it does not significantly affect the share of consumption and housing investment in GDP. However, like standard TFP shocks, investment specific technical progress cannot explain a falling trade balance and low interest rates.

3. Money shock (Figure 6)

Expansionary monetary policy can account for some stylised features of the boom. The reduction of interest rates favours investment growth over consumption growth, it worsen the trade balance and leads to a real depreciation of the US dollar. This makes it a relevant shock especially for the period 2002-2005.

4. Collateral constraint for debtors (Figure 7)

An increase/reduction in the loan to value ratio for debtors increases/reduces consumption and residential investment in the same direction. However, corporate investment has the opposite sign because of interest rate effects. A loosening of credit constraints can therefore only be a partial explanation of the boom since it suggests too much of a co-movement between
residential investment and private consumption and it wrongly predicts a decline of corporate investment.

For the same reason, a credit crunch for subprime borrowers (a reduction of the loan to value ratio) cannot explain the strong discrepancy between the fall of residential investment and the relative stability of private consumption.

5. Mortgage Default shock (Figure 8)

Defaulting loans result in persistent financial losses in the corporate sector and are borne as income losses by equity owners. Especially the expectation of protracted losses and long lasting recapitalisation efforts of shareholders increases the required rate of return on equity. This effect becomes stronger when financial losses cannot be diversified across all savers of the economy but are borne by a group of equity owners only. This can be seen by comparing the solid line IRFs with the dotted lines. By increasing the required return on equity, financial losses originating in the mortgage market adversely affects corporate investment. This persistent negative investment response leads to long lasting level shift of GDP which seems to be a stylised fact of many financial crises (see Saxena et al 2009). By reducing the debt burden on credit constrained households it also stabilises private consumption, but for the same reason it does not generate the strong decline in residential investment that we have seen in the US in recent years.

6. Savings glut (Figure 9)

It leads to an initial real appreciation of the US dollar and a fall of interest rates. It increases all domestic demand components at similar magnitudes and causes a deterioration of the trade balance. However, higher indebtedness of domestic households leads to a relatively rapid turnaround of demand and the exchange rate. This feature could therefore partly explain the depreciation following the appreciation until 2002.
7. External risk premium (‘flight to safety’) (Figure 10)

A falling risk premium for the US dollar has similar effects on the US economy as an increase in world savings. It lowers real interest rates in the US and leads to an increase in both corporate and residential investment, followed by a more modest increase in private consumption. Like in the previous case, this shock lowers interest rates in the US and reduces demand for US exports, in this case via an appreciation of the dollar. Both shocks taken together match qualitatively a large number of US stylised facts.

8. Housing bubble (Figure 11)

The housing bubble explanation is attractive, since it can explain especially well two features of the data which are hard to match with shocks discussed so far, namely first the extraordinary increase of housing investment (and house prices), followed by a strong and rapid collapse of house prices. However, it can only be a partial explanation for the boom, because this hypothesis does not explain why interest rates have been so low between 2002 and 2005.

9. Stock market bubble (Figure 12)

The stock market bubble is also attractive as an explanation for strong corporate investment growth. Unlike the housing bubble which makes the counterfactual prediction of a decline of consumption, the stock market bubble generates more co-movement between demand components. As in the case of the housing bubble, the stock market bubble is not well suited to explain the fall of real interest rates. However, here the timing of the bubble becomes important. If the corporate investment bubble emerges after 2004 then it could be consistent with an increase in real rates starting in this year.

4. Empirical Analysis
4.1 Shocks driving the boom and bust cycle

Some of the shocks discussed above can be directly observed, such as the loan default shock and the shock to investment and we can therefore directly specify shock processes as exogenous variables in the model\textsuperscript{14}. The other remaining shocks to labour augmenting technology, preferences, loan supply, monetary policy and bubbles in the stock market and house prices can be identified as residuals to specific structural equations of the DSGE model.

We capture \textit{labour augmenting technology shocks} to final goods by the terms $Z_t^Y$ in the production function and we specify it as a random walk processes. We identify \textit{investment specific technical change} $Z_t^J$ by differences in growth rates between a weighted average of the GDP deflator and the import price deflator on the one hand and the investment deflator on the other. We identify shocks to \textit{monetary policy} $Z_t^M$ as stationary deviations of the nominal interest rate from a standard Taylor rule and we capture shifts in \textit{lending conditions} as shocks to the collateral constraint of debtor households $Z_t^\chi$. Concerning \textit{loan defaults (DEF)}, we use time series information on charge off and delinquency rates from real estate loans published by the US FED. We identify the \textit{savings glut hypothesis} as a shock $Z_t^{CW}$ to the rate of time preference in the RoW while the \textit{flight to safety} hypothesis is identified via shocks $Z_t^{\pi}$ to the risk premium in the interest parity condition. By adding exogenous shocks to the discount factors of the various asset market arbitrage equations we allow for non-fundamental shocks (bubbles) in the model. In particular we identify \textit{stock market bubbles} as a shock $Z_t^V$ to the discount factor for dividends, and a \textit{house price bubble} as shocks $Z_t^H$ (see section 2.2 for the bubble interpretation of correlated shocks to asset price equations).

\textsuperscript{14} It is difficult to specify the default shock for mortgage loans empirically because of the exceptional events in 2007. Therefore we fix the autocorrelation parameter to be large in order to capture the expected persistence of US foreclosures (see Hatzius (2008)).
Figure 13 shows the estimated historical evolution of these fundamental and non-fundamental shocks of the model over the period 1995Q1 to 2009Q4. Both TFP and investment specific technical change show a general positive trend over the sample. However the evolution is not uniform across time and interrupted by periods where technical progress takes on a lower pace. It is interesting to note that TFP growth is strongly positive in both recent recessions.

The lending conditions shock ($Z_t^x$) shows a high degree of cyclicality. It is, however, noteworthy that lending conditions loosened around 2005. This process was then reversed around 2007 and in 2009 we see a strong tightening of lending conditions. Notice that, although we do not use particular information about subprime lending in the US, the process we identify for recent years seems to be consistent with the rise and collapse of the subprime mortgage market in the US. The monetary policy shock ($Z_t^M$) shows some signs of a lax monetary stance in early 2000 and deviations from the Taylor rule remained negative until 2006. In 2007, the FED again deviated strongly from the Taylor rule. The positive deviations in 2009 indicate the zero lower bound constraint. We find that a stock market bubble ($Z_t^V$) built up in the second half of the 1990s and burst in 2000-2001. Since 2004 a new bubble was building up, which burst again at the end of 2008. The house price bubble ($Z_t^H$) starts inflating at the beginning of 2000 and bursts at the end of 2005. Throughout the 90s but especially over the period 95-2000, the model identifies an increase in the savings rate (reduction in the rate of time preference) in the RoW which is consistent with the savings glut hypothesis. In parallel, from the uncovered interest parity condition we identify a strong decline in the risk premium of the dollar from the late 90s, reaching a trough at around 2003 and remaining low until 2008. For the residential loan default shock we use actual data. Apart from the early 90s which show somewhat elevated default rates, loan defaults have been stable until 2007, when they shot up to unprecedented levels.

4.2 Shock decompositions
This section looks at the quantitative importance of the shocks discussed above Figures 14 to 20 provide shock decompositions for US GDP growth, the individual demand components, the real interest rate and the real exchange rate.

*US GDP growth (Figure 14)*

In the period immediately following the bursting of the dot com bubble in 2001 (until the end of 2004) US GDP growth was primarily driven by high TFP growth. The external shocks, financial market and bubble shocks become increasingly more important as drivers for US growth starting from the beginning of 2004. It is worth emphasising that in this period the stock market shock had a positive impact on growth. The small growth impact of the external shocks can be explained by their offsetting effects on domestic and foreign demand. Also the residential investment bubble cannot be of major importance for US growth given the small share of residential investment in US GDP.

In 2007 the fall in house prices and deteriorating lending conditions exerted a drag on GDP growth. Monetary policy was largely offsetting these negative shocks. In 2008 the default shock started to have a stronger negative effect and we can also observe first negative contributions from a deteriorating stock market. In 2009 we identify the stock market collapse as the most important negative growth factor, followed by the default shock. Also as nominal interest rates are hitting the zero lower bound monetary policy loses its power to stabilise the economy. Good fundamentals, especially accelerating TFP growth over the year 2009 prevents a stronger collapse of GDP. The US economy is also helped by an inflow of capital in 2009.

*US domestic demand shares*

Figures 15 to 17 show how real domestic demand shares have been affected by the selected shocks. Both flight to safety and the savings glut hypothesis can explain some of the increase
in private consumption and corporate investment in GDP since the end of the 90s. Relaxing collateral constraints in 2004 also supported consumption growth over the period 2004 until the beginning of 2007. The share of corporate investment has been strongly and persistently positively affected by investment specific technical progress, related to the IT boom. However, the cyclical variation of corporate investment cannot entirely be explained by fundamentals, Figure 16 shows the dot com bubble plus its collapse in 2002. Also the corporate investment boom in 2006-2007 cannot be explained entirely by fundamental factors. In fact, the investment boom over these two years is associated with relatively modest TFP growth. Figure 18 shows that the strong increase of residential investment cannot be explained by fundamentals but must to a large extent be attributed to a housing bubble.

The fall in residential investment, starting in early 2006 is clearly leading the downturn. It is mostly driven by a deflating bubble, collateral tightening only plays a minor role. The reason why the model attributes only a small contractionary role to the credit crunch in the mortgage market is due to the fact that private consumption remains relatively stable. Initially corporate investment is not significantly affected from the fall of residential investment. Only with the emergence of increased default rates at the end of 2007 do we see a decline in the investment share. This by itself does not entirely explain why investment growth declined so much in 2008/09. Another factor playing a role is a correction of the stock market bubble that started to emerge in 2004. Robust TFP growth has prevented a stronger decline of investment in the US.

**Trade balance and real exchange rate**

The savings glut hypothesis turns out to be an important factor behind the worsening of the US trade balance in years 2000-2002 (Figure 18). After 2002 we find that both the savings shock as well as the risk premium shock to the US dollar start to stabilise which makes it difficult to attribute the further decline in the trade balance until 2006 to the savings glut.
Interestingly the domestic demand impulses are also not sufficient to explain a further deterioration of the trade balance. Our analysis attributes at least 50% of the decline to the combined effect of negative shocks to world demand and adverse shocks to US trade. A temporary fall of domestic demand in 2008 explains well the improvement of the trade balance. Our analysis also shows the important effect of the international spillover of the default shock, which leads to a reduction in US foreign indebtedness and therefore an appreciation of the US dollar. *(Figure 19)*

**Real interest rate**

What explains the strong cyclical movement of US real interest rates *(Figure 20)*, which fell from a peak in 2001 to a long time historic low in 2004 and then reached a peak again at the end of 2007, followed by a rapid decline until the end of 2009? The two peaks are clearly identifiable as domestic demand expansions generated by looser collateral constraints and high corporate investment. Also the negative shocks to the policy rate can be associated with the fall in real rates immediately after the peak. Interestingly, expansionary monetary policy shocks persist beyond the mild recession in 2002. It is also clear from the Figure that foreign capital inflows reduced US rates especially after 2002. The decline of real rates after 2007 reflects first of all deteriorating domestic demand conditions, monetary policy stimulus and defaulting mortgage loans.

5. **Conclusion**

The aim of this paper is to look at the validity of various competing explanations about the recent boom bust cycle. We use an estimated open economy DSGE model with various financial frictions for the US interacting with the RoW in goods and financial markets. We single out the US in this analysis because of its prominent role both as a recipient of international capital flows but also as a source of shocks originating in US asset markets.
Finally, the well documented losses in the US financial sector and its international dissemination make this an appealing choice for studying the effects of a mortgage default shock not only on US GDP but also on the real exchange rate and the trade balance.

Concerning the boom period, we examine the role of fundamental and non fundamental shocks. The savings glut, while important, cannot explain all aspects of the data we analyse. A story based on high TFP growth can explain why the share of corporate investment increased but it has problems tracking the volatility of corporate investment. Also a story for the decline of investment based on a revision of TFP growth expectations as put forward by Kahn et al. (2009) does not seem to fit the facts, given the persistently high rates of technical progress in the US.

Our estimation identifies the dot com bubble in the late 90s and indicates a second bubble starting to emerge in 2004. Also, we find a housing bubble to emerge at the beginning of this decade and starting to deflate at the end of 2006, well in advance of the turnaround in growth. Concerning the downturn in 2008/09, the fall in house prices and residential investment only plays a minor role. The mortgage defaults associated with the fall in house prices have more explanatory power and can explain a decline of US growth by about 2% in 2009, suggesting a significant role played by increases in required rates of return associated with losses borne by equity holders. Finally, the bursting of the stock market bubble was at least as important in this recession as it was in the previous one. Because of four negative shocks hitting the economy at the same time in 2008/09 and continued positive technology growth, not only the real interest rate declined but inflation fell rapidly and left insufficient room for monetary policy to play a similar stabilising role as in previous recessions.
References


Appendix A: Nominal and real frictions

Firms face technological and regulatory constraints which restrict their price setting, employment and capacity utilisation decisions. Price setting rigidities can be the result of the internal organisation of the firm or specific customer-firm relationships associated with certain market structures. Costs of adjusting labour have a strong job specific component (e.g. training costs) but higher employment adjustment costs may also arise in heavily regulated labour markets with search frictions. Costs associated with the utilisation of capital can result from higher maintenance costs associated with a more intensive use of a piece of capital equipment. The following convex functional forms are chosen:

Labour adjustment costs: $adj^L(L_i) = w_i(L_i u_i^L + \frac{\gamma_L}{2} \Delta L_i^2)$

Wage adjustment costs: $adj^W(W_i) = \frac{\gamma_W}{2} \left( \frac{(W_i - W_{i-1})^2}{W_{i-1}} \right)$

Price adjustment costs: $adj^P(P_i) = \frac{\gamma_P}{2} \left( \frac{(P_i - P_{i-1})^2}{P_{i-1}} \right)$

Capacity utilization adjustment costs:

$adj^{UCAP}(ucap_i) = p_i K_i (\gamma_{ucap_i} u_i^{ucap} - 1) + \frac{\gamma_{ucap}}{2} (ucap_i - 1)^2$

Corporate investment adjustment costs:

$\left( \frac{\gamma_K}{2} + u_i^L \right) \left( \frac{J_i^{K_i}}{K_i} \right) + \frac{\gamma_J}{2} (\Delta J_i)^2$

Residential investment adjustment costs:

$\left( \frac{\gamma_H}{2} + u_i^H \right) \left( \frac{J_i^{H_{i,r}}}{H_i^r} \right) + \frac{\gamma_J}{2} (\Delta J_i^{H_{i,r}})^2$

where $u_i^L$, $u_i^H$ and $u_i^{ucap}$ are shocks to adjustment costs of labour and corporate and residential investment respectively.
Appendix C: Data

The time series of real and nominal values of US output, consumption, corporate investment, government spending, government investment, construction investment, exports and imports used in the estimation are from the Bureau of Economic Analysis database. So are the data on nominal transfers and compensation. As the US policy rate the Federal funds rate recorded in monthly frequency by the Conference board is used. The US house prices are from the Federal Housing Finance Agency (an all-transactions index estimated using sales prices and appraisal data). Both labour (total overall civilian employment, household survey) and hours worked (index for nonfarm business) are from the Bureau of Labour Statistics. The data on default used were based on the 'charge-off and delinquency rates' series (total loans and leases) provided by the US Federal Reserve.

All 'Rest-of-the-World' variables – the exchange rates, real output growth rate, output deflator and the nominal interest rate – are trade-weighted averages across US main trade partners: Argentina, Australia, Brazil, Canada, China, euro area (12), Hong Kong, India, Israel, Japan, Malaysia, Mexico, Norway, Russia, Singapore, South Korea, Switzerland, Taiwan, Turkey and UK, altogether 41 countries. The composition of the averages varies depending on the availability of the data at the beginning of the sample. At no point in the sample the total sum of the trade-weights of the US trade partners included falls below 85%. Most of these data were taken from the IMF’s IFS, but in some cases national sources were used.

All the series (apart from the interest rates and the exchange rates) were seasonally and calendar-effect adjusted.

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15 Euro area (12) consists of Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Portugal and Spain.
Appendix D: Tables and Figures

TABLE 1: Estimation Results for structural parameters\(^{16}\)

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Prior distrib</th>
<th>Prior mean</th>
<th>Prior std</th>
<th>Posterior mean</th>
<th>Posterior std</th>
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\(^{16}\) The Bayesian estimation has been performed using the DYNARE Toolbox for MATLAB (Juillard, 2005). The estimation of the posterior distributions of parameters and shocks has been obtained with the Metropolis algorithm, using four parallel chains, each of length 220,000 runs.
<p>| $\rho^{PWPX}$ | beta | 0.5 | 0.2 | 0.126 | 0.08 | 1.5745 |
| $\omega^X$ | beta | 0.87 | 0.04 | 0.8799 | 0.0058 | 150.5343 |
| $Sfp$ | beta | 0.7 | 0.1 | 0.8949 | 0.0693 | 12.9075 |
| $Sfpconstr$ | beta | 0.7 | 0.1 | 0.8786 | 0.0645 | 13.6196 |
| $Sfphouse$ | beta | 0.7 | 0.1 | 0.8254 | 0.0856 | 9.6423 |
| $Sfpm$ | beta | 0.7 | 0.1 | 0.823 | 0.0804 | 10.2409 |
| $Sfp\times$ | beta | 0.7 | 0.1 | 0.6665 | 0.1234 | 5.4001 |
| $Sfpw$ | beta | 0.7 | 0.1 | 0.8928 | 0.0768 | 11.623 |
| $Sfw$ | beta | 0.7 | 0.1 | 0.7142 | 0.1447 | 4.937 |
| $\sigma^e$ | gamma | 1.5 | 0.5 | 1.11 | 0.3709 | 2.9929 |
| $\sigma_{H}$ | gamma | 0.5 | 0.1 | 0.4914 | 0.0998 | 4.9257 |
| $\sigma^Y$ | gamma | 1.25 | 0.5 | 1.2278 | 0.2926 | 4.1959 |
| $\sigma^M$ | gamma | 1.25 | 0.5 | 0.3866 | 0.1268 | 3.0491 |
| $\sigma^L$ | beta | 0.5 | 0.2 | 0.4499 | 0.1578 | 2.8503 |
| $S^e$ | beta | 0.15 | 0.05 | 0.2558 | 0.025 | 10.2361 |
| $\tau^M$ | beta | 2 | 0.4 | 2.506 | 0.2879 | 8.7033 |
| $\tau^{MW}$ | beta | 2 | 0.4 | 2.1101 | 0.4047 | 5.2136 |
| $b^U$ | beta | 0.2 | 0.1 | 0.242 | 0.0275 | 8.794 |
| $\tau^W - 1$ | gamma | 6 | 4 | 4.9304 | 1.8096 | 2.7246 |
| $\tau^M$ | beta | 0.3 | 0.2 | 0.5585 | 0.2012 | 2.7753 |
| $\tau^{MW}$ | beta | 0.3 | 0.2 | 0.1053 | 0.0517 | 2.0373 |</p>
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<th>Calibrated value</th>
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<td>$1 - 1/\beta^r$</td>
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TABLE 3: Estimation Results for exogenous shocks

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</tr>
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<tr>
<td>$\sigma^{upland}$</td>
<td>gamm</td>
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<td>gamm</td>
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<td>$\rho_{UP}$</td>
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<td>$\rho_{TB}$</td>
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<tr>
<td>$\rho^{TR}$</td>
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</table>
Figure 1: US demand components (log shares)
Figure 2: US and RoW real ex-post interest rates.
Figure 3: US nominal and real effective exchange rates.
Figure 4: Impulse-response functions: TFP shock.

Dashed line – integrated national capital market (no separation between savers and equity holders)
Solid line – segregated national capital market (separation between savers and equity holders)

LY: log of GDP; LC: log of consumption; LCCC: log of consumption (debtors); LCNLC: log of consumption (savers); LI: log of corporate investment; LIHOUSE: log of residential investment; LIHOUSECC: log of residential investment (debtors); LIHOUSENLC: log of residential investment (savers); DEBTCC: Stock of mortgage loans; R: real interest rate; LER: log of real exchange rate; LWR: log of real wage rate; LL: log of hours worked; TBYN: trade balance to GDP ratio; LPHOUSEPY: log of hose prices to price of final output; GXW: Growth rate of RoW; LCEQUITY: log of consumption (equity owners); REQUITY: required return on equity.
Figure 5: Impulse-response functions: Investment-specific technology shock.

Dashed line – integrated national capital market (no separation between savers and equity holders)
Solid line – segregated national capital market (separation between savers and equity holders)
Figure 6: Impulse-response functions: monetary shock.

Dashed line – integrated national capital market (no separation between savers and equity holders)
Solid line – segregated national capital market (separation between savers and equity holders)
Figure 7: Impulse-response functions: collateral shock.

Dashed line – integrated national capital market (no separation between savers and equity holders)
Solid line – segregated national capital market (separation between savers and equity holders)
Figure 8: Impulse-response functions: default shock.

Dashed line – integrated national capital market (no separation between savers and equity holders)
Solid line – segregated national capital market (separation between savers and equity holders)
Dashed line – integrated national capital market (no separation between savers and equity holders)
Solid line – segregated national capital market (separation between savers and equity holders)
Figure 10: Impulse-response functions: external risk premium shock.

Dashed line – integrated national capital market (no separation between savers and equity holders)
Solid line – segregated national capital market (separation between savers and equity holders)
Figure 11: Impulse-response functions: housing bubble shock.

Dashed line – integrated national capital market (no separation between savers and equity holders)
Solid line – segregated national capital market (separation between savers and equity holders)
Figure 12: Impulse-response functions: stock market bubble shock.

Dashed line – integrated national capital market (no separation between savers and equity holders)
Solid line – segregated national capital market (separation between savers and equity holders)
Figure 13: Main shocks of interest - evolution.
Figure 14: Shock decomposition: output growth rate.
Figure 15: Shock decomposition: log consumption to output ratio.
Figure 16: Shock decomposition: log investment to output ratio.
Figure 17: Shock decomposition: log housing investment to output ratio.
Figure 18: Shock decomposition: trade balance to output ratio.
Figure 19: Shock decomposition: real exchange rate growth rate.
Figure 20: Shock decomposition: real interest rate.