House Prices, Consumption and Trade Balance in the U.S.

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Abstract

I study the business cycle implications of changes in U.S. real estate prices on the U.S. trade balance dynamics. I calibrate an open economy DSGE model whose main feature is the presence of a domestic real estate credit channel. The main result - in line with the empirical evidence on U.S. obtained by estimating a VAR - is that in correspondence of a positive (negative) change in real estate prices the trade balance moves towards deficit (surplus): higher (lower) values of houses, used as collateral in financial transactions, allow higher (lower) borrowing and hence higher (lower) consumption and imports. Other results suggest that: (a) in the aftermath of a positive housing price shock, the increase in trade deficit is higher for higher values of the loan-to-value ratio; (b) the increase of the trade deficit is lower for lower values of the elasticity of substitution between domestic and imported goods; (c) exchange rate depreciations limit the size of the external deficit when the degree of pass-through of nominal exchange rate into import prices is, counterfactually, high.

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1 Introduction

The high level of trade and financial global unbalances is stimulating a large debate about the determinants of the U.S. trade balance and current account dynamics. The main views are two. One, the so called "global saving glut", explains the widening of the U.S. trade and current account unbalances in terms of three factors: (1) a sharp rise in national savings in China and oil-exporting countries; (2) relatively weak investments in some key industrial countries such as Germany and Japan and in some emerging Asian countries; (3) relatively high investments in the U.S..[1] The other view emphasizes the reduction in domestic saving; it can be split in two strands: one highlights the influence of the widening U.S. public budget deficit on the reduction of national savings ("twin deficit" hypothesis); the other, points out the negative effect of the booming house prices on household saving.[2]

Recent contributions tend to downplay the "global saving glut" and the "twin deficit" hypotheses. Regarding the first hypothesis, some authors observe that in the period 2001-2004 U.S. investments have decreased.[3] Regarding the second, the ricardian effect of public deficit on private saving seems to be not negligible: an increase in the federal budget, resulting in higher interest rates, lower private domestic consumption and investment, would have a rather low net effect on the external deficit.[4]

To the contrary, several observers emphasize the existence of a relationship between the recent boom in U.S. house prices and higher trade balance deficit.[5] This pattern is experienced not only by the U.S.. The OECD, for example, reports that between 1996 and 2004 the countries whose current account have moved toward deficit have also experienced substantial housing appreciation and increasing in house wealth, contrary to countries, such as

[1] See Bernanke (2005).

[2] See Roubini and Setser (2005).

[3] See Roubini (2005).

[4] See Ergeg, Guerrieri and Gust (2005) and Kim and Roubini (2004).

[5] Rogoff (2005) says that "...low interest rates that have fuelled an increasingly speculative housing price boom, which has in turn contributed to low personal savings and a bigger current account deficit". Greenspan (2005) notes a strong correlation between the U.S. mortgage debt and the U.S. current account deficit. Bernanke (2005) points out "...the expansion of housing wealth, much of it easily accessible to households through cash-out refinancing and home equity lines of credit" and "...the evident link between rising household wealth and a tendency for the current account to shift toward deficit".

Germany and Japan, where the housing appreciation has been slow.[6]

Following the latter strand of the debate, I investigate the relationship between the U.S. housing prices and trade balance.

To this purpose, I initially estimate two vectors autoregressive (VARs from now on) models to give some empirical evidence of the positive relationship between U.S. housing prices, consumption and trade deficit; then I rationalize the evidence in terms of an open economy dynamic stochastic general equilibrium (DSGE from now on) model.

Main feature of the model is the presence of a domestic borrowing constraint: some of the agents in the country have only access to domestic financial markets and can borrow using their domestic real estate holdings as collateral.[7] The trade balance is determined by the difference between the value of the domestic output and that of the total domestic consumption. Other features of the model are rather standard, so to get a model as simple as possible: in each country two tradable non durable goods are consumed, one domestically produced, the other imported from the other country; domestic monetary policy is introduced in form of Taylor rule; there are nominal rigidities in form of staggered prices; to capture the observed low degree of import price pass-through at consumer level, there is home bias in consumption and import prices are set in local currency terms.

The main result of the model, roughly in line with the empirical evidence suggested by the estimated VARs, is that changes in house prices contribute to the determine the trade balance dynamics through a collateral effect on agents subject to the constraint. For example, higher housing prices allow a higher domestic borrowing and hence higher consumption; as a consequence, imports increase contributing to shift the trade balance towards deficit.[8]

Other results are the following ones. First, the effect of a house price shock on the trade balance is higher for higher values of the loan-to-value ratios faced by the U.S. agents. Second, lower values of the elasticity of substitution

[6] OECD Economic Outloook (2004).

[7] Zeldes (1989), Jappelli and Pagano (1989), Campbell and Mankiw (1989) document evidence of financing constraint at household level.

[8] Several empirical papers find a positive relationship between consumption and house prices. Case et al. (2001) find long-run elasticities of consumption to housing prices of around 0.06 for a panel of U.S. states. Davis and Palumbo (2001) estimate a long-run elasticity of consumption to housing wealth of 0.08. These positive elasticities are hard to reconcile with the traditional life-cycle model. For more detailed discussion, see Iacoviello (2005)

between domestically produced and imported goods limit the size of the trade balance deficit in the aftermath of a shock. Finally, I analyze how the nominal exchange rate depreciation affects the trade balance dynamics when the assumption of low pass-through of nominal exchange rate into import prices is relaxed and it is assumed that pass-through is complete (so that the depreciation of, let's say, the U.S. nominal exchange rate can modify international relative prices and shift world demand towards U.S. produced goods). I show that the depreciation of the exchange rate contributes to some extent to limit the increase of the trade deficit under the assumption, counterfactual, of complete pass-through.

This paper is related to recent studies that have formalized the 'credit view' in open economy general equilibrium models.

Iacoviello and Minetti (2005) and Paasche (2001) develop international real business cycle models based on a borrowing constraint a la Kiyotaki-Moore, having real estate as collateral.[9] I use the same type of constraint; however, differently from them, I study the spillovers in the context of a model with sticky prices and monetary policy.

Also Faia (2005), Gilchrist et al. (2002) study the open economy implications of financial frictions, which are introduced via a risk premium on borrowing proportional to the level of leverage.[10] The performed analysis focuses on how cross-country financial heterogeneity affects and amplifies the propagation of international spillovers under alternative monetary policies and exchange rate regimes.

My paper, which also analyses the monetary policy implications, differ in three main aspects. First, I perform a systematic evaluation of the implications of the household borrowing constraint for the trade balance dynamics. Second, I focus on the real estate market and consumer's expenditures. Third, I focus on the U.S. economy by estimating the VARs and appropriately calibrating the DSGE model.

The plan of the paper is as follows. Next section illustrates the VAR evidence on the relationship between trade deficit and real estate price. Section three rationalizes the evidence in terms of a two country general equilibrium model with real estate credit channel. Section four contains the solution of the model. Section five reports the main results. Conclusions are in section

[9] See Kiyotaki and Moore (1997) and Kiyotaki (1998).

[10] The theoretical framework is based on Bernanke and Gertler (1989), Bernanke et al (1999), Carlstrom and Fuerst (1997, 2001).

six.

2 VAR Evidence

I use the VAR methodology to find evidence of a relationship between U.S. monetary policy, house prices, private consumption and external deficit.

I estimate two VARs. The two models share the variables needed for a monetary policy and a house price shock; they differ in the variable representing the U.S. trade. The shared variables are the detrended log of real gross domestic product (Y), the change in the log of consumer price index (π), the detrended log of real house prices (q), the Fed Funds rate (R), the detrended log of private consumption (C). The model-specific variables are: 1) the ratio of detrended real net exports to the mean real gross domestic product (TB); 2) detrended log of real export (X) and imports (M).[11] Data are from 1974Q1 to 2005Q2. The Fed Funds rate is the average value in the first month of each quarter. The house price series (deflated with the consumer price deflator) is the Conventional Mortgage Home Price Index from Freddie Mac.[12] The logs of real GDP, real housing prices, consumption. real exports and real imports are detrended with a band-pass filter that removed frequencies above 32 quarters. All the considered variables are expressed in percentages and in quarterly rates.

The VARs have lag length equal to three (chosen according to the Hannah-Quinn criterion) and include a constant, a time trend, a shift dummy from 1979Q4 and one lag of the log of the CRB commodity spot price index. To make the VAR and the DSGE models more comparable, the shocks are orthogonalized in the order R, π, q, Y, C, TB; in the other VAR X and M, taken in that order, substitute TB, while the order of the remaining variables does not change.[13]

Figure 1 presents impulse responses to a negative interest rate shock.[14] As

[11] The variable TB is a proxy of the trade balance to real gross domestic product ratio which has the property of being consistent with the trade balance variable used in the DSGE model. Results in the VAR do not change when the trade balance variable (always as a ratio to the real gross domestic product) is used.

[12] Data on GDP, private consumption, consumer prices, export, imports, trade balance are taken from the database FREDII of the St. Louis Federal Reserve.

[13] However changing the order does not greatly affects the results.

[14] All the VAR impulses have 90-percent bootstrapped confidence bands. Shocks have a

it can be seen, there is a positive response of real housing prices, consumption, while inflation increases with some lag. The trade balance moves towards deficit.

Figure 2 presents impulse responses to a positive house price shock. Also in this case, there is a positive comovement between house prices and consumption and the trade balance moves towards deficit.

To better understand the dynamics of the trade balance, I run the VAR substituting the trade balance variable with U.S. export and imports.

Figure 3 presents impulse responses to a negative interest rate shock. Also in this case both consumption and real estate prices increase, as well as imports.

A similar pattern - an increase in consumption and imports - is observed when a positive house price shock is considered, as shown by Figure 4.

Hence, the reported evidence suggests two points. First, following an exogenous increase in housing prices or decrease in interest rate, there is a positive comovement between housing real prices and consumption; this evidence, which is in line with the results found by Iacoviello (2005) suggests the existence of a real estate credit channel, through which the asset "real estate" affects domestic demand for consumption.[15] Second, trade balance deteriorates when real estate prices and consumption increase, because of the increase in imports.

In what follows, I rationalize this evidence through a microfounded open economy DSGE model having a real estate credit channel. This channel, in fact, is able to create, following a positive house price shock, a collateral effect of housing prices on consumption and hence a positive comovements between the two variables, in line with the found empirical evidence.

3 The Setup

The framework is based on an open economy DSGE model. The country, denominated home (H) can be interpreted as a stylized representation of the U.S. economy. The rest of the world is denominated foreign (F). In country H there is a continuum of economic agents. Some agents are financially

one standard deviation size.

[15] See also Aoki et al. (2004) and Iacoviello (2002) for other VAR models on the real estate credit channel.

unconstrained (they lie on the interval $(0,1]$) and the others are constrained (they lie on $(1,2]$).

Constrained agents are subject to a borrowing constraint: they can borrow a certain fraction of the expected value of the collateral, which is the real estate. Thanks to this assumption, I formalize in a simple way the real estate credit channel. Both types of households belonging to country H consume, work, demand money and real estate services. I assume real estate is fixed in aggregate and not tradable at international level. Agents rent labor to a wholesale sector which, according to a Cobb-Douglas technology, produces a homogenous good. The former is differentiated by the retailer sector, and sold domestically and in the rest of the world. Firms in the retail sector, owned by the unconstrained agents, are the source of nominal rigidity in the model. In the country there is a central bank that adjusts money supply and transfers to support an interest rate rule.

The rest of the world is assumed to be exogenous a similar structure. In what follows, starred variables are referred to variables belonging to rest of the world.

3.1 Consumption and Price Indexes

The consumption index C of agents belonging to country H is given by the following CES aggregator:

$$C_t \equiv \left[a_H^{\frac{1}{\rho}} C_{H,t}^{\frac{\rho-1}{\rho}} + (1-a_H)^{\frac{1}{\rho}} C_{F,t}^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}, \quad \rho > 0 \tag{1}$$

where C_H (C_F) is the consumption of home (foreign) produced good, a_H , $(0.5 < a_H < 1)$ measures the home bias in consumption, ρ is the intratemporal elasticity of substitution between home and imported goods. In the rest of the world, the CES aggregator is:

$$C_t^* \equiv \left[(1-a_H)^{\frac{1}{\rho}} C_{H,t}^{*\frac{\rho-1}{\rho}} + a_H^{\frac{1}{\rho}} C_{F,t}^{*\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \tag{2}$$

The consumption bundles are defined as:

$$C_{H,t} \equiv \left(\int_0^1 C_t(h)^{\frac{\theta-1}{\theta}} dh \right)^{\frac{\theta}{\theta-1}}, \quad C_{F,t} \equiv \left(\int_0^1 C_t(f)^{\frac{\theta-1}{\theta}} df \right)^{\frac{\theta}{\theta-1}}, \quad \theta > 1 \tag{3}$$

where $C(h)$ and $C(f)$ are respectively the consumption of the generic home and imported brand. $C^*(h)$ and $C^*(f)$ are similarly defined. For each type of good, I assume that one brand is an imperfect substitute for all the other brands produced within a country, with a constant elasticity of substitution equal to θ.

The utility-based consumer price index in the home country is:

$$P_t = \left[a_H P_{H,t}^{1-\rho} + (1-a_H) P_{F,t}^{1-\rho}\right]^{\frac{1}{1-\rho}} \tag{4}$$

where prices are in units of currency H.

I consider a similar price index of tradable goods in the rest of the world is:

$$P_t^* = \left[(1-a_H) P_{H,t}^{*1-\rho} + a_H P_{F,t}^{*1-\rho}\right]^{\frac{1}{1-\rho}} \tag{5}$$

where prices are in units of currency F.

The utility-based price index of the home-produced good is:

$$P_{H,t} \equiv \left(\int_0^1 p_t(h)^{1-\theta} dh\right)^{\frac{1}{1-\theta}} \tag{6}$$

The indexes P_F, P_H^* and P_F^* are analogously defined.

Given the structure of preferences of home agents, the demands for the home and foreign aggregate goods in the home country are respectively:

$$C_{H,t} = a_H \left(\frac{P_{H,t}}{P_t}\right)^{-\rho} C_t \tag{7}$$

$$C_{F,t} = (1-a_H) \left(\frac{P_F}{P}\right)^{-\rho} C_t \tag{8}$$

They are functions of the relative price and the total consumption.

In the rest of the world, the demands for the aggregate home good is equal to:

$$C_{H,t}^* = (1-a_H) \left(\frac{P_{H,t}^*}{P_t^*}\right)^{-\rho} C_t^* \tag{9}$$

In the home country, the demands for the brands h and f are respectively:

$$C_t(h) = \left(\frac{p_t(h)}{P_{H,t}}\right)^{-\theta} C_{H,t} \tag{10}$$

$$C_t(f) = \left(\frac{p_t(f)}{P_{F,t}}\right)^{-\theta} C_{F,t} \tag{11}$$

They are function of the relative price and the total consumption of the home and imported goods. Demands for brands h and f in the rest of the world are similarly defined. I assume that investment goods, introduced in the model only to correctly calibrate the model, have the same compositon as the consumption goods.

Here I define the following relative price:

$$T_t \equiv \frac{P_{F,t}}{P_{H,t}}, \qquad T_t^* \equiv \frac{P_{F,t}^*}{P_{H,t}^*} \tag{12}$$

They represent the relative prices of the foreign good in terms of the home good, expressed in local currency, respectively in the home and in the rest of the world. Finally, I define the "real exchange rate" of the home country:

$$RS_t \equiv \frac{S_t P_t^*}{P_t} \tag{13}$$

where S is the nominal exchange rate, defined as number of home currency units per unit of foreign currency.

3.2 Households

The home country, corresponding to the U.S., is populated by unconstrained and constrained households, each infinitely lived and of measure one. Households consume tradable goods, supply work services, demand real estate, money and a riskless bond which is denominated in home currency. Real estate is fixed in the aggregate. Unconstrained agents have access to international financial markets. In what follows, unconstrained agents are indexed by j, constrained agents by j'.

Unconstrained Agents.

Each unconstrained household maximizes a lifetime utility function given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\ln C_t(j) + j_t^h \ln ho_t(j) + \chi \ln \frac{M_t(j)}{P_t} - \frac{\kappa}{\tau} L_t^{\tau}(j)\right] \tag{14}$$

where E_0 is the expectation operator at time 0, $\beta \in (0,1)$ is the discount factor, C is consumption of tradable goods, ho denotes the holdings of housing (which is a nontradable good), L are hours of work and M/P are money balances divided by the price level. The subscript t under j^h allows for random disturbances to the marginal utility of housing; it constitutes a parsimonious way to formalize an exogenous disturbance on housing prices. The budget constraint of the agent j is defined as follows:

$$\frac{B_t(j)}{(1+i_t)} - B_{t-1}(j) + \frac{B_{H,t}(j)}{1+i_{H,t}} - B_{H,t-1}(j) + M_t(j) - M_{t-1}(j) \tag{15}$$
$$= \int_0^1 \Pi_t(h,j)dh + R^K K(j) + W_t L_t(j) - P_t C_t(j) - Q_t(ho_t(j) - ho_{t-1}(j))$$
$$- TR_t(j) - P_t I(j)$$

B and B_H are respectively household's holding of an internationally traded and of a domestically traded risk-free one-period nominal bond, both denominated in units of home currency.[16] This assumption is consistent with empirical evidence, which suggests that a large fraction of U.S. foreign debt is denominated in U.S. dollars. The nominal interest rate on B is i, while the nominal interest on B_H is i_H. The nominal dividends from the ownership of the domestic retailers (which are illustrated in the next section), $\int_0^1 \Pi(h,j)dh$, are equally distributed across domestic unconstrained agents. W is the nominal wage. K is the capital stock Given the focus of the paper on households consumption, I assume capital is set equal to its steady state level (see appendix). I introduce it only to correctly calibrate the model. I also assume, as I'll show later, that in each period firms demand of capital is constant.Hence also R^k, the rental rate of capital, is constant and equal to its steady state level. Real estate ho is a durable good and Q is its nominal price. I is the investment in phisical capital, which I assume to be constant at its steasy state level. TR denotes the government transfers to unconstrained households. I assume that: (a) preferences and initial wealth conditions $(K(j) + B_{-1}(j) + B_{H,-1}(j) + M_{-1}(j) + Q_0 ho_{-1}(j))$ are the same for all agents; (b) retailer profits are equally shared across agents. As a consequence, all unconstrained agents take the same optimal consumption and labor paths; I can drop the index j and consider a representative unconstrained agent. The first order conditions for the choice of the internationally

[16] The international financial structure of the model is similar to that of Baxter and Crucini (1995), who develop an international real business cycle model with incomplete markets at international level. See also Kehoe and Perri (2002) and Heathcote and Perri (2002).

traded bond, domestically traded bond, real estate demand, labor supply are respectively:

$$\frac{1}{P_t C_t (1+i_t)} = E_t \left(\beta \frac{1}{P_{t+1} C_{t+1}} \right) \tag{16}$$

$$(1+i_t) = (1+i_{H,t}) \tag{17}$$

$$\frac{Q_t}{P_t C_t} = j_t^h \frac{1}{ho_t} + \beta E_t \left(\frac{Q_{t+1}}{P_{t+1} C_{t+1}} \right) \tag{18}$$

$$\frac{W_t}{P_t C_t} = \kappa L_t^{\tau-1} \tag{19}$$

First order conditions are rather standard. Equation (17) is the no-arbitrage condition, which derives from the fact that at the margin the agent equates the bonds revenues.[17] Since I assume that in each country the local monetary authority follows an interest rate rule (as illustrated later in the text), money supply will always respond to meet money demand at the desired equilibrium nominal interest rate; as utility is separable in money balances and the assumption of equality between money injections and transfer for each group of agents holds (see later), the actual quantity of money has no implications for the rest of the model; therefore the money first order condition can be ignored.

Constrained Agents.

[17] To make the model stationary and well define the steady state, in solving the model I introduce a financial friction, $\phi\left(\frac{B}{P}\right)$, that multiplies the nominal interest rate $(1+i)$ on internationally traded bonds. I set it as small as possible (to minimize its effects on the model dynamics) compatibly with the stationarity of the model. $\phi\left(\frac{B}{P}\right)$ depends on the real holdings of internationally traded bonds by the entire class of unconstrained agents. Hence unconstrained agents take the fuction $\phi(.)$ as given when deciding the optimal holding of the bond. I impose $\phi(0) = 1$ only when $B = 0$. $\phi(.)$ is a differentiable at least decreasing function in the noighborhood of zero. The function $\phi(.)$ captures the costs of undertaking financial positions As borrowers, they will charged a premium on the interest rate, as lenders, they will receive a remuneration lower than the interest rate. Unconstrained agents are the only agents in the model subject to this costs; home constrained agents nor foreign agents are subject to this cost.

Revenues from the financial frictions (which are always positive given the shape of the function $\phi(.)$) are assumed to be distributed to foreign agents: $K^* = \frac{B}{P(1+i)}\left[\frac{1}{\phi\left(\frac{B}{P}\right)} - 1\right]$. Benigno (2001) and Schmitt-Grohé and Uribe (2001) use a similar feature to make the model stationary.

Constrained households (denoted with a j') have the same preferences as the unconstrained ones. The only difference is in that their discount rate, β', is lower than that of patient agents, β. This assumption guarantees that the constrained agents face a binding borrowing constraint in equilibrium (see the appendix A). The budget constraint of the impatient agents is defined as:

$$\begin{aligned} &\frac{B_{H,t}(j')}{1+i_t^H} - B_{H,t-1}(j') + M_t(j') - M_{t-1}(j') \\ &= W_t L_t(j') - P_t C_t(j') - Q_t(ho_t(j') - ho_{t-1}(j')) + TR_t(j') \end{aligned} \tag{20}$$

Constrained agents do not have access to international financial markets. I make this assumption for tractability of the model: it allows to uniquely determine in a simple way the asset position of the constrained agents.

Main aspect of the allocation problem is the presence of the borrowing constraint. Following Kiyotaki and Moore (1997), it is assumed the existence of a limit on the debt of the agent j'. In each period t, the amount she can borrow from other domestic agents, comprehensive of interest payment, cannot exceed a fraction $m \leq 1$ of next period's expected value of real estate holdings. Hence, impatient household debt is limited by:

$$-B_{H,t}(j') \leq mE_t(Q_{t+1}h_t(j')) \tag{21}$$

One way to rationalize this constraint is by thinking to the existence of liquidation costs: in case of default, costs amount to a fraction $1-m$ of the real estate value. As in the case of unconstrained agents, I assume that initial wealth conditions $(B_{H,-1}(j') + M_{-1}(j') + Q_0 h_{-1}(j'))$ are the same across constrained agents. Given that they face the same prices, they choose the same optimal path for borrowing, consumption and labor supply. I hence drop the index j' and consider a constrained representative agent.

The first order conditions are:

$$E_t\left(-\frac{1}{P_t C_t'(1+i_{H,t})} + \beta' \frac{1}{P_{t+1}C_{t+1}'} + \frac{1}{P_t}\lambda_t'\right) = 0 \tag{22}$$

$$\frac{Q_t}{P_t C_t'} = j^h \frac{1}{ho_t'} + \beta' E_t\left(\frac{Q_{t+1}}{P_{t+1}C_{t+1}'}\right) + \lambda_t m E_t\left(\frac{Q_{t+1}}{P_{t+1}C_{t+1}'}\right) \tag{23}$$

$$\frac{W_t}{P_t C_t'} = \kappa L_t'^{\tau-1} \tag{24}$$

Both the Euler and the housing demand equations differ from the usual formulations because of the presence of λ'_t, the Lagrange multiplier on the borrowing constraint, which distorces both intratemporal and intertemporal allocation between houses and non durable consumption.

As in the case of patient agents, the assumptions of an interest rate rule, equality between money injections and transfer for each group of agents (see later), separable utility in money balances imply the actual quantity of money has no implications for the rest of the model; the money first order condition of constrained agents can therefore be ignored.

I take the rest of the world as exogenous. I assume that foreign agents can allocate their wealth among domestic money and two bonds. Both bonds are risk-free with one-period maturity. One, B_F^*, is denominated in foreign currency and pays a nominal interest rate equal to $(1+i_t^*)$; the other, B^*, is denominated in home currency. The former, differently from the latter, is not internationally traded. Optimal behavior requires that at the margin revenues from the two bonds must be equal; hence, in the log-linearized model, the following uncovered interest parity holds:

$$\widehat{(1+i_t)} - \widehat{(1+i_t^*)} = E_t\left(\widehat{\Delta S_{t+1}}\right)$$

where $E_t\left(\widehat{\Delta S_{t+1}}\right)$ is the expected variation of the nominal exchange rate.

3.3 The Production Sector

The supply side of the home economy is constituted by a wholesale and a retailer sectors. The former produces a homogeneous good, and sell it to the retailers, which differentiate and sell it both domestically and abroad. In this section, I illustrate the problems solved in each sector.

3.4 The wholesale sector

The wholesale sector produces a homogenous wholesale good under a perfect competition regime. It assembles labor supplied by the two agents to operate a constant return to scale production function:

$$Y_t = K^\alpha L_t^{(1-\alpha)\mu} L_t'^{(1-\alpha)(1-\mu)} \quad 0<\alpha<1 \quad 0<\mu<1 \tag{25}$$

Capital is assumed to be constant. The optimizing decision of labor is made by solving a static optimization problem for cost minimization. First order conditions for L_t and L'_t are:

$$W_t = \mu P_{W,t} Y_t / L_t \tag{26}$$

$$W'_t = (1-\mu)\, P_{W,t} Y_t / L'_t \tag{27}$$

where P_W is the price of the wholesale good, equal to its marginal cost.

3.5 Retailers

There is a continuum of retailers having mass one which buy the domestic homogeneous good at the given price P_W from the domestic wholesale sector, differentiate at no cost and then sell it both domestically and internationally. Each retailer is the only producer of a single differentiated good. The retail sector is subject to a monopolistic competition regime. In this way I introduce price stickiness as in Calvo (1983): when a home retailer h has the opportunity to set a new price in the home or in the foreign market in period t, it does so to maximize the expected valued of its profits taking into account that there is a nonzero probability of not adjusting prices in each future period.

I assume there is international good market segmentation: retailers engage in third degree price discrimination across countries and set prices in each country in terms of local currency, taking the demand curve as given (hence the international law of one price does not hold). In this way I introduce a low degree of nominal exchange rate pass-through into import prices and reduce the size of substitution effect (between domestic and imported goods) induced by changes in the nominal exchange rate. This assumption has two advantages: first, it is consistent with empirical evidence on the degree of nominal exchange rate pass-through into import prices, which is extremely low in the short run; second, it allows to better emphasize the real estate credit channel and the wealth effect of changes in the housing prices on the trade balance and imports (however, in the section "Results" I also consider the case of complete pass-through).[18] Home retailers choose

[18] The assumptions of international price discrimation, local currency pricing, incomplete pass-through, their implications for the monetary policy and the empirical evidence are widely discussed in Bergin (2002), Bergin and Feenstra (2001), Betts and Devereux (1996, 2000), Burstein et al. (2003), Campa and Goldberg (2002), Chari et al. (2002) Corsetti and Dedola (2002), Devereux and Engel (2001, 2002), Engel (2002).

home and foreign currency prices, respectively $p_t^o(h)$ and $p_t^{o*}(h)$, to maximize the expected discounted value of profits. Hence, they solve the following problem:[19]

$$\max_{p_t^o(h), p_t^{*o}(h)} \sum_{k=0}^{\infty} \vartheta^k \Lambda_{t,t+k} E_t \left(\begin{array}{c} \frac{p_t^o(h) Y_{t+k}(h) + S_t p_t^{o*}(h) Y_{t+k}^*(h)}{P_{t+k}} \\ -\frac{P_{W,t+k}(Y_{t+k}(h) + Y_{t+k}^*(h))}{P_{t+k}} \end{array} \right) \tag{28}$$

where $Y_{t+k}(h)$ and $Y_{t+k}^*(h)$ are respectively the home and foreign demand for home produced good:

$$Y_{t+k}(h) = \left(\frac{p_t^o(h)}{P_{H,t+k}} \right)^{-\theta} \left[a_H \left(\frac{P_{H,t+k}}{P_{t+k}} \right)^{-\rho} \left(C_{t+k} + C'_{t+k} - I \right) \right] \tag{29}$$

and

$$Y_{t+k}^*(h) = \left(\frac{p_t^{o*}(h)}{P_{H,t+k}^*} \right)^{-\theta} \left[(1 - a_H) \left(\frac{P_{H,t+k}^*}{P_{t+k}^*} \right)^{-\rho} (C^*) \right] \tag{30}$$

$\Lambda_{t,t+k} = \beta(C_t/C_{t+k})$ is the unconstrained household discount rate (retailers are agents for the unconstrained household, to whom transfer profits in a lump-sum fashion). The parameter ϑ is the probability of not adjusting the price of the brand h in the home and in the foreign market. Since retailers simply repackage wholesale goods, $P_t^W$is the marginal cost of producing a unit of output. The optimal choices of $p_t^o(h)$ and $p_t^{o*}(h)$ satisfy the following first order conditions, respectively:

$$\sum_{k=0}^{\infty} \vartheta^k E_t \left(\Lambda_{t,t+k} \frac{(\theta - 1) p_t^o(h) - \theta P_{W,t+k}}{P_{t+k}} Y_{t+k}(h) \right) = 0 \tag{31}$$

$$\sum_{k=0}^{\infty} \vartheta^k E_t \left(\Lambda_{t,t+k} \frac{(\theta - 1) S_t p_t^{o*}(h) - \theta P_{W,t+k}}{P_{t+k}} Y_{t+k}^*(h) \right) = 0 \tag{32}$$

Since there are no firm-specific state variables, all retailers setting price at t will choose the same optimal prices $p_t^o(h)$ and $p_t^{o*}(h)$. It can be shown that, in the neighborhood of the steady state, the price indexes of the home good evolve in the home and in rest of the world respectively according to:

$$P_{H,t} = \left(\vartheta P_{H,t-1}^{1-\theta} + (1 - \vartheta) \left(p_t^o(h) \right)^{1-\theta} \right)^{1/(1-\theta)} \tag{33}$$

[19] Benigno (2004) solves a similar problem.

$$P^*_{H,t} = \left(\vartheta P^{*1-\theta}_{H,t-1} + (1-\vartheta)\left(p^{o*}_t(h)\right)^{1-\theta}\right)^{1/(1-\theta)} \quad (34)$$

Equations (31) and (33) from one side and equations (32) and (34) from the other, once log-linearized around the steady state, yield a Phillips curve of the home produced good holding respectively in the home and in the rest of the world: the first positively relates home good inflation rate in the home country, $P_{H,t}/P_{H,t-1}$, to its expected value $E_t\left(P_{H,t+1}/P_{H,t}\right)$ and to the marginal cost $P_{W,t}$; the second express a similar relations between the home good inflation rate in the rest of the world, $P^*_{H,t}/P^*_{H,t-1}$, its expected value $E_t\left(P^*_{H,t+1}/P^*_{H,t}\right)$ and the marginal cost $P_{W,t}$.

I assume similar equations hold for the foreign retailers that export to the home country:

$$\sum_{k=0}^{\infty}\vartheta^k E_t\left(\Lambda_{t,t+k}\frac{(\theta-1)\,p^o_t(f)-\theta P^*_{W,t+k}}{P_{t+k}}Y_{t+k}(f)\right)=0 \quad (35)$$

$$P_{F,t} = \left(\vartheta P^{1-\theta}_{F,t-1} + (1-\vartheta)\left(p^o_t(f)\right)^{1-\theta}\right)^{1/(1-\theta)} \quad (36)$$

As said, producers set prices in the local market currency (LCP case) and not in their own currency (PCP case); hence the international law of one price does not hold and the degree of pass-through of nominal exchange rate into import prices is incomplete. As a consequence the substitution effect, due to changes in the international relative prices induced by changes in the nominal exchange rate, would be lower than in the PCP case. The implications of this pricing policy for the relationship between trade balance dynamics and the exchange rate regime would be further analyzed later.

In agreement with the preferences of home and foreign agents, the aggregate final goods are defined as the CES composite of individual retail goods:

$$Y'_{H,t} \equiv \left(\int_0^1 Y_t(h)^{\frac{\theta-1}{\theta}}\,dh\right)^{\frac{\theta}{\theta-1}} \quad (37)$$

$$Y^{*\prime}_{H,t} \equiv \left(\int_0^1 Y^*_t(h)^{\frac{\theta-1}{\theta}}\,dh\right)^{\frac{\theta}{\theta-1}} \quad (38)$$

Similar aggregators hold for goods produced in the rest of the world.[20]

[20] CES makes aggregation difficult. However, it is possible to show that within a small neighborhood of the steady-state a linear aggregator $Y'_{H,t} = \int_0^1 Y_t(h)\,dh$

3.6 Monetary Policy Rules

In the home country, the central bank makes lump sum transfers of money to the unconstrained and constrained agents to implement a Taylor-type interest rate rule. The rule has the form:

$$\left(\frac{1+i_{H,t}}{1+\bar{\imath}_H}\right) = \left(\frac{1+i_{H,t-1}}{1+\bar{\imath}_H}\right)^{\rho_R} \left(\frac{P_{t-1}}{P_{t-2}}/\pi\right)^{(1-\rho_R)\rho_\pi} \left(\frac{Y_{t-1}}{Y}\right)^{(1-\rho_R)\rho_Y} e_{R,t} \quad (39)$$

Monetary policy responds systematically to past inflation P_{t-1}/P_{t-2} and past output. R, π, Y are the steady state values of the nominal interest rate, the domestic inflation rate and output. The lagged value of the nominal interest rate, R_{t-1}, is introduced to allow for interest rate inertia. $e_{R,t}$ is a white noise shock process with zero mean and variance σ_e.

3.7 Market Clearing Conditions, Public Sector Budget Constraints and the trade balance

The model is closed by the market clearing conditions and the public sector budget constraints. Equation (40) represents the home country house market clearing condition:

$$ho_t + ho'_t = H \quad (40)$$

Equations (41) and (42)are the home good market clearing conditions respectively in the home and of the rest of the world:

$$Y_{H,t} = C_{H,t} + C'_{H,t} \quad (41)$$

$$Y^*_{H,t} = C^*_{H,t} \quad (42)$$

Equation (43) is the home demand for the good produced in the rest of the world:

$$Y_{F,t} = C_{F,t} + C'_{F,t} \quad (43)$$

Equations (44) represent the home country resource constraints, respectively:

$$Y_t = Y_{H,t} + Y^*_{H,t} \quad (44)$$

$\left(Y^{*\prime}_{H,t} = \int_0^1 Y_t(h)\, dh\right)$ is equal to $Y_{H,t}$ $\left(Y^*_{H,t}\right)$, with the sum of $Y_{H,t}$ and $Y^*_{H,t}$ equal to the aggregate wholesale output Y_t. In what follows I'll consider Y_t as home aggregate outputs. A similar reasoning hold for the aggregation of the brands produced in the foreign country.

Equation (45) represent the market clearing of the bond traded in the home country:

$$B_{H,t} + B'_{H,t} = 0 \tag{45}$$

In country H, government rebate seigniorage revenues in a lump-sum fashion to domestic agents. Hence public sector budget constraint in the home country implies:

$$M_t - M_{t-1} = TR_t \tag{46}$$

$$M'_t - M'_{t-1} = TR'_t \tag{47}$$

Home country trade balance is obtained by consolidating the budget constraints of the home country agents, equations (15) and (20) and it is equal to:

$$TB_t = \frac{B_t}{(1 + i_t)} - B_{t-1} \tag{48}$$

Hence the trade balance is expressed as the change in the international asset position of the home unconstrained agent, comprehensive of interest payments.

3.8 The Equilibrium

The equilibrium is defined as a sequence of allocations and prices such that, given the initial conditions of the state variables and the stochastic processes of the exogenous shocks, (a) households, firms in the wholesale sectors and retailers solve their respective maximization problems, (b) the market clearing conditions, the government budget constraint and the monetary policy rules hold. For simplicity, and consistently with the focus of the paper (which is on the trade balance effects of U.S. real estate credit channel) I assume that in the rest of the world the aggregate consumption, interest rate, marginal costs of production, inflation rate of the foreign good do not change after a shock in the U.S. economy; to the contrary, international relative prices, imports and export change.

4 Solution of the model

The equilibrium dynamics is characterized by solving a first-order log-linear approximation to the equilibrium conditions around the non-stochastic steady state. The steady state is shown in appendix A. The log-linearized system in appendix B.

I calibrate the model as similarly as possible to Iacoviello (2005), who studies the real estate credit channel of monetary policy in the U.S. economy using a closed economy DSGE model. The time period is one quarter. Values are reported in table 1. For the standard parameters, values which are within the range considered in the monetary business cycle literature are chosen. The calibration is the same for both the home country and . The discount factor of the unconstrained agents, β, is set equal to 0.99; the value of the parameter α - determining the unconstrained agent' wage share - is set equal to 0.64. Following Lawrance (1991), which estimates discount factors for poor households (which are more likely to be debtors) in the range of 0.97 - 0.98, the discount rate of constrained agents, β', is set equal to 0.98. The parameter measuring the marginal rate of substitution between consumption and housing, j^h, is set to 0.1, so to have a residential real estate over annual output equal to 1.3. The parameter governing disutility of labor effort is set to 1.01. This value rationalizes the weak observed response of real wages to macroeconomic disturbances. For the Taylor rules, which I have estimated, the parameters are set as follows: ρ_R is set equal to 0.79, ρ_π is set equal to 1.29, ρ_y is set equal to 0.16.[21] The parameter m, which measures the loan-to-value ratio, is equal to 0.4. The parameter ϑ, which measures the retailers' probability of not adjusting prices, is set equal to 0.75. The parameter a_H, which measures the degree of home bias, is set equal to 0.75. The parameter ρ, which measures the elasticity of substitution between home and foreign goods, is equal to 1.5. The parameter θ, which measures the elasticity of substitution between the various types of brands, is set equal to 21, so that the steady-state markup is equal to 1.05. The autocorrelation parameter, ρ_j, of the stochastic process of the preference shock, is set equal to 0.85, while its standard deviation σ_j is set equal to 24.89. The home monetary shock has a standard deviation σ_R equal to 0.29, in line with the standard error of the interest rate equation in the VARs. Table 1 summarizes the calibrated values. The steady state net foreign asset position is assumed to be equal to zero.

[21] I have estimated an OLS regression of the Fed Funds rate on its own lag, past inflation, and detrended output yields for the period 1974Q1–2003Q2. I use a shift dummy from 1979Q4 to capture monetary policy changes.

5 Results

Results are articulated in two sections. In the first I report the main predictions of the theoretical model and compare them with those of the VAR, to explain how the real estate credit channel affects the trade balance dynamics. In the second, I perform some robustness analysis.

5.1 The Model Dynamics

In what follows I consider the effects of a monetary policy shock and of a house price shock. To highlight the role of the collateral, I also report the results obtained when the loan to value ratio m has a lower value than in the benchmark case. Finally, I compare the model and VAR predictions.

Monetary Policy Shock. In Figure 5 I consider a negative one standard deviation shock to the nominal interest rate (positive monetary shock).

The lower nominal (and real) interest rate (which makes current consumption more convenient than future consumption), the higher inflation (which lowers the costs of debt) and the increase in housing prices induce constrained agents to increase borrowing and consumption.

Unconstrained households, instead, reduce to a limited extent present consumption: the higher inflation rate and the lower interest rate reduce the real value of domestic outstanding credit and the revenue from the credit service; these effects more than compensate the positive substitution effect of lower interest rate on current consumption.

The total consumption, however, increases; the higher consumption is partly satisfied by the domestic output, which increases, and partly by increasing the amount of imported goods. As a result, the trade balance moves towards a deficit position.

Housing Price shock. In Figure 6 I consider a shock to the marginal rate of substitution j^h between housing and consumption for unconstrained households. This shock can be interpreted as a temporary tax advantage to housing investment, which shifts housing demand.

The increase in house pricing induces a positive collateral effect on constrained agents, who increase their borrowing, consumption of the nondurable goods and consumption of the real estate.

Given the rise in the inflation rate and output, monetary policy increases the nominal interest rate.

Unconstrained agents reduce consumption of both housing and nondurable good: the increase in the interest rate discourage current consumption by increasing its price in terms of future consumption.

However, the aggregate consumption increases and induces a higher domestic output and a deterioration of the trade balance, because of higher imports.

Comparison with VAR. I compare the DSGE impulse responses with those of the estimated VARs (the one including the trade balance, the other including the export and imports separately). To make this comparison is not strictly correct, given that the identification schemes of the two models are different. However, this exercise is usually done in the DSGE literature to assess the empirical properties of the model.

Figures 7 and 8 report the responses estimated to a one standard deviation decrease in the nominal interest rate.

As it can be seen, the sign of the trade balance and imports responses in the impact period are the same in the data and in the model. The same is true for the remaining variables. However, the initial increase in trade deficit and in the imports is higher in the model than in the VAR.

The figure suggests that the model is able to reproduce qualitatively and to some extent quantitatively the empirical evidence: from one side, the model is rather stylized to capture the main point of the paper, and hence lacks the vertical structure (intermediate sectors and distribution costs, for example) that characterizes the actual economies and filter the effects of consumption on trade balance (note that consumption, output, inflation and real estate price responses in the model are rather similar to their empirical counterparts); from the other, the model lacks the ad hoc features, for example habits in consumption and inflation indexation, that are usually used in literature to reproduce the hump-shaped and persistent response of the considered variables.

Figures 9 and 10 report the responses to an increase in the housing preference shock. Also in this case, qualitatively and to some extent quantitatively the model is able to reproduce the main features of the data. Given its extreme degree of stylization, the model accentuates the size of the responses with respect to the data.

5.2 Robustness Analysis.

Different values of m. In Figure 11, to emphasize the implications of the real estate credit channel, I consider the effects on aggregate consumption and on trade balance of a one standard deviation positive shock to house price under two alternative values of m, the loan-to-value ratio: when m is equal to its benchmark value, 0.4, and when it assumes a lower value, equal to 0.26.

In correspondence of the lower value of m, the collateral effect is lower and the model predicts a lower deterioration of the trade balance, because the increase of the constrained agent's consumption, and hence imports, is lower.

Given these responses, it is possible to infer that the conditional correlation between housing prices and consumption would be rather low, if not negative, when the collateral effect, associated to the real estate credit channel, is close to zero (m extremely low): housing prices and consumption of non durable goods would have a one to one relationship (the multiplier effect of higher housing prices on consumption would almost disappear) and the depressing effect of the interest rate would dominate. However, a negative correlation between housing prices and consumption of non durable goods is counterfactual, as shown by the VARs.

Different values of the elasticity of substitution ρ

In Figure 12, I consider the effects on on trade balance of a one standard deviation positive monetary policy shock under two alternative values of the elasticity of substitution between domestically produced and imported goods ρ: when *it* is equal to its benchmark value, 1.2, and when it assumes a lower value, equal to 0.85.

In correspondence of the lower value of ρ, the model predicts a lower deterioration of the trade balance because, given the increase in the relative price of imported good, households are less willing to substitute domestic for imported goods; hence, while the increase in aggregate consumption is the roughly the same in the two cases, the increase of the constrained agent's imports is lower in the case of lower elasticity.

The effects of the nominal exchange rate fluctuations

One strand of debate on the U.S. current account has focused on the possibility that the U.S. nominal exchange rate fluctuations help in reducing U.S. external unbalance. A depreciating U.S. dollar, in fact, would increase the relative price of foreign goods and shift world demand towards U.S.

goods (substitution effect). The implicit assumption behind this statement is that nominal exchange rate fluctuations are, at least to some extent, passed-through to the import and export prices. Until now I have assumed that the prices are set in local currency terms, so that the degree of pass-through is relatively low.

To understand if the substitution effect of the nominal exchange rate can counteracts the (expansionary) collateral effect of the housing prices increase on the trade balance, I make the assumption of price setting in the producer currency, so that the international law of one price holds and the pass-through is complete. I then consider a U.S. positive monetary shock and compare the responses of the U.S. trade balance, imports and export under the two price setting assumption.

Retailers in the home country now choose a price $p_t^o(h)$ so to solve the following problem:

$$\max_{p_t^o(h), p_t^{*o}(h)} \sum_{k=0}^{\infty} \vartheta^k \Lambda_{t,t+k} E_t \left(\Lambda_{t,t+k} \frac{\left(p_t^o(h) - P_{t+k}^W\right)\left(Y_{t+k}(h) + Y_{t+k}^*(h)\right)}{P_{t+k}} \right) \quad (49)$$

where

$$Y_{t+k}(h) = \left(\frac{p_t^o(h)}{P_{H,t+k}}\right)^{-\theta} \left[a_H \left(\frac{P_{H,t+k}}{P_{t+k}}\right)^{-\rho} \left(C_{t+k} + C'_{t+k} + I\right)\right] \quad (50)$$

and

$$Y_{t+k}^*(h) = \left(\frac{p_t^o(h)}{P_{H,t+k}}\right)^{-\theta} \left[(1 - a_H) \left(\frac{P_{H,t+k}^*}{P_{t+k}^*}\right)^{-\rho} (C^*)\right] \quad (51)$$

where C^* is assumed to be constant.

Note that the international law one price, $p^{o*} = p^o/S$ and the equality $P_H^* = P_H/S$ (which hold because of the law of one price and symmetric preferences) are used in the above equation.

The optimal choice of $p_t^o(h)$ satisfies the following first order condition:

$$\sum_{k=0}^{\infty} \vartheta^k E_t \left(\Lambda_{t,t+k} \frac{(\theta - 1)\, p_t^o(h) - \theta P_{t+k}^W}{P_{t+k}} \left(Y_{t+k}(h) + Y_{t+k}^*(h)\right)\right) = 0 \quad (52)$$

Since there are no firm-specific state variables, all retailers setting price at t will choose the same optimal price $p_t^o(h)$. It can be shown that, in the neighborhood of the steady state, the price index of the home good evolve respectively in the home country according to:

$$P_{H,t} = \left(\vartheta P_{H,t-1}^{1-\theta} + (1-\vartheta) \left(p_t^o (h) \right)^{1-\theta} \right)^{1/(1-\theta)} \tag{53}$$

Equations (52) and (53), once log-linearized around the steady state, yields a Phillips curve of the home produced good. The prices p^{o*} and P_H^* of the home brand h and of the composite good H can be derived using the law of one price $p^{o*} = p^o/S$ and the equality $P_H^* = P_H/S$.

As it can be seen in figure 13, the substitution effect at least partially counteracts the collateral effect and contributes to reduce the trade balance deficit in the aftermath of a interest rate reduction, by increasing the relative price of foreign goods (the U.S. terms of trade worsen), reducing the imports and increasing U.S. exports.

In the performed exercise I have considered two extreme cases, that of complete pass-through and that of low pass-through. The determination of the degree of pass-through, and hence of the relative size of the substitution effect with respect to the collateral effect, is an empirical matter. Evidence suggests that the degree of pass-through is rather low at the border and at consumer level, and hence a more flexible exchange rate hardly would be able to limit the effects of the higher housing prices on the trade balance dynamics.

6 Conclusions

Recent contributions emphasize the role of technology and fiscal shocks to explain the U.S. trade balance deficit. I add to the existing literature a new dimension, by investigating whether changes in real estate prices influence the U.S. trade balance dynamics.

The model, calibrated on the U.S. economy, shows that the domestic monetary and housing price shocks can also contribute to explain the movement of the U.S. trade balance through the real estate credit channel. Because of households' imperfect access to financial markets, real estate price changes generate a collateral effect which induces consumption to positively comove with house price; as a consequence, the trade balance moves towards deficit. Impulse responses obtained from the model are roughly in line with those obtained from an estimated VAR using U.S. data. I also show that a depreciation of the U.S. dollar limits the shift of the trade balance towards deficit when the pass-through is, counterfactually, complete.

The analysis suggests indirectly suggests that other measures should be analyzed to reduce international unbalances. From one side, the possibility that anemic U.S. trade partner such as the Euroarea and Japan coordinate along an expansionary equilibrium by implementing expansionary policies, such as structural reforms that, by incrementing the productivity of sector producing nontradable goods, would be able to generate a wealth and income effects and a related increase in consumption of tradable goods. From other, U.S. partners such as China should have a growth policy more oriented towards the increase of domestic demand then towards the increase of exports, as they actually are; in this respect, structural reforms that improve the soundness of the chinese domestic banking and financial systems, by contributing to reducing the households high propensity to save, could help.

References

[1] Aoki, Kosuke, James Proudman, and Jan Vlieghe (2004). "House Prices, Consumption, and Monetary Policy: A Financial Accelerator Approach," *Journal of Financial Intermediation*, 13(4), pp. 414–35.

[2] Baxter, Marianne and Mario J. Crucini (1995). "Business Cycles and the Asset Structure of Foreign Trade," *International Economic Review*, 36, 821-854.

[3] Benigno, Gianluca (2004). "Real Exchange Rate Persistence and Monetary Policy Rules," *Journal of Monetary Economics*, no. 51, pp. 473-502.

[4] Benigno, Pierpaolo (2001). "Price Stability with Imperfect Financial Integration," unpublished manuscript.

[5] Bergin, Paul R.(2003). "Putting the new open economy macroeconomics to a test," *Journal of International Economics* 60, pp. 3-34.

[6] Bergin, Paul R.and Robert C. Feenstra (2001). "Pricing-to-market, staggered contracts, and real exchange rate persistence," *Journal of International Economics* 54, 333– 359.

[7] Bernanke, Ben S. (2005). "The Global Saving Glut and U.S. Current Account Deficit," *Remarks by Governor Ben S. Bernanke at the Home Jones Lecture*, St. Louis, Missouri, Apri 14.

[8] Bernanke, Ben S. and Mark Gertler (1989). "Agency Costs, Net Worth, and Business Fluctuations," *American Economic Review*, 79(1), pp. 14–31.

[9] Bernanke, Ben S. and Mark Gertler (2001). "Should Central Banks Respond to Movements in Asset Prices?" *American Economic Review*, (Papers and Proceedings), 91(2), pp. 253–57.

[10] Bernanke, Ben, Mark Gertler and Simon Gilchrist (1999). "The Financial Accelerator in a Quantitative Business Cycle Model," in John Taylor and Michael Woodford (eds.), *Handbook of Macroeconomics*, Volume 1c, Amsterdam: North Holland: pp. 1341-1393.

[11] Betts, Caroline and Michael B. Devereux (1996). "The exchange rate in a model of pricing-to-market," *European Economic Review* 40, pp. 1007– 1021.

[12] Betts, Caroline and Michael B. Devereux (2000). "Exchange rate dynamics in a model of pricing-to-market," *Journal of International Economics* 50, pp. 215–244.

[13] Burstein, Ariel .T., Joao C. Neves and Sergio Rebelo (2003). "Distribution costs and real exchange rate dynamics during exchange-rate-based stabilizations," *Journal of Monetary Economics* 50, pp. 1189–1214.

[14] Calvo, Guillermo (1983). "Staggered Prices in a Utility Maximizing Framework," *Journal of Monetary Economics*, no.12: pp. 383-398.

[15] Campa, Jose and Linda Goldberg (2002). "Exchange Rate Pass Through Into Import Prices," National Bureau of Economic Research Working Paper 8934.

[16] Campbell, John Y. and N. Gregory Mankiw (1989). "Consumption, Income, and Interest Rates: Reinterpreting the Time Series Evidence," in Oliver J. Blanchard and Stanley Fischer, eds., NBER macroeconomics annual. Vol. 4. Cambridge, MA: MIT Press, pp. 185–216.

[17] Carlstrom, Charles T. and Timothy S. Fuerst (1997) "Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis," *American Economic Review*, 87(5), pp. 893–910.

[18] Carlstrom, Charles T. and Timothy S. Fuerst (2001) "Monetary Shocks, Agency Costs, and Business Cycles," *Carnegie-Rochester Conference Series on Public Policy*, 54(0), pp. 1–27.

[19] Case, Karl E., Robert J. Shiller and John M. Quigley (2001). "Comparing Wealth Effects: The Stock Market versus the Housing Market," University of California, Berkeley, Institute of Business and Economic Research Papers: No. E01–308.

[20] Chari, V.V., Patrick J. Kehoe and Ellen McGrattan (2002). "Can Sticky Prices Generate Volatile and Persistent Real Exchange Rates?" *Review of Economic Studies* 69, pp. 633-63.

[21] Corsetti, Giancarlo and Luca Dedola (2002). "Macroeconomics of International Price Discrimination," *Journal of International Economics.*

[22] Davis, Morris A. and Michael G. Palumbo (2001). "A Primer on the Economics and Time Series Econometrics of Wealth Effects," Board of Governors of the Federal Reserve System (U.S.), Finance and Economics Discussion Series: No. 2001-09, 2001.

[23] Devereux, Michael B. and Charles Engel (2001). "Monetary Policy in the Open Economy Revisited: Price Setting and Exchange Rate Flexibility," Unpublished.

[24] Devereux, Michael B. and Charles Engel (2002). "Exchange rate pass-through, exchange rate volatility, and exchange rate disconnect," *Journal of Monetary Economics* 49, 913–940.

[25] Engel, Charles, (2002). "The responsiveness of consumer prices to exchange rates and the implications for exchange rate policy: a survey of a few recent new-open-economy models," NBER Working Paper No. 8725.

[26] Erceg, Christopher J, Luca Guerrieri and Christopher Gust (2005). "Expansionary Fiscal Shocks and the Trade Deficit," Board of Governors of the Federal Reserve System (U.S.), International Finance Discussion Paper, 2005-825, January 2005.

[27] Faia, Ester (2005). "International Transmission Mechanism with Different Financial Systems," forthcoming *Journal of Monetary Economics.*

[28] Gilchrist, S., J.O. Hairault, and H. Kempf (2002) "Monetary Policy and the Financial Accelerator in a Monetary Union," European Central Bank Workin Paper no. 175.

[29] Greenspan, Alan (2005). "Current Account," *Remarks by Chairman Alan Greenspan at Advancing Enterpricise 2005 Conference*, London, England, February.

[30] Heathcote, J., and Fabrizio Perri (2002) "Financial Autarky and International Business Cycles," *Journal of Monetary Economics*, 49, 3, 601-627.

[31] Iacoviello, Matteo (2002). "House Prices and Business Cycles in Europe: a VAR Analysis," BC Working Paper 540, Boston College.

[32] Iacoviello, Matteo (2005). "House Prices, Borrowing Constraints and Monetary Policy in the Business Cycle," American Economic Review, vol.5, no.3, June.

[33] Iacoviello, Matteo and Raoul Minetti (2003). "Domestic and Foreign Lenders and International Business Cycles," BC Working Paper no. 554, Boston College.

[34] International Monetary Fund (2000). "Asset prices and the business cycle" in *World economic outlook*, Washington, DC.

[35] Jappelli, Tullio and Marco Pagano (1989). "Consumption and Capital Market Imperfections: An International Comparison," *American Economic Review*, 79(5), pp. 1088–1105.

[36] Kehoe, Patrick J., and Fabrizio Perri (2002) "International Business Cycles with Endogenous Incomplete Markets," *Econometrica*, 70, 3, 907-928.

[37] Kim, Soyoung and Nouriel Roubini (2004). "Twin Deficit or Twin Divergence? Fiscal Policy, Current Account and the Real Exchange Rate in the U.S.," revised April.

[38] Kiyotaki, Nobuhiro (1998). "Credit and Business Cycles," *The Japanese Economic Review*, vol. 49, No.1, March: pp. 18-35.

[39] Kiyotaki, Nobuhiro, and John Moore (1997). "Credit Cycles," *Journal of Political Economy*,105, 2, 211-248.

[40] OECD (2004). "Housing markets, wealth and the business cycle," in *OECD Economic Outloook*, vol. 2004/1, no. 75, June.

[41] Paasche, Bernard (2001). "Credit Constraints and International Financial Crises," *Journal of Monetary Economics*, 48, 3, 623-650.

[42] Rogoff, Kenneth (2005), "A Healty Global Economy begins at Home," Financial Times, May 19.

[43] Roubini, Nouriel, and Setser Brad (2005). "The U.S. Twin Deficits and External Debt Accumulation: Are They Sustainable?" work in progress, August 2004.

[44] Schmitt-Grohé, Stephanie, and Martin Uribe (2001). "Closing Small Open Economy Models," *Journal of International Economics*, 61, October: pp. 163-185.

[45] Zeldes, Stephen P (1989). "Consumption and Liquidity Constraints: An Empirical Investigation," *Journal of Political Economy*, 97(2), pp. 305–46.

Appendix A. The Steady State

I assume a symmetric steady-state flexible price equilibrium in which all the shocks are zero, there is no change in asset position ($B_t = B_{t-1} = B$, $B_{H,t} = B_{H,t-1} = B_H$,), in house holdings ($ho_t = ho_{t-1}$,), all price inflation rates as well as exchange rate depreciation are zero ($P_t/P_{t-1} = 1$, $Q_t/Q_{t-1} = 1$, $S_t/S_{t-1} = 1$), the net foreign asset position is zero (hence also the trade balance is equal to zero). Let's consider the home country equations.

The pricing equation (31) implies:

$$P_H = \frac{\theta}{\theta - 1} P_W \tag{54}$$

Given that the prices are flexible, the international law of one price holds; hence:

$$P_H^* = P_H/S \tag{55}$$

The price of the tradable consumption good, equation (4), becomes:

$$P = \left[a_H P_H^{1-\rho} + (1 - a_H) P_F^{1-\rho}\right]^{\frac{1}{1-\rho}} \tag{56}$$

Labor supply first order conditions, equations (19) and (24), become respectively:

$$\frac{W}{PC} = \kappa L^{\tau-1} \tag{57}$$

$$\frac{W'}{PC'} = \kappa L'^{\tau-1} \tag{58}$$

Labor demand first order conditions, equations (26) and (27), become respectively:

$$L = (1 - \alpha) \mu (P_W Y/P)/(W/P) \tag{59}$$

$$L' = (1 - \alpha) (1 - \mu) (P_W Y/P)/(W'/P) \tag{60}$$

The production function, equation (25), is equal to:

$$Y = L^{(1-\alpha)\mu} L'^{(1-\alpha)(1-\mu)} \tag{61}$$

The home demand function for the home produced good, using equations (7) and (41), is:

$$Y_H = a_H \left(\frac{P_H}{P}\right)^{-\rho} (C + C' + I) \tag{62}$$

The home demand function for the home produced good, using equations (9) and (43) is:

$$Y_H^* = (1 - a_H)\left(\frac{P_H^*}{P^*}\right)^{-\rho} C^* \tag{63}$$

Total demand for the home produced good, equation (44), is:

$$Y = Y_H + Y_H^* \tag{64}$$

The value of real estate held by the unconstrained agent, obtained from equation (18), is equal to:

$$Qho = \frac{j^h}{1-\beta} C \tag{65}$$

The consumer euler equations of the home patient agent, equation (16) and (17), imply:

$$\beta = \frac{1}{1+\bar{\imath}} = \frac{1}{1+\bar{\imath}_H} \tag{66}$$

Combining the steady state versions of the constrained and unconstrained agent euler equations, (16) and (23), the following value for λ, the lagrange multiplier of the borrowing constraint, can be obtained:

$$\lambda = \left(\frac{\beta - \beta'}{C}\right) \tag{67}$$

By assumption, $0 < \beta' < \beta < 1$; so the lagrange multiplier is strictly greater than zero in the steady state (and in a small neighborhood of it). As a consequence, the borrowing constraint is binding.

From the first order equations, (22) and (23), the real estate held by the constrained agent is:

$$Qho' = \frac{j^h}{1 - \beta' - m(\beta - \beta')} PC' \tag{68}$$

The borrowing constraint equation (21) becomes:

$$B_H' = -m \frac{\mu \beta'}{(1-\beta') - m(\beta - \beta')} P_W Y \tag{69}$$

Using the budget constraint of the constrained agent and the above two equations it is possible to derive the equation of the constrained agent's consumption, C':

$$C' = (1-\mu)\left[\frac{1-\beta'-m(\beta-\beta')}{1-\beta'-m(\beta-\beta')+mj^h(1-\beta)}\right]P_W Y \qquad (70)$$

From the above equation and the trade balance equation (48) the consumption of the unconstrained agent, C, can be derived:

$$C = \frac{P_H}{P}Y - C' - I \qquad (71)$$

where I assume that the investment I is done to replace the depreciated capital (δ is the depreciation rate):

$$I = \delta K$$

and the steady state capital stock satisifies the traditional first order condition:

$$K = \frac{\alpha\beta}{1-\beta(1-\delta)}Y$$

Using the market clearing condition for the bonds traded in the home country, equation (45), the asset position of the unconstrained agent can be determined:

$$B_H = -B'_H \qquad (72)$$

I assume all tradable goods will have the same price ($P_H = P_F = P = SP^* = SP^*_F = P^*_H/S$) and I normalize them to one. Normalizing all the variable by Y (the total national production), the steady state values become function of the deep parameters (technology and preferences) and hence are uniquely determined. In particular, it can be seen that

$$\frac{Y_H}{Y} = a_H \qquad (73)$$

$$\frac{Y_F}{Y} = (1-a_H) \qquad (74)$$

Appendix B. The loglinearized System

Let hatted variables denote percent changes from the steady state, and those without subscript denote steady-state values. The trade balance and the asset position variables are not loglinearized, given that some of them are equal to zero in steady state; for each, I exploit the following definition (applied as an example to the trade balance variable): $Y_t(tb_t) = (TB_t - TB)$. Note that $\hat{\pi}_{\cdot,t} \equiv \ln(1+\pi_{\cdot,t}) \equiv \ln(P_{\cdot,t}/P_{\cdot,t-1})$ and that $\widehat{\Delta S_t} \equiv \ln(S_t/S_{t-1})$.To save on notation, I drop the expectation operator before variables dated $t-1$, which must be intended in expected value conditional on the information available at time t. The model can be reduced to the following linearized system.

I. Relative Price and Inflation Rates.

$$\widehat{T}_t = \widehat{T}_{t-1} + \hat{\pi}_{F,t} - \hat{\pi}_{H,t} \tag{RP1}$$

$$\widehat{T}_t^* = \widehat{T}_{t-1}^* - \hat{\pi}_{H,t}^* \tag{RP2}$$

$$\widehat{RS}_t = \widehat{RS}_t + \widehat{\Delta S}_t + \hat{\pi}_t^* - \hat{\pi}_t \tag{RP3}$$

$$\hat{\pi}_t = a_H \hat{\pi}_{H,t} + (1-a_H)\,\hat{\pi}_{F,t} \tag{RP4}$$

$$\hat{\pi}_t^* = (1-a_H)\,\hat{\pi}_{H,t}^* \tag{RP5}$$

II. Aggregate supply

$$\hat{Y}_t = (1-\alpha)\,\mu \hat{L}_t + (1-\alpha)(1-\mu)\,\hat{L}_t' \tag{AS1}$$

$$\widehat{p_{W,t}} + \hat{Y}_t = \hat{C}_t + \tau \hat{L}_t \tag{AS2}$$

$$\widehat{p_{W,t}} + \hat{Y}_t = \hat{C}_t + \tau \hat{L}_t' \tag{AS3}$$

$$\hat{\pi}_{H,t} = \beta \hat{\pi}_{H,t+1} + \frac{(1-\vartheta)(1-\beta\vartheta)}{\vartheta}\left(\widehat{p_{W,t}} + (1-a_H)\,\widehat{T}_t\right) \tag{AS4}$$

$$\hat{\pi}_{F,t} = \beta \hat{\pi}_{F,t+1} + \frac{(1-\vartheta)(1-\beta\vartheta)}{\vartheta}\left(-a_H \widehat{T}_t + \widehat{RS}_t\right) \tag{AS5}$$

$$\hat{\pi}_{H,t}^* = \beta \hat{\pi}_{H,t+1}^* + \frac{(1-\vartheta)(1-\beta\vartheta)}{\vartheta}\left(\widehat{p_{W,t}} + a_H \widehat{T}_t^* - \widehat{RS}_t\right) \tag{AS6}$$

III. Aggregate Demand

The aggregate demand block is composed by the log-linearized home Euler equations

$$-\hat{C}_t = -\hat{C}_{t+1} + \widehat{(1+i_t)} - \delta \frac{B}{Y}\hat{b}_t - \hat{\pi}_{t+1} \tag{AD1}$$

$$\widehat{(1+i_{H,t})} = \widehat{(1+i_t)} \tag{AD2}$$

$$\hat{q}_t = \hat{C}_t + \beta \hat{q}_{t+1} - \beta \hat{C}_{t+1} + (1-\beta)\frac{ho'}{ho}\widehat{ho'_t} + (1-\beta)\hat{\jmath}_t \tag{AD3}$$

$$\begin{aligned} \hat{q}_t &= (1-m\beta)C'_t + \hat{q}_{t+1}(\beta' + m(\beta-\beta')) - \hat{C}'_{t+1}\beta'(1-m) \\ &- \widehat{ho'_t}(1-\beta' - m(\beta-\beta')) - m\beta\hat{R}_t + m\beta\hat{\pi}_t \end{aligned} \tag{AD4}$$

$$-\widehat{(1+i_t)} = -\Delta S_t \tag{AD5}$$

$$\hat{Y}_{H,t} = (1-a_H)\rho\widehat{T_t} + \frac{C}{Y}\hat{C}_t + \frac{C'}{Y}\hat{C}'_t \tag{AD6}$$

$$\hat{Y}^*_{H,t} = a_H\rho\widehat{T^*_t} \tag{AD7}$$

$$\hat{Y}_{F,t} = a_H\rho\widehat{T_t} + \frac{C}{Y}\hat{C}_t + \frac{C'}{Y}\hat{C}'_t \tag{AD8}$$

$$Y_t = a_H\hat{Y}_{H,t} + (1-a_H)Y^*_{H,t} \tag{AD9}$$

IV. Borrowing constraint and flows of funds

$$\begin{aligned} &\beta b_t - b_{t-1} \\ &= \frac{Y_H}{Y}\left(-(1-a_H)\hat{T}_t + \hat{Y}_{H,t}\right) + \frac{Y^*_H}{Y}\left(-a_H\hat{T}^*_t + \widehat{RS}_t + \hat{Y}^*_{H,t}\right) - \frac{C}{Y}\hat{C}_t - \frac{C}{Y}\hat{C}'_t \end{aligned} \tag{BC1}$$

$$\begin{aligned} &\beta\frac{B'_H}{Y}\left[b'_{H,t} - \widehat{(1+i_t)} + \delta b_t\right] - \frac{B'_H}{Y}\left(b'_{H,t-1} - \hat{\pi}_{t-1}\right) \\ &= (1-\mu)p_W\left(\widehat{p_{W,t}} + \hat{Y}_t\right) - \frac{qho'}{Y}\widehat{ho'_t} - \widehat{ho'_{t-1}} - \frac{C}{Y}\hat{C}'_t \end{aligned} \tag{BC2}$$

$$-b'_{H,t} = m\frac{qho'}{Y}\left(\hat{q}_{t+1} + \hat{\pi}_t + \widehat{ho'_t}\right) \tag{BC3}$$

$$tb_t = \beta b_t - b_{t-1} \tag{BC4}$$

V. Monetary Policy rules and shock processes

$$\widehat{(1+i_{H,t})} = \rho_R\widehat{(1+i_{H,t-1})} + (1-\rho_R)\rho_\pi\hat{\pi}_{t-1} + (1-\rho_R)\rho_Y\hat{Y}_{t-1} + \hat{\varepsilon}_{R,t} \tag{MP1}$$

$$\hat{j} = \rho_j \hat{j} + \hat{\varepsilon}_{j,t} \tag{PRE1}$$

The first block contains the definitions of international relative prices and of inflation rates: equations (RP1) and (RP2) represent the log-linearized versions of relative prices (12); equation (RP3) is the log-linearized home country real exchange rate (13); equations (RP4) and (RP5) are the home and foreign country inflation rates, respectively obtained from equations (4) and (5) .

The second block is formed by the equations describing the supply side of the economy: (AS1) is the loglinearized version of the home country production function (25); (AS2) is obtained from loglinearizing labor demand (26) and supply (19) in the home country; (AS3) is the analogous of (AS2) in the case of the constrained agent (obtained from equations (24) and (27)); the short run phillips curves, equations (AS4), (AS5), (AS6) are obtained from the solution of the retailers' problem.

The third block is the demand block, composed by the home unconstrained agent and interest parity, (AD1) and (AD2), respectively obtained by loglinearizing equations (16) and (17); the unconstrained and constrained agent real estate euler equations, (AD3) and (AD4), respectively obtained by loglinearizing (18) and (23) (using the house market clearing condition (40)); the modified uncovered interest parity (AD5), in which the foreign interest rate is assumed to be constant; the market clearing conditions (AD6), (AD7), (AD8), (AD9), respectively obtained from equations (41), (42), (43), (44).

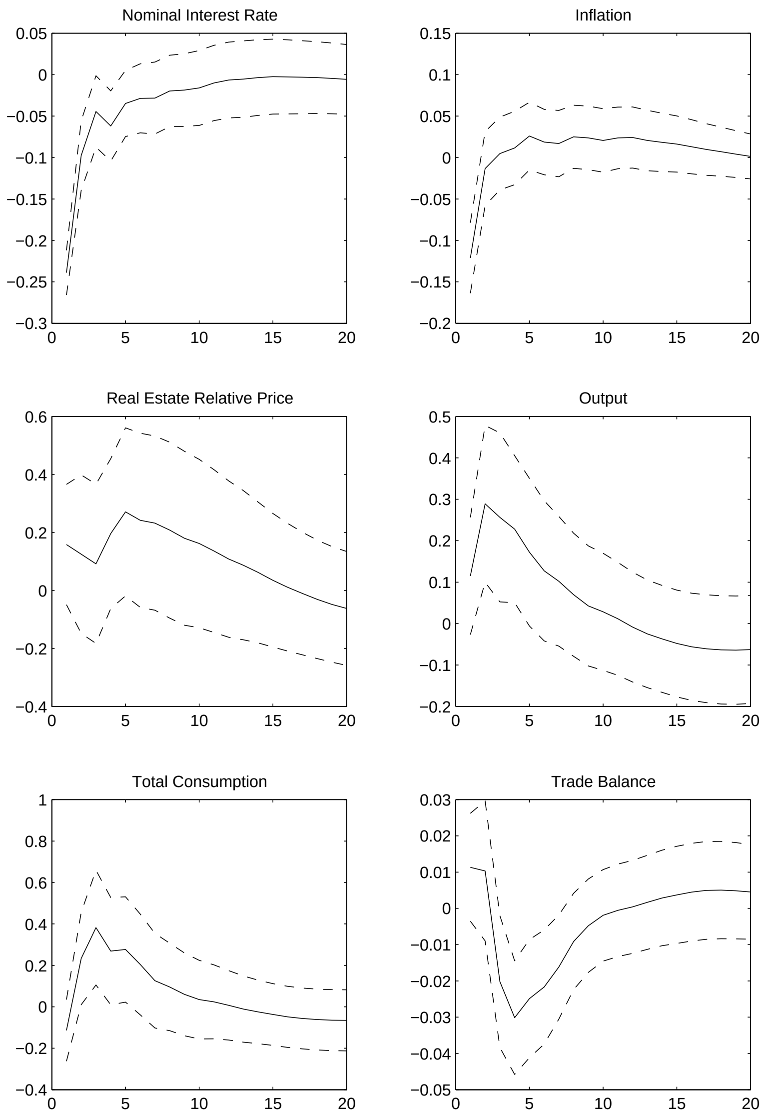
The fourth block is formed by the equations describing the borrowing constraint, the flows of funds and the trade balance: equation (BC1) describes the home country's net foreign asset position and it is obtained by consolidating equations (15), (20), (40), (46), (47); equations (BC2) and (BC3) are respectively the constrained agent's budget and borrowing constraints (obtained respectively from equations (20) and (21)); equation (BC4) is the home country's trade balance, obtained from the equation (48).

The last block is formed by equations describing the monetary policy and the exogenous shocks: equations (MP1) and (MP2) are the log-linearized versions of equations (39) and (**??**), respectively. (PRE1) is the exogenous law of motion of the housing preference shock.

Table 1. Model Calibration

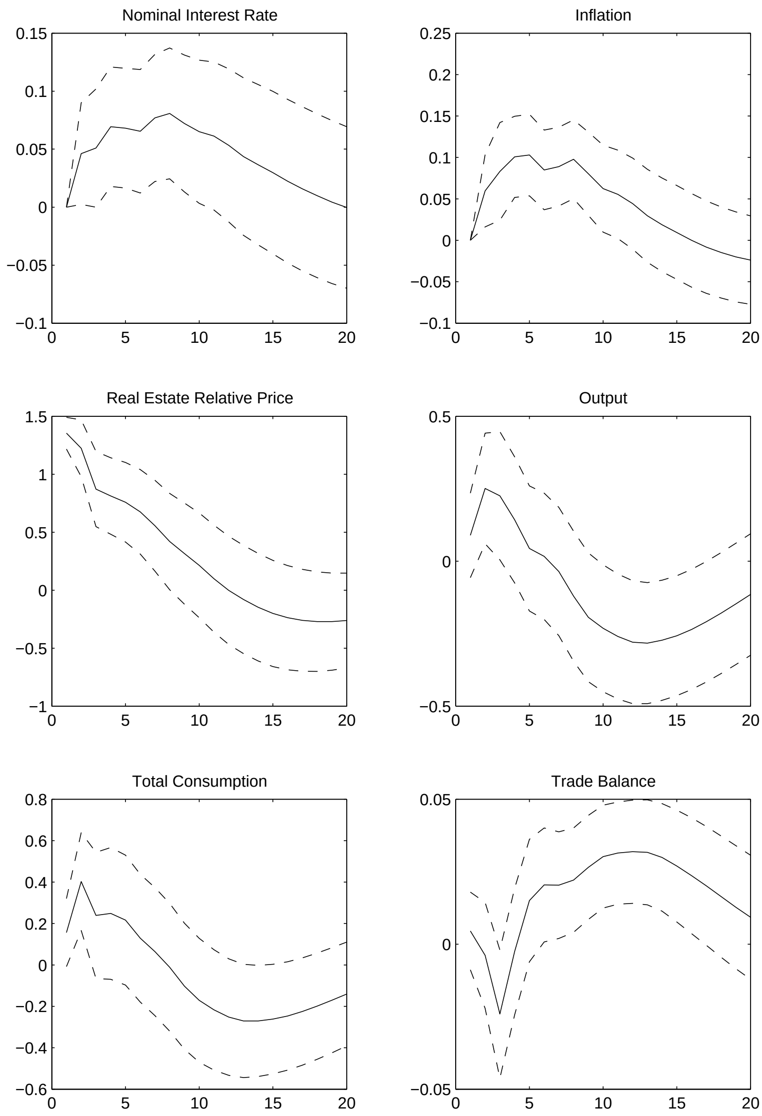
Parameter	Value
β consumer discount rate	0.99
β' impatient consumer discount rate	0.98
ρ intratemporal elasticity of substitution	1.5
τ labor disutility	1.05
m loan to value ratio	0.4
δ financial friction parameter	0.0001
a_H home bias	0.95
j^h Weight on house services	0.1
$1/X$ Steady state markup	1.2
ϑ Probability of not adjusting tradable goods prices	0.75
μ Patient agent wage share	0.64
α Capital rental rate share	0.33
ρ_R Interest rate persistence	0.73
ρ_π Inflation rate	1.29
ρ_Y Output	0.16
δ Capital depreciation rate	0.025
ρ_j Persistence preference shock	0.85
σ_j Volatility preference shock	28.5
σ_R Volatility monetary shock	0.29

Figure 1. VAR responses to a U.S. positive monetary policy shock: the U.S. trade balance



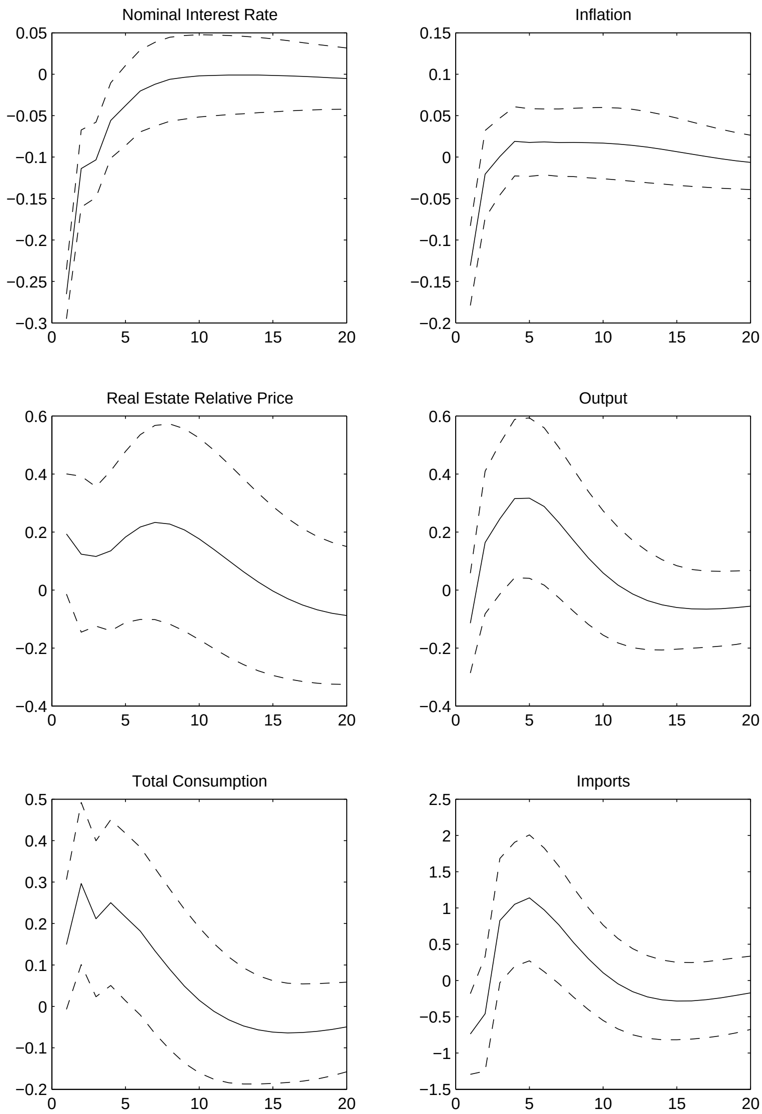
Notes: The dashed lines indicate 90-percent confidence bands. Ordinate: time horizon in quarters. Coordinate: percent deviation from steady state. Size of the shock: one standard deviation.

Figure 2. VAR responses to a U.S. positive housing price shock: the U.S. trade balance



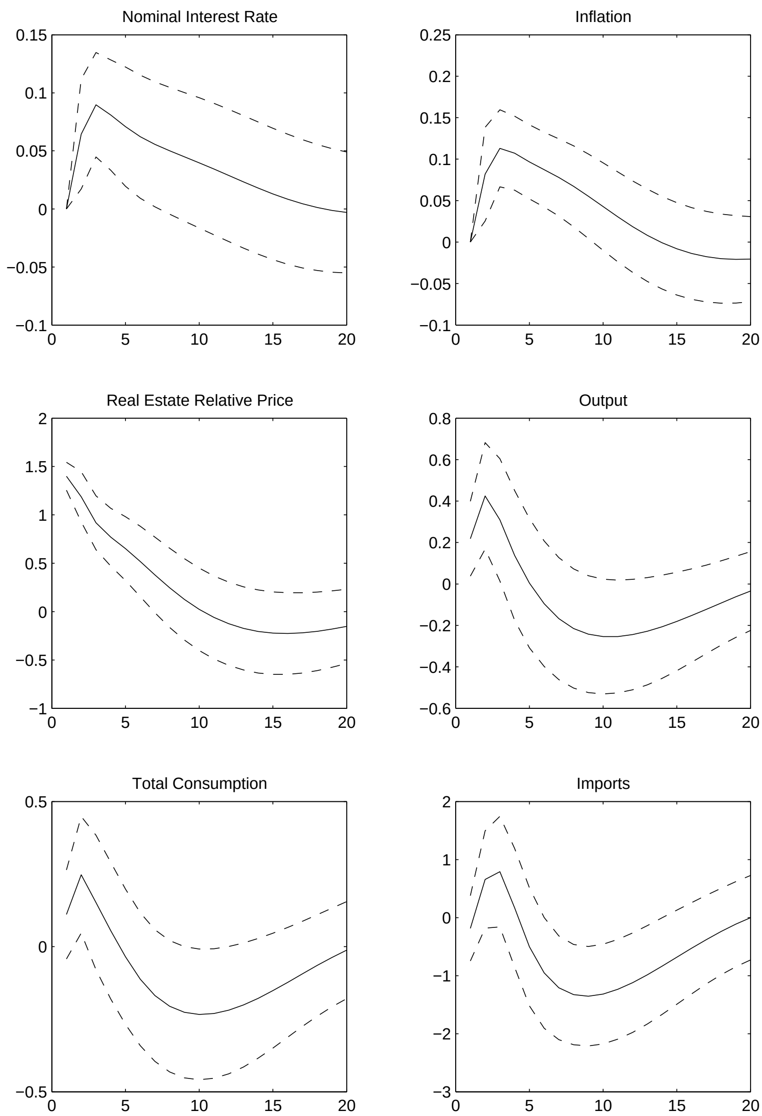
Notes: The dashed lines indicate 90-percent confidence bands. Ordinate: time horizon in quarters. Coordinate: percent deviation from steady state. Size of the shock: one standard deviation.

Figure 3. VAR responses to a U.S. positive monetary shock: the U.S. imports



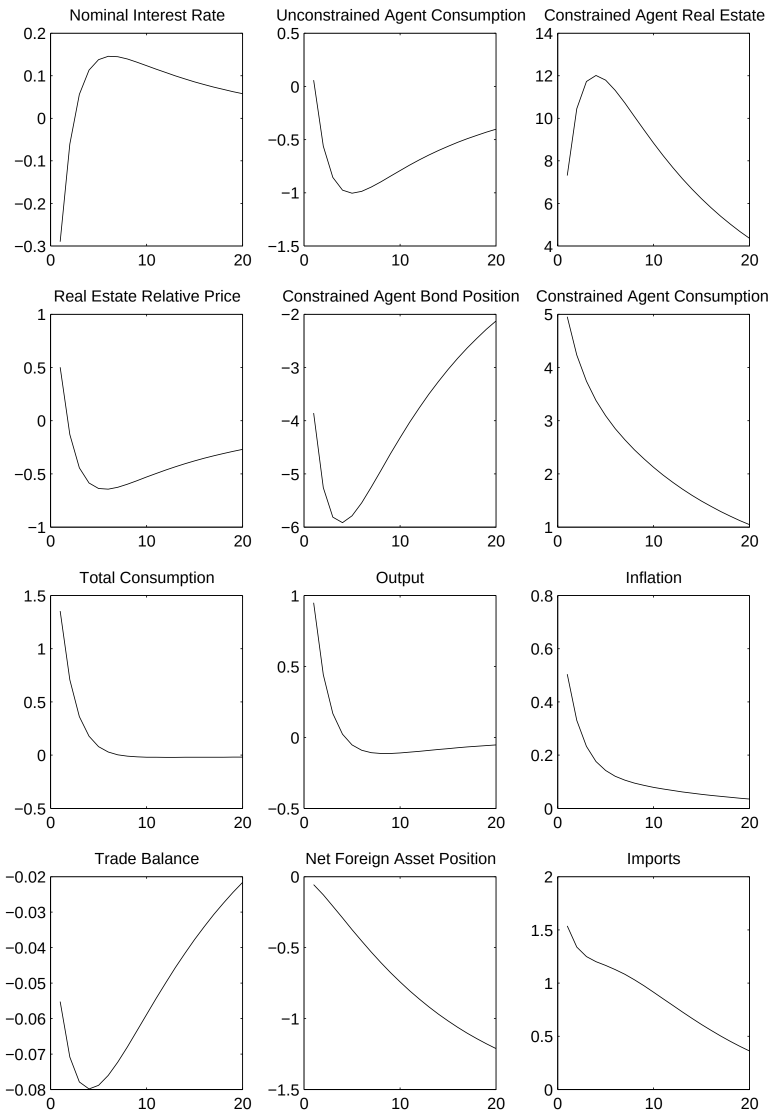
Notes: The dashed lines indicate 90-percent confidence bands. Ordinate: time horizon in quarters. Coordinate: percent deviation from steady state. Size of the shock: one standard deviation.

Figure 4. VAR responses to a U.S. positive housing prices shock: the U.S. imports



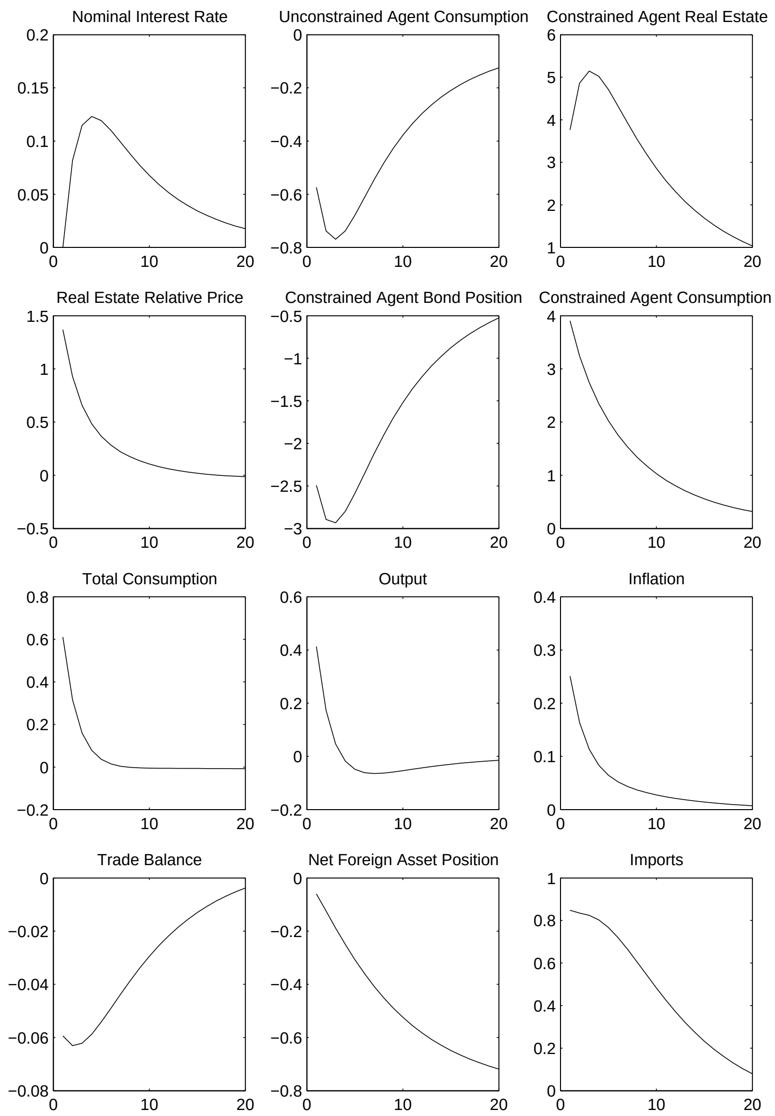
Notes: The dashed lines indicate 90-percent confidence bands. Ordinate: time horizon in quarters. Coordinate: percent deviation from steady state. Size of the shock: one standard deviation.

Figure 5. DSGE responses to a U.S. positive monetary policy shock



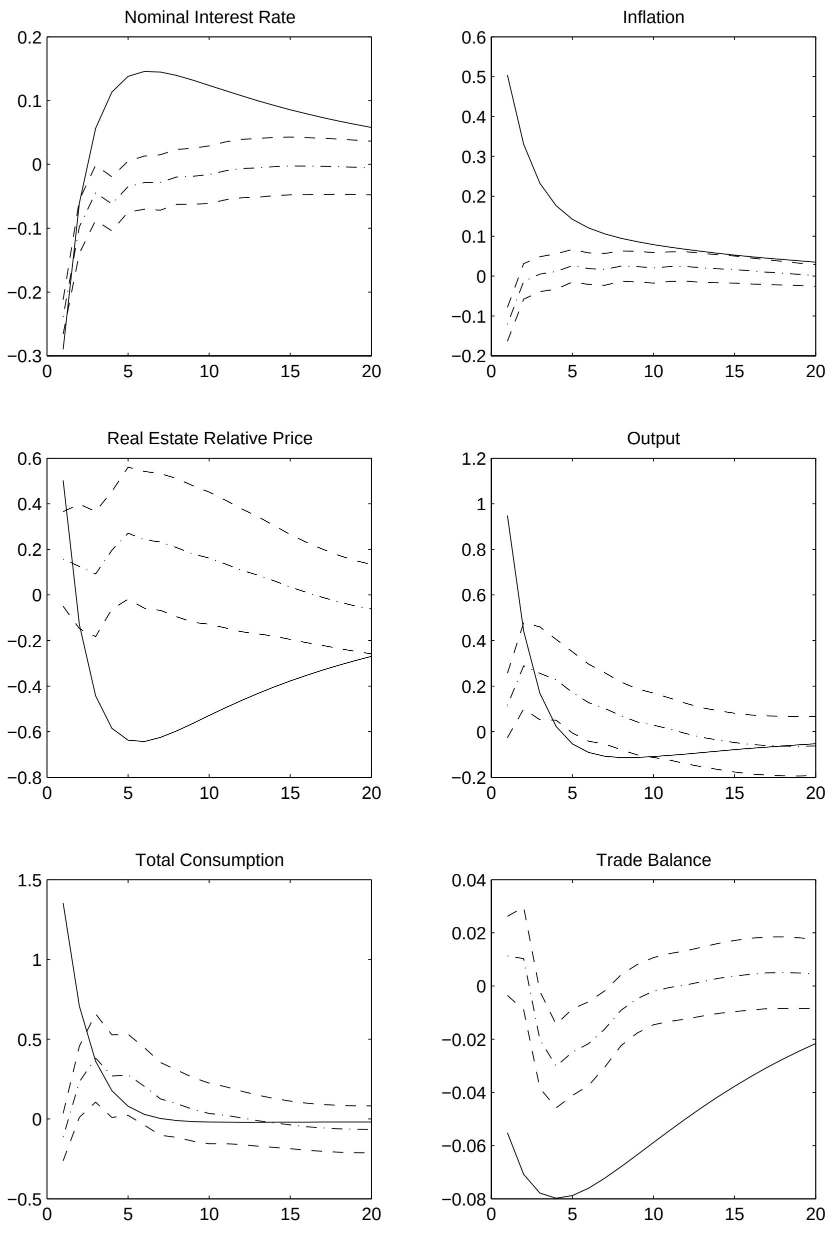
Notes: Ordinate: time horizon in quarters. Coordinate: all variable are in percent deviation from steady state, with the exception of asset positions(deviations from steady state value to steady state output ratio)

Figure 6. DSGE responses to a U.S. positive housing prices shock



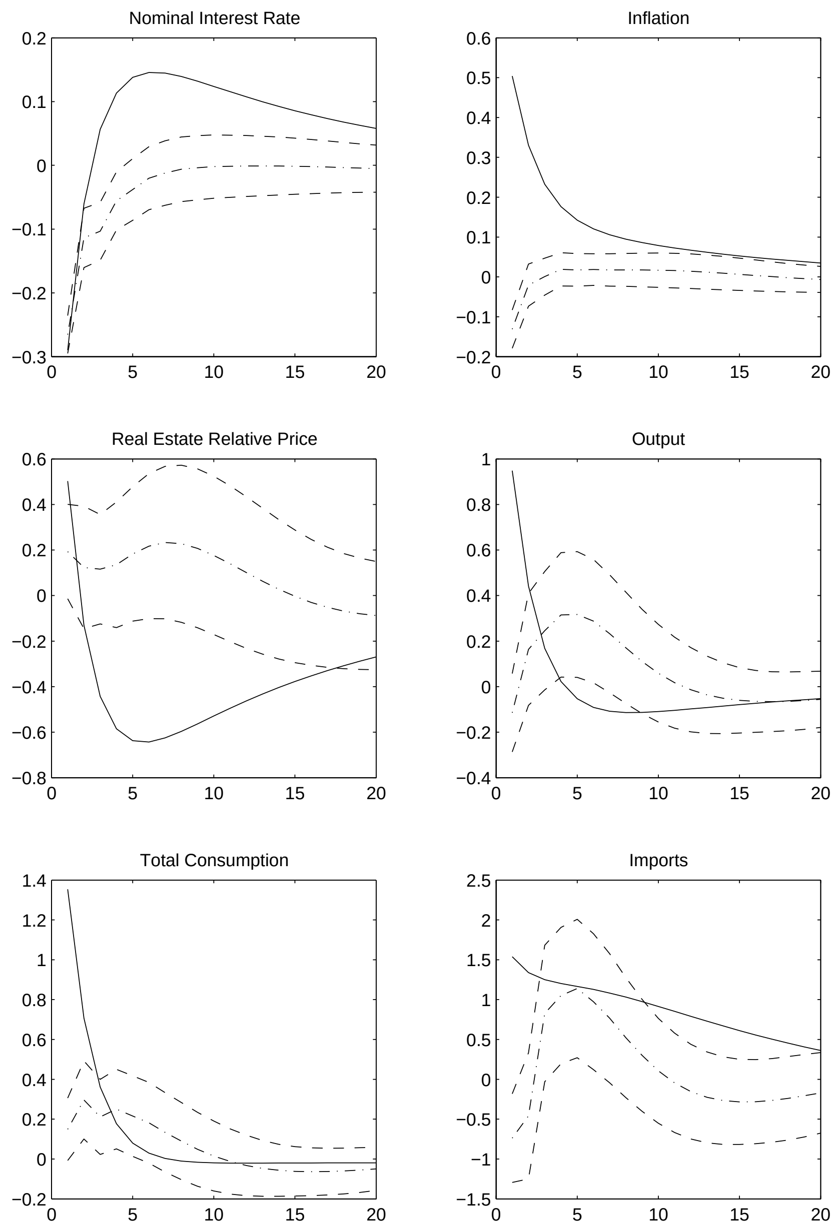
Notes: Ordinate: time horizon in quarters. Coordinate: all variable are in percent deviation from steady state, with the exception of asset positions(deviations from steady state value to steady state output ratio)

Figure 7. DSGE and VAR responses to a U.S. positive monetary policy shock



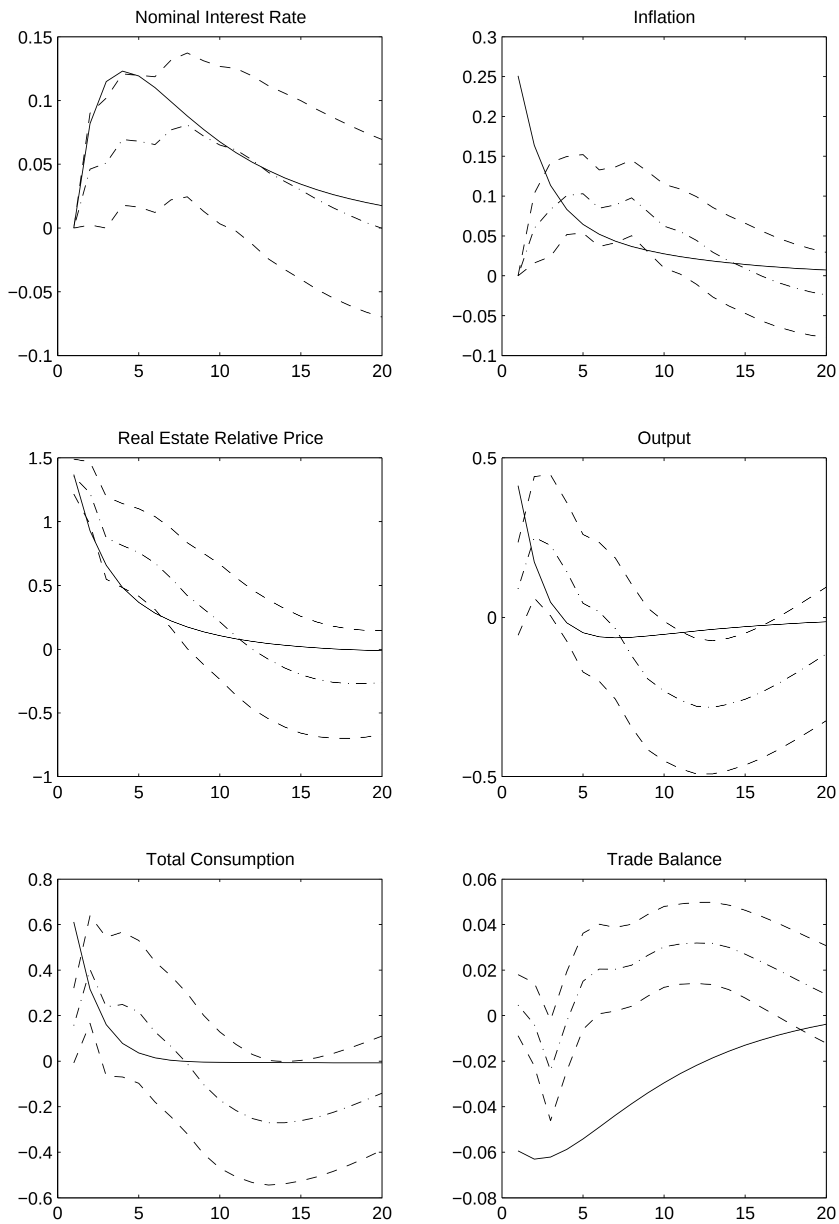
Notes: Ordinate: quarters. Coordinate: percent deviation from the steady state. Solid line: DSGE responses. Dashed line:

Figure 8. DSGE and VAR responses to a U.S. positive monetary policy shock: the U.S. imports



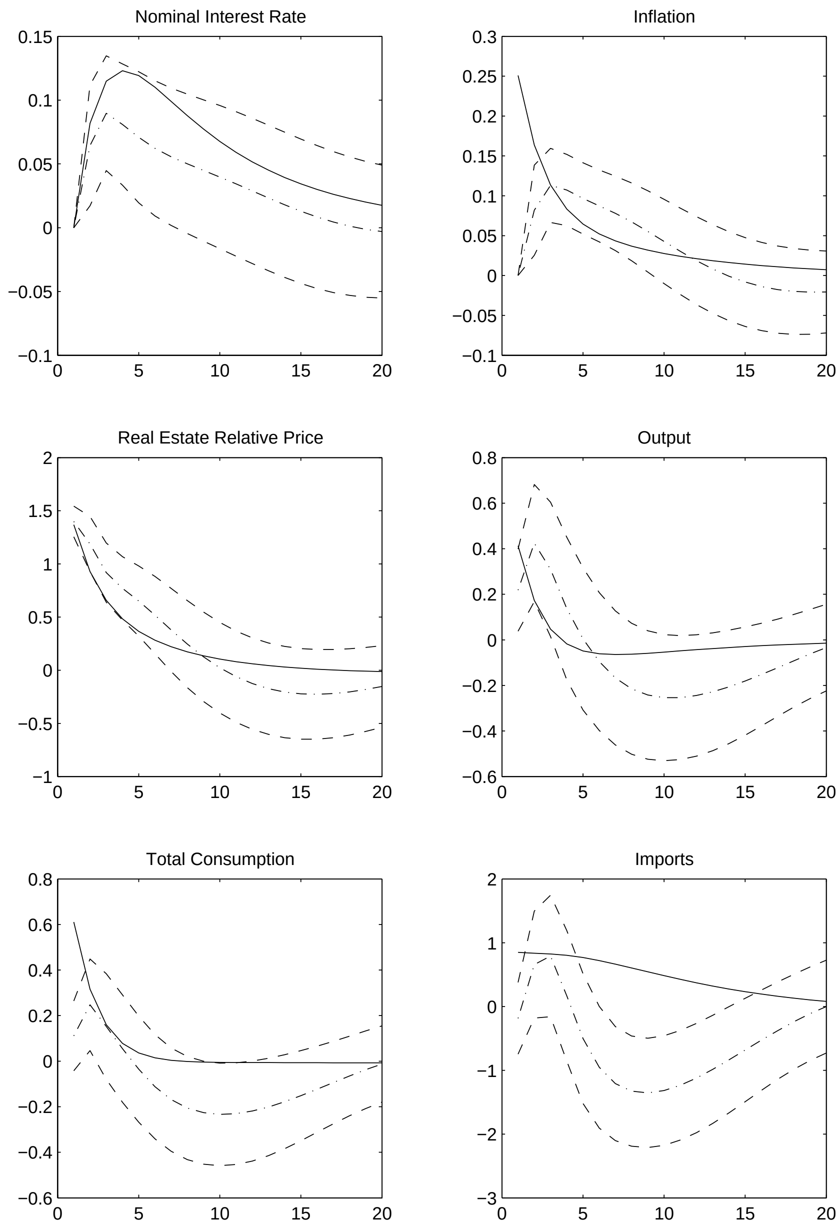
Notes: Ordinate: quarters. Coordinate: percent deviation from the steady state. Solid line: DSGE responses. Dashed line: VAR responses + 90 c.i.

Figure 9. DSGE and VAR responses to a U.S. positive housing prices shock: the U.S. trade balance



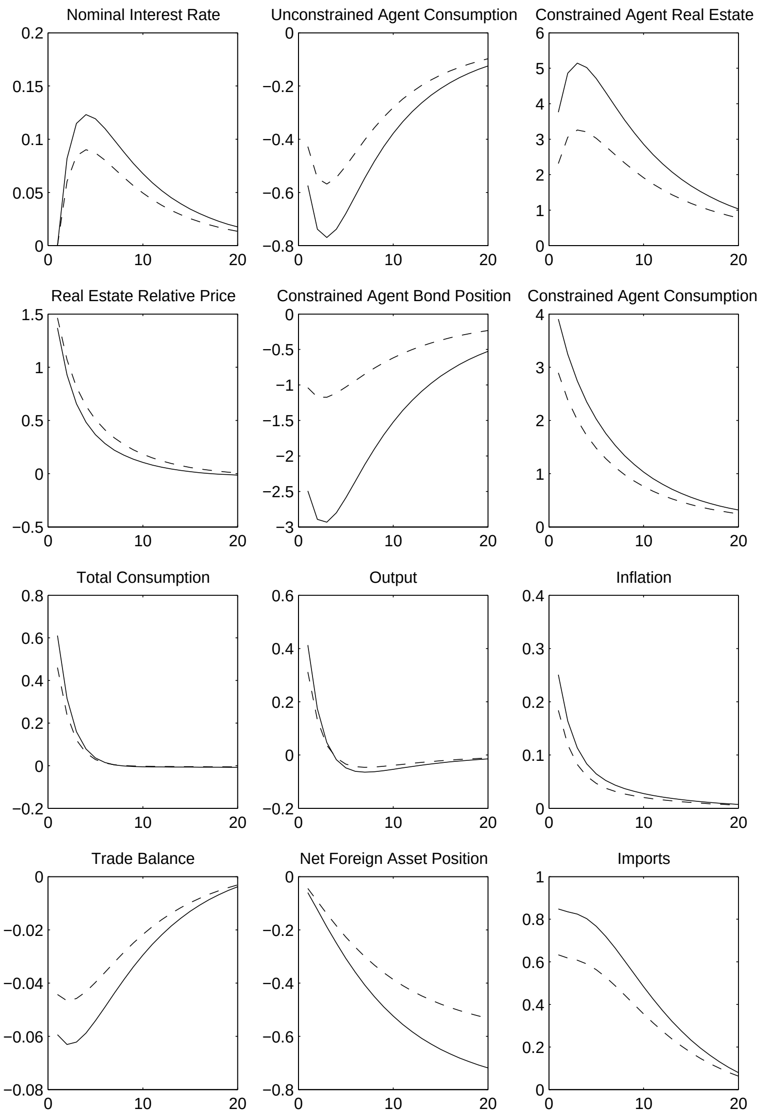
Notes: Ordinate: quarters. Coordinate: percent deviation from the steady state. Solid line: DSGE responses. Dashed line: VAR responses + 90 c.i.

Figure 10. DSGE and VAR responses to a U.S. positive housing prices shock: the U.S. imports



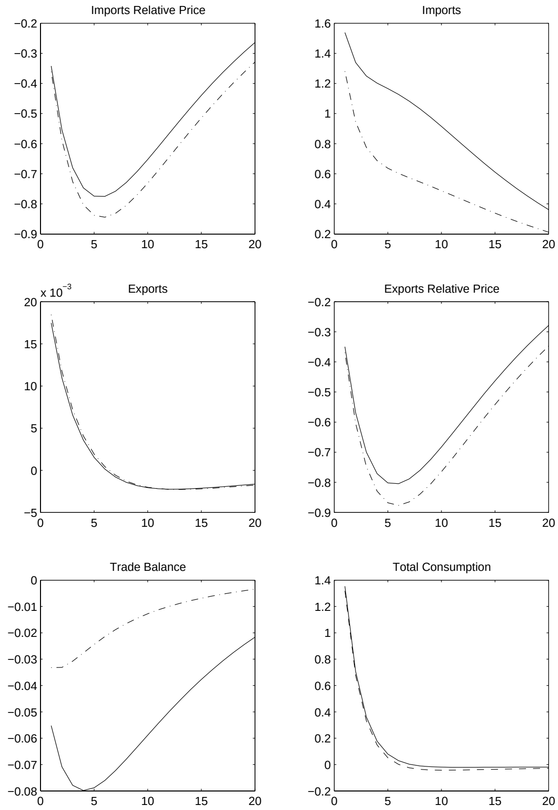
Notes: Ordinate: quarters. Coordinate: percent deviation from the steady state. Solid line: DSGE responses. Dashed line: VAR responses + 90 c.i.

Figure 11. DSGE responses of U.S. variables to a positive U.S. housing price shock: different values of the loan-to-value ratio m



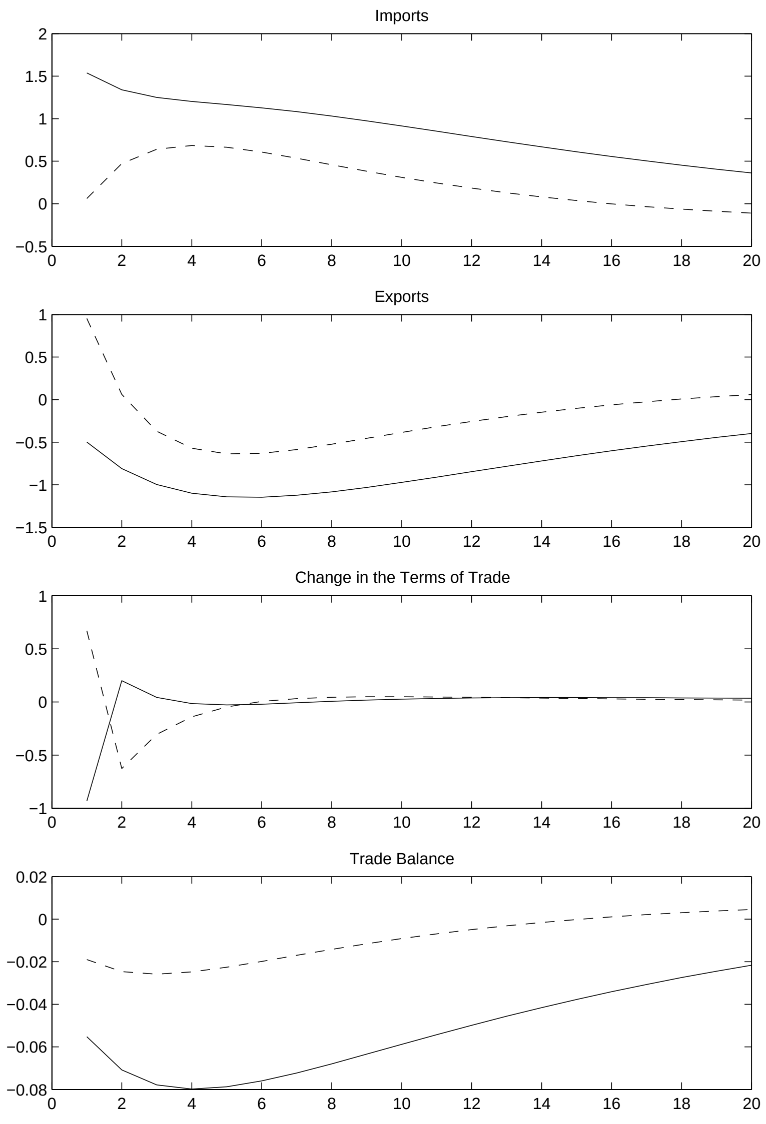
Notes: Ordinate: time horizon in quarters. Coordinate: all variable are in percent deviation from steady state, with the exception of asset positions(deviations from steady state value to steady state output ratio). Solid line: $m = 0.4$.Dotted line: $m = 0.25$.

Figure 12. Responses of U.S. variables to a positive U.S. monetary shock under alternative elasticities of substitution



Notes: Ordinate: quarters. Coordinate: percent deviation from the steady state. Solid line: $\rho = 1.5$. Dashed line: $\rho = 0.75$.

Figure 13. DSGE responses of U.S. variables to a positive U.S. monetary policy shock under different degrees of exchange rate pass-through



Notes: Ordinate: quarters. Coordinate: percent deviation from the steady state. Solid line: incomplete pass-through. Dashed line: complete pass-through.