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House Prices and Monetary Policy in Colombia

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Precios de la vivienda y política monetaria en Colombia

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Resumen

En este documento se estudian los resultados de diferentes alternativas de política bajo el régimen de inflación objetivo cuando los precios de los activos presentan desviaciones de sus fundamentales. Específicamente, se analiza el caso de los precios de la vivienda mediante un modelo de equilibrio general dinámico con restricciones de crédito y burbujas en el precio de la vivienda. Se muestra que una regla de política monetaria que reacciona directamente a los precios de la vivienda es menos eficiente que una en la cual se reacciona únicamente a las desviaciones de la tasa de inflación esperada de su objetivo. También se encuentra que la regulación prudencial puede resultar en una mejor alternativa.

Clasificación JEL: E32, E40, E47, E52.

Palabras claves: *burbujas en precios de la vivienda, reglas de tasas de interés, política monetaria, inflación objetivo,*

House Prices and Monetary Policy in Colombia

Martha López [*]

This paper investigates the possible responses of an inflation-targeting monetary policy in the face of asset price deviations from fundamental values. Focusing on the housing sector of the Colombian economy, we consider a general equilibrium model with frictions in credit market and bubbles in housing prices. We show that monetary policy is less efficient when it responds directly to asset price of housing than a policy that reacts only to deviations of expected inflation (CPI) from target. Some prudential regulation may provide a better outcome in terms of output and inflation variability.

JEL Classification: E32, E40, E47, E52.

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Keywords: house price bubbles, interest rate rules, monetary policy, inflation targeting.

I. INTRODUCTION

During the nineties, monetary authorities in many countries achieved a goal that was very elusive during the seventies and the eighties: to keep inflation in a low and stable level. However, this price stability has not came hand-in-hand with higher asset price stability. Countries such as Australia, the United Kingdom, Japan and the United States are facing cycles in asset prices even more pronounced than those they faced during the decades of high inflation (Borio *et al*., 2003). Asset prices, credit and investment booms, and bust, have become a more important source of macroeconomic instability in both developed and developing countries.

A high volatility in asset prices is worrisome because, when financial unbalances unwind, the real economy is exposed to a substantial economic downturn and, very frequently, to recession and possible deflation. Therefore, asset price cycles still remains an important challenge for monetary authorities.

Policy-makers should also be aware of the fact that bubbles in housing prices are more worrisome that those in equity prices, in part, because these tend to reflect domestic credit conditions, whereas equity prices tend to reflect global forces (Selody and Wilkins, 2004). Most industrial countries experienced sometimes violent boom and bust cycles in credit markets in the late 1980s and early 1990s (Hofmann, 2001). Similarly, Latin American countries experienced a boom and bust cycle in both, property prices and credit aggregates. There is clear evidence that in Latin American countries during the 1990s, asset prices booms contributed to an increased perception among individuals about positives changes in wealth and their creditworthiness that allowed agents to increase their indebtedness (Herrera and Perry, 2003).

Likewise, housing prices are more likely to end in a bust and to be costly. For example, Helbling and Terrones (2003) find that only 25% of the equity-price booms in the past 30 years ended in busts, while around 50% of house price booms ended in bust. Housing price bubbles give home buyers a false sense of the real return they can expect on their investment, which can lead to speculative home buying and overinvestment in the real housing stock. This can lead to overinvestment in physical capital, overconsumption, and overextension of credit. The process reverses when the bubble bursts. The decline in housing prices results in a deterioration in balance sheets that constrains spending and investment. Given a lower value of collateral, the financial institutions are less willing to lend. This can cause decreased spending on investment, consumption and increased bankruptcies.

The main goal of this paper is to provide some elements in the debate about a direct response of monetary policy to asset prices based in the recent Colombian experience with the housing sector. The analysis is based on an extension of a structural dynamic general equilibrium model of financial accelerator for the housing sector developed by Aoki *et al*. (2004). The extension of the model consists in allowing the possibility of non-fundamental movements in housing prices (bubbles). The model is calibrated for the Colombian economy and then some simulation exercises are performed to establish the response of the main macroeconomic variables when monetary policy react to housing prices misalignments and when it does not.

The rest of the paper is organized as follows. Section II of the paper presents a brief overview of the debate on monetary policy and asset prices. A description of some stylized facts of the Colombian economy is presented in section III. Section IV presents the model used for simulations and some econometric evidence for Colombia. The results of the model-based simulations under alternative scenarios are presented in section V. Section VI concludes.

II. A BRIEF OVERVIEW OF THE DEBATE ON THE REACTION OF MONETARY POLICY TO ASSET PRICES

The developments addressed before and their consequence for macroeconomic stability have led economists and policymakers to wonder whether central banks should take greater account of asset price movements in making interest rate policy (Goodfriend, 2003).

Some work has been done in order to identify asset prices misalignments and certain consensus about some indicators that can be used to identify when a bubble is building up. However, economists have yet to reach a consensus about the use of monetary policy as the appropriate policy for fighting asset prices misalignments.

Some economists think that the Central Banks should have a monetary framework to allow for a pre-emptive tightening of policy to limit the build up of bubbles in financial markets, (Cecchetti, 2000; Borio *et al*., 2003; Filardo, 2001, among others). This strategy requires, however, that asset price bubbles and their effect on the economy be identified with some precision. Other economists sustain that the fickle nature of bubbles suggest that there is much potential for an activist policy-maker to get the timing wrong, thereby making matters worse (Bernanke and Gertler, 1999; Stockton, 2003; Goodfriend, 2003; Bordo and Jeanne, 2002, among others). This is so because speculative pressures could be too strong and expected returns too high. Therefore, attempts to restrain them could derail other, more expenditure-sensitive sectors, possibly causing the very recession that policy was designed to avert.

This lack of consensus among economist and policymakers is reflected in the reluctance of central banks to use their policy rate as an instrument lo lean against the growing bubbles. Some other factors reinforce this reluctance. First, given the likely effects of tightening, on output and earnings, the central bank may not be able to demonstrate convincingly that the action was necessary (Borio *et al*., 2003). Moreover, the decision to tighten when output growth is robust but inflation appears to remain in check would be difficult to justify to the public. Second, in practice, current techniques for identification of asset prices misalignments are not precise enough. Third, asset prices can mislead interest rate policy in practice. For example, as described by Goodfriend (2003), under a scenario of rising trend productivity, firms and households are induced to borrow against their improved future income prospects in order to spend some of the expected increase in future income currently. Initially, aggregate demand may increase at a higher pace than current potential output but inflation pressures may take time to build up. Eventually, trend productivity growth will stop rising and firms profits will grow slowly. However, by that time inflation may start rising. Labor markets will be tighter and firms will find it harder to finance wage growth out of productivity. At that moment, the central bank may have to raise short term interest rates to keep inflation under control, even if equity prices fall.

Therefore, given the uncertainties involved, policy-makers generally show a preference to respond to the financial imbalances fairly gradually as illustrated by the experience in Japan and the United States, and to use prudential regulation as an additional instrument that could help to contain the financial excesses. During the upswing of the boom supervisors could induce the lenders to limit their exposures.

III. FINANCIAL MARKETS AND CYCLICAL FLUCTUATIONS IN THE COLOMBIAN ECONOMY

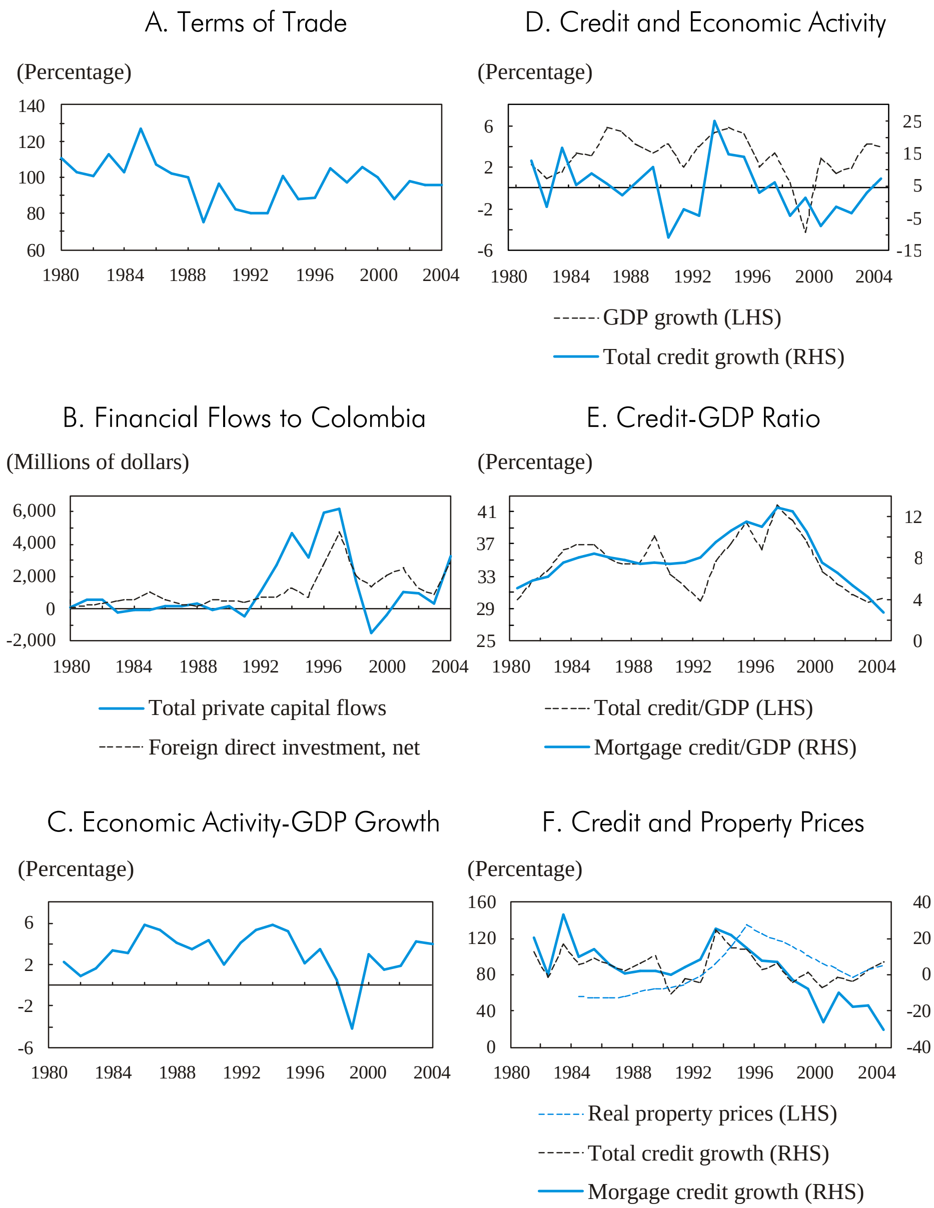
The most important stylized facts about the relationship between financial variables and economic fluctuations in Colombia are also common to different economies:

The first factor has to do with growing financial liberalization around the world. Countries of the G-7 began a move towards financial liberalization in the mid-1970s. Developing countries, among them Colombia, started their financial liberalization during the late 1980s. The greater financial market integration fostered an acceleration of cross-border financial flows. The Colombian business cycle was mainly determined by changes in the prices of coffee and, in general, by the terms of trade during the 1980s (graphs 1.A and 1.B). In contrast, financial capital inflows were highly correlated with the business cycle during the 1990s and 2000s (Graph 1.A).

The second stylized fact has to do with credit markets. Since the 1970s many countries have experienced two mayor output cycles that typically coexisted with similar fluctuations in credit. This correlation is also observed in the Colombian business cycle (Graph 1.D). Graph 1.E shows that over the period 1980-2005 private sector credit was characterized by pronounced cycles. Most industrial countries experienced violent boom and bust cycles in credit markets in the late 1980s and early 1990s. Colombia experienced a boom and bust cycle in the mid 1980s and another boom in the mid 1990s. The severity of the bust in the late 1990s was stronger that in the late 1980s. Likewise, the boom and bust cycle of mortgage credit was more severe in the 1990s than in the eighties (Graph 1.E).

The third fact is related to the wealth effects of changes in property prices over household indebtedness and over the business cycle. Several studies show that there is a close correlation between developments in credit markets and property prices. In Graph 1.F we show this correlation for the Colombian data. The positive correlation between credit and property prices can be explained from both a credit demand and a credit supply perspective. Real asset prices depend on the discounted future stream of real dividend payments. Higher liquidity may have an indirect effect on asset valuations by lowering interest rates and the discount factor or by indicating brighter economic conditions and prospects and thus higher expected dividend payments. But it may also be that additionally available liquidity simply increases the demand for a fixed supply of property, driving up real property prices (Hofmann, 2001).

Graph 1



Source: A. Banco de la República. B. Banco de la República. C. Departamento Administrativo Nacional de Estadística (DANE). D. Banco de la República. E. Banco de la República and Corporación de Ahorro y Vivienda (ICAV). F. Banco de la República, ICAV, Departamento Nacional de Planeación (DNP) and Carrasquilla (1994).

Finally, changes in asset prices «accelerate» the business cycle through a wealth effect. The correlations between housing prices and some aggregate variables in Colombia are presented in Table 1. Even though these correlations are lower than correlations observed in industrialized countries, their magnitude are not small. As expected, the higher correlations are between housing prices, housing investment and durable consumption.

The importance of changes in housing prices in the Colombian economy has to do with the fact that more than half of household assets are invested in housing. Table 2 reports the composition of household assets in the G-7 countries and Colombia. The figures reveal that housing assets represent a higher share of total household assets in Colombia than in developed countries. In contrast, the equity market is very small. Thus changes in property prices have a more considerable impact on private sector wealth than changes in stock prices.

In the next section we model the transmission mechanism between changes in housing prices and the business cycles for an economy like the Colombian, and we analyze the effects of different responses of monetary policy to bubbles in housing prices.

Table 1

Correlations of House Prices with Aggregate Variables

	House prices						
	***t*-3**	***t*-2**	***t*-1**	***t***	***t*+1**	***t*+2**	***t*+3**
Output	0.50	0.51	0.50	0.51	0.48	0.37	0.29
Investment housing	0.28	0.39	0.53	0.59	0.56	0.51	0.41
Total consumption	0.54	0.58	0.45	0.33	0.24	0.15	0.10
Durable consumption	0.30	0.42	0.51	0.60	0.49	0.38	0.35
Non-durable consumption	0.56	0.58	0.43	0.28	0.18	0.09	0.03

Deviations of trend. Sample period: 1987 I-Qtr.-2000 IV-Qtr.

Table 2
Composition of Household Assets (in percentages)

	Housing assets	Equity	Other financial assets	Other tangible assets
United States	21	20	50	8
Japan	10	3	44	43
Germany	32	3	35	30
France	40	3	47	9
Italy	31	17	39	13
United Kingdom	34	12	47	7
Canada	21	17	39	23
Colombia	64	1	35	n.a

n.a. Not available
Source: OECD Economic Outlook, 68, December 2000, Table VI.1, and Banco de la República for colombian data.

IV. HOUSES PRICES AND MONETARY POLICY IN A MODEL FOR THE COLOMBIAN ECONOMY

In this section we describe, intuitively, the model used in the simulations that compares the performance of alternative monetary rules in the presence of housing prices misalignments from fundamentals. The model that explains the correlations between housing prices, investment and consumption was developed by Aoki, Proudman and Vlieghe (2004), henceforth APV. The APV model describes the transmission mechanism that allows financial frictions in the credit markets to have an important impact on consumption and housing investment. We extend the APV model based on Bernanke and Gertler (1999) to allow for the possibility of exogenous bubbles in housing prices.

This section is divided in three parts: in part *A* we describe the main characteristics of the APV model; in part *B* we extend the model explaining how exogenous house price bubbles are introduced to the model, and in part *C* we present some econometric evidence that the model can be applied to the Colombian economy.

A. THE APV MODEL

The central hypothesis of the model is that house prices play a role because housing is used as collateral to reduce agency costs associated with borrowing to finance housing investment and consumption. In the model, households are exposed to idiosyncratic risk of fluctuations in their house prices and personal bankruptcy is associated with significant monitoring costs faced by lenders. The costly state verification problem induces lenders to charge a premium over a risk-free interest rate to borrowers.

Fluctuations in housing prices play a large role in the determination of borrowing conditions of households. When net worth is lower, the probability of default is higher and therefore the external finance premium charged by lenders will also be higher leaving households with less scope to finance housing investment and consumption. When house prices fall, households that are moving to a new home have a smaller deposit available to buy their next home. Therefore the mortgage rates that they obtain from lenders are higher which leave them with less capacity to finance consumption. Moreover, given that interest rates on collateralized loans are lower than interest rates for unsecured credits, households use all the collateralized borrowing that they are allowed but all additional credit they need is obtained at a higher cost.

The presence of these credit-market frictions gives rise to a “financial accelerator mechanism” that affects housing investment dynamics. For example, a positive shock to economic activity causes a rise in housing demand, which leads to a rise in house prices and net worth. The external finance premium decreases which in turn leads to a further increase in housing investment and consumption. This general equilibrium feedback mechanism provides an additional source of amplification and propagation to underlying disturbances to the macroeconomy.

In the APV model, the main modeling issue is how to generate both consumers borrowing and lending within a general equilibrium framework without losing tractability. To model consumer behavior in a rather stylized way, each household is modeled as a composite of two behavioral types: homeowners and consumers. Homeowners decide on the investment in housing, borrow funds to purchase the houses and rent them to consumers. They finance the purchase of houses partly with their net worth and partly from funds provided by the financial system. The financial intermediaries charge a premium to the homeowners for the intermediated funds. Consumers, on the other hand, save, supply labor, consume goods and rent housing services from the homeowners. In order to capture the fact that households use part of their housing equity to finance consumption, consumers and homeowners are further linked by a 'transfer' that homeowners pay to consumers. Whenever house prices increases, households face a decision choice between increasing the transfer (current consumption) and a cheaper future finance premium to finance housing investment.

Another particular characteristic of the APV model is that it divides the consumers into two types. Some fraction of consumers has accumulated enough wealth, so their behavior is well described by the permanent income hypothesis (PIH) with consumption satisfying the standard Euler equation. This fraction of consumers saves and is able to smooth consumption. The other fraction of consumers might be impatient or might have borrowing constraints which makes them consume their current income in each period, in this sense they behave as consumers rule-of-thumb (ROT). Their sources of income in each period are their labor wages and the transfer that receive from homeowners. More specifically, ROT consumers are assumed to only borrow contingent on the value of their houses. This separation between consumers captures the fact that households with high liquid assets (PIH consumers) are less likely to extract home equity to finance consumption.

The rest of the model follows a standard New Keynesian model. The consumption goods sector presents nominal price stickiness so that monetary policy has real effects in the short run. Only fundamentals drive house prices which are determined by a q-theory of investment with a convex adjustment cost. Adjustment costs are included to permit a variable price of capital. Therefore, changes in fundamental price of houses will affect the balance sheets of households and their cost of borrowing. Thus, the financial accelerator serves to amplify only fundamental shocks. In this paper, the extension of the APV model allows that non-fundamental shock to houses prices affect the real economy.

B. ADDING EXOGENOUS HOUSE PRICE BUBBLES TO THE APV MODEL

This section follows closely the Bernanke and Gertler (1999) model. We add exogenous bubbles to the APV model as follows. Investment is related to the fundamental value of housing capital, Q_t. The fundamental value capital is the present value of dividends the capital is expected to generate.

(1) $$Q_t = E_t\{[D_{t+1} + (1 - d)Q_{t+1}]/R^Q_{t+1}\}$$

where d is the physical depreciation of capital, D_{t+1} are dividends, and R^Q_{t+1} is the relevant stochastic gross discount rate at t for dividends received in period $t + 1$.

However, observed house prices, S_t, may temporarily differ from fundamental values because of bubbles for example. A bubble exists whenever $S_t - Q_t \neq 0$. It is assumed that if a bubble exists at date t, it persists with probability p and grows as follows:

(2) $$S_{t+1} - Q_{t+1} = a/p(S_t - Q_t)R^Q_{t+1},$$

and $p < a < 1$. When a is close to one this bubble specification can be made arbitrarily close to a rational bubble[1]. Given that $a / p > 1$, the bubble will grow until such time when it bursts. The expected part of the bubble follows the process:

(3) $$E_t\ ((S_{t+1} - Q_{t+1})/R^Q_{t+1}) = a(S_t - Q_t)$$

Because the parameter is restricted to be less than unity, the discounted value of the bubble converges to zero over time.

It is possible to derive an expression for the evolution of the market price of houses inclusive of the bubble using the expressions (1) and (3):

(4) $$S_t = E_t\{[D_{t+1} + (1 - d)S_{t+1}]/R^S_{t+1}\}$$

where the return on housing stocks, R^S_{t+1}, is related to the fundamental return on capital, R^Q_{t+1}, by:

(5) $$R^S_{t+1} = R^Q_{t+1}[b + (1 - b)Q_t/S_t]$$

and $b \equiv a(1 - d)$

1 See Blanchard and Watson (1982); like in Bernanke and Gertler (1999), we assume $p = 0.5$ and $a = 0.98$.

When there is a positive bubble, $S_t > Q_t$ therefore the expected return on market price of housing will be bellow the fundamental return, $R^S_{t+1} < R^Q_{t+1}$.

A market price of housing higher than its fundamental value will affect real activity in two ways. First, the external finance premium is assumed to depend on the market value of housing. So whenever it is higher than the fundamental value, the financial conditions of homeowners improve and they will be able to obtain funds from financial institutions at a lower financial premium. Second, rule-of-thumb consumers will be able to finance more consumption because the value of their houses increases. Therefore, the main link between changes in housing prices and the real economy remains the financial accelerator.

The equations of the extended model used for simulations are presented in the appendix.

C. *EMPIRICAL EVIDENCE OF THE LINK BETWEEN REAL ACTIVITY AND FINANCIAL POSITION OF HOUSEHOLDS IN COLOMBIA*

In this sub-section we present some empirical evidence on how balance sheet conditions have important effects on the demand side of the Colombian economy. Remember that, in our general equilibrium framework, when house prices rise and balance sheets improve, the increased demand for housing induces an even further increase in prices. The rise in house prices causes improvements in financial conditions of households, which fuel further increases in consumption and housing investment.

Aggregate demand is a weighted average of the expenditures components, PIH consumption, ROT consumption and investment. Besides, the premium on external financing of investment is related to homeowners leverage ratio, and consumption of ROT consumers depends on household net worth. Therefore, it is possible to obtain an expression for a dynamic IS curve that depends on the real interest rate and the leverage ratio as follows[2]:

$$y_t - w_r c(n_t - s_t - h_t) \tag{6}$$

$$= E_t\,(y_{t+1} - w_r c(n_{t+1} - s_{t+1} - h_{t+1})) - (w_p - w_i) E_t r_{t+1} + w_i J(n_t - s_t - h_t) + t_t$$

2 For details see Gilchrist (2002).

or

$$(7) \qquad y_t = w_r c(n_t - s_t - h_t) - sE_t\left[\sum_{i=1}^{\infty} r_{t+i}\right] + w_i J E_t\left[\sum_{i=1}^{\infty}(n_{t+i} - s_{t+i} - h_{t+i})\right]$$

where y_t is the output gap; r_t is the real interest rate; n_t measures housing equity; s_t is the market price of housing; h_t is capital stock in housing; $(s_t + h_t)$ represent housing expenditures, therefore $(s_t + h_t - n_t)$ measures leverage; w_r, w_p, w_i are the corresponding weights of rule of thumb consumption, permanent income consumption, and investment; c is the elasticity of rule-of-thumb consumers to their leverage ratio; J is the elasticity of external finance premium with respect to leverage, and s is the elasticity of aggregate demand to real interest rate, and t_t is an aggregate demand shock.

The first term on the right-hand side of equation (6) implies that aggregate demand depends on current balance-sheet conditions owing to rule-of-thumb consumers (Gilchrist, 2002). The last term implies that aggregate demand also depends on future balance-sheet conditions owing to the forward-looking nature of housing investment decisions.

Estimation proceeds by substituting actual for expected values in (6) and taking into account some level persistence in the aggregate demand. Under rational expectations, the actual values represent the appropriate expectations up to an additive and orthogonal expectation error (McCallum, 1979), and thus (6) yields the following:

$$(8) \qquad y_t = w_r c((n_t - s_t - h_t) - (n_{t+1} - s_{t+1} - h_{t+1})) - s.r_{t+1} + w_i J(n_t - s_t - h_t) + h_1 y_{t+1}$$
$$+ h_2 y_{t-1} + u_t$$

where the error term is a combination of aggregate demand shocks and expectation errors. Because u_t is correlated with the regressors, instrumental variables are needed to ensure consistency. We used the Generalized Method of Moments for the estimation. The set of parameters to be estimated is $W = (s, c, J, h_1, h_2)$. The vector of instruments used to conform the orthogonality conditions is $\{1, y_{t-2}, y_{t-3}, (r_t^s - r_t), (r_{t-1}^s - r_{t-1}), r_t, r_{t-1}, s_t, s_{t-1}\}$. Real market price of houses, s_t, are house price index deflated by the consumer price index (Carrasquilla *et al*., 1994); leverage ratio is calculated based on information published by Greco (2002) and the stock on mortgage loans from ICAV; $r_t^s - r_t$

is the premium between the mortgage rate and the interest rate on CDTs. The sample period is 1990:1 through 2000:4.

The estimations results are reported in Table 3. All parameter estimates have the expected signe and are significant. The Hansen (1982) statistic for testing the validity of the over-identifying restrictions implied by the model, J-statistic, does not allow the rejection of the null hypothesis that the model is correctly specified at a five percent significance level. The first and second row in the table corresponds to the forward and the backward looking coefficients of aggregate demand, respectively. The estimate of the elasticity of aggregate demand to real interest rate, s, is in line with estimations in other studies[3]. The elasticity of consumption to the balance sheet of households, c, is near one and significant. This elasticity seems low with respect to estimates in countries such as United Kingdom but it is reasonable given the poor level of financial instruments in Colombia. The elasticity of the external finance premium to the financial conditions

Table 3
Dynamic aggregate demand equation
and balance sheet effects

Parameter	Coefficient	*t*-statistic	*P*-value
h_1	0.285	5.319	0.000
h_2	0.738	11.821	0.000
c	0.930	3.117	0.004
s	-0.066	-3.767	0.001
J	0.814	2.527	0.016
$J(T)$ =	2.053		

Sample adjusted 1990:4 2000:4
Newey-West HAC Standard Errors & Covariance
Bandwidth: Fixed (4.5)
Kernel: Quadratic Spectral
Adjusted R-squared 0.7042
$J(T)$ (5% sig.) = 5.762.

3 See for example Gómez et al (2002).

of households is near one and significant, which is evidence of the importance of the financial accelerator mechanism in the real economy.

V. MODEL SIMULATIONS AND OUTPUT AND INFLATION VARIABILITY

A. ASSET BUBBLES WITH AND WITHOUT DIRECT RESPONSE OF MONETARY POLICY TO ASSET PRICES

In this section we use the model described in section IV in order to asses the effects of a housing bubble when monetary policy does not respond directly to housing prices and when monetary policy responds directly to housing prices. We perform two alternative analysis. First, we describe the transmission mechanisms of monetary policy and the results on some macroeconomic variables of the model based on simulations under two alternative policy rules. Second, we compute the unconditional variances of output and inflation under four alternative policy rules. The complete model used for simulations and its calibration for the Colombian economy is presented in the Appendix.

In the first exercise, we compare the impulse responses of output, inflation rate, housing investment, house prices and net worth under two alternative monetary policy rules: one policy rule react only to inflation rate and the other policy rule responds to both inflation rate and housing prices. The policy rule used for the simulations of the model when monetary policy responds only to the inflation rate is:

$$R_t^n = r_R R_{t-1}^n + (1 - r_R) r_p \hat{p}_{t+1} + e_{R,t} \tag{9}$$

The alternative policy rule used in the simulations is a rule where monetary policy reacts directly to market house prices besides responding to inflation rate:

$$R_t^n = r_R R_{t-1}^n + r_p \hat{p}_{t+1} + r_s S_{t-1} + e_{R,t} \tag{10}$$

were R_t^n is the nominal interest policy rate, p_t is the inflation rate, and S_t is the market price of housing.

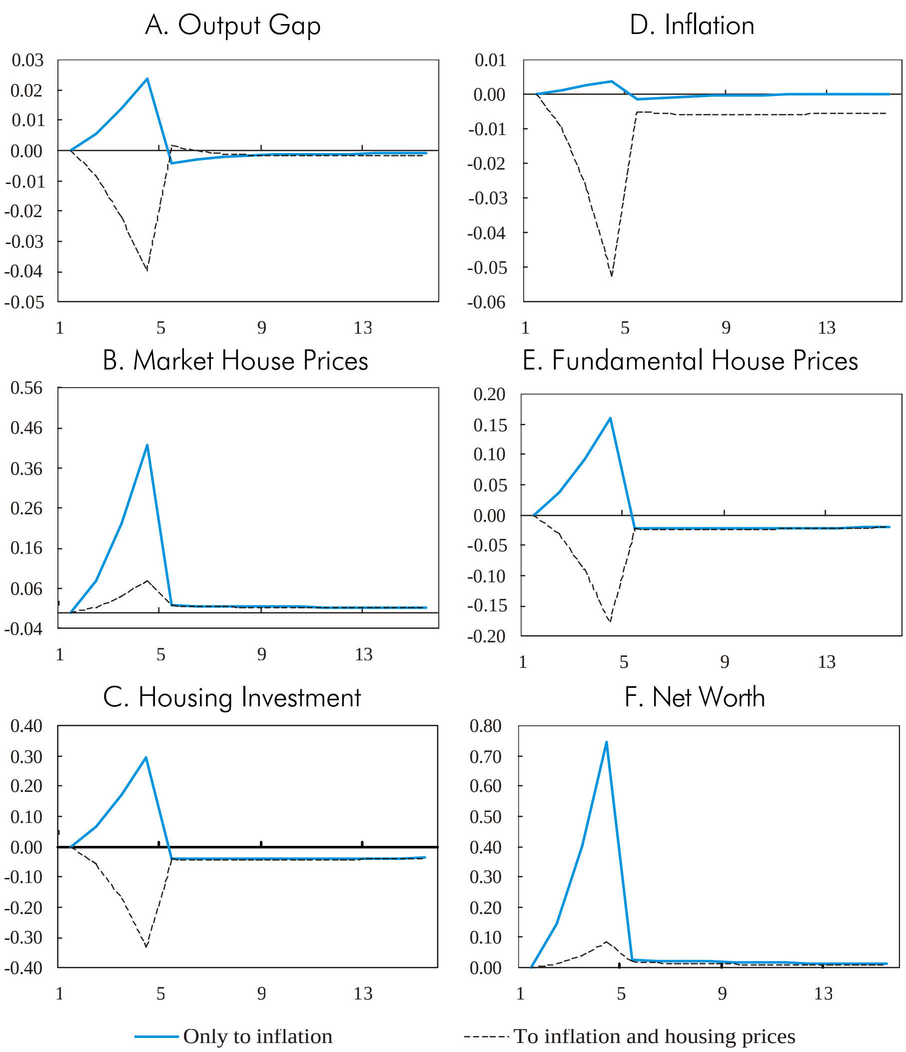
Notice that these rules are simple Inflation Forecast Based rules, IFB. The literature on simple policy rules has pointed out the advantages of using such rules compared to optimal policy rules. Optimal policy rules are the most efficient rules in terms of minimizing the long run output and inflation volatility (Svensson and Rudebush, 1998). However, optimal-contingent rules respond to current and lagged values of all the state variables in the model. Specifically, they may respond not only to deviation of inflation from target, but also to the output gap, foreign inflation rate, real exchange rate, and so on (Dennis, 2000). Therefore, given their complexity, optimal policy rules may be very impractical to implement. Simple policy rules, on the other hand, have several advantages: they are much easier to implement; it is easy for private agents to understand policy and they can verify the central bank behavior. Among simple policy rules, IFB rules are more efficient than other simple rules that respond to a few set of variables. Because IFB rules respond to a model-consistent inflation forecast, they respond to a wide array of macroeconomic variables, which make them very efficient (Haldane and Batini, 1998).

For the first set of simulations, we set the values of $r_R = 0.9$, $r_p = 0.25$ and $r_s = 0.1$. Graph 2 shows the effect of a housing price bubble when monetary policy reacts only to inflation rate and when monetary policy reacts to both inflation and housing prices. When monetary policy reacts only to inflation rate, the bubble in housing market translates into an increase in output, inflation, housing investment, consumption and net worth, leading the economy to "overheat". Initially, the fundamental price of houses increases because the public knows that monetary authorities will not react to the bubble, so the present value of the dividends the capital is expected to generate is high. Investment responds to fundamentals so it increases. The rise in market price of housing stimulates spending and output further both through the balance sheet effects given that the external finance premium decreases significantly, and through the wealth effect on consumption. Given that inflation rate has increased, the policy interest rate increases. When the bubble bursts, financial conditions of the firms deteriorate which is reflected in a strong increase in external finance premium and lower investment and output.

If monetary policy reacts directly to housing prices, it may cause the very recession in output that it was intended to prevent. The mechanism is the following. As in the previous case, investment depends on the fundamental value of house prices. Given that the public now knows that the central bank will rise interest rates as a reaction to the bubble, the present value of the dividends the capital is expected to generate falls causing the fundamental price of housing to fall even though its market price is positive due to the bubble. Investment decisions depend on fundamentals and the financial conditions of firms. The decline in fundamental

Graph 2

Response to a housing bubble: with and without direct monetary policy reaction to housing prices



The chart shows simulated reponses of selected variable to a positive innovation to the bubble process in period zero equal to one percent of the steady-state fundamental price. The solid lines show reponses when monetary policy target only expected inflation $\hat{R}_t^n = 0.9\ \hat{R}_{t-1}^n + 0.25\hat{p}_{t+1}$. The dashed lines show responses when monetary policy reacts to the both expected inflation and housing prices $\hat{R}_t^n = 0.9\ \hat{R}_{t-1}^n + 0.25\hat{p}_{t+1} + 0.1S_{t-1}$.

values more than offset the stimulating effect of the bubble causing recession and deflation.

As a complement of the previous analysis, we compute the unconditional variance of output and inflation under four different monetary policy rules. The results are reported in Table 4. As we can see, the policy rule that reacts strongly and only to inflation rate is the most efficient among the rules considered. Output and inflation variability are significantly higher whenever central bank reacts to house prices.

B. *ASSET BUBBLE THEN ASSET BUST*

As described in section III, some bubbles are more probable to end in a bust. Here we contemplate such scenario. In order to model this situation in a simple way we proceed as Bernanke and Gertler (1999) by assuming that the crash of the bubble sets off a negative bubble in housing prices (undervaluation) that is exactly symmetric with the positive bubble that preceded it.

Graph 3 shows simulation results under accommodative ($r_p = 0.25$) and aggressive ($r_p = 1.3$) policy rules, and assuming no direct response of policy to housing prices ($r_S = 0.0$). As expected, output responds with an initial boom followed by a recession under both policy rules. However, a monetary policy rule that targets inflation rate more aggressively is able to stabilize output and inflation by reducing their volatility.

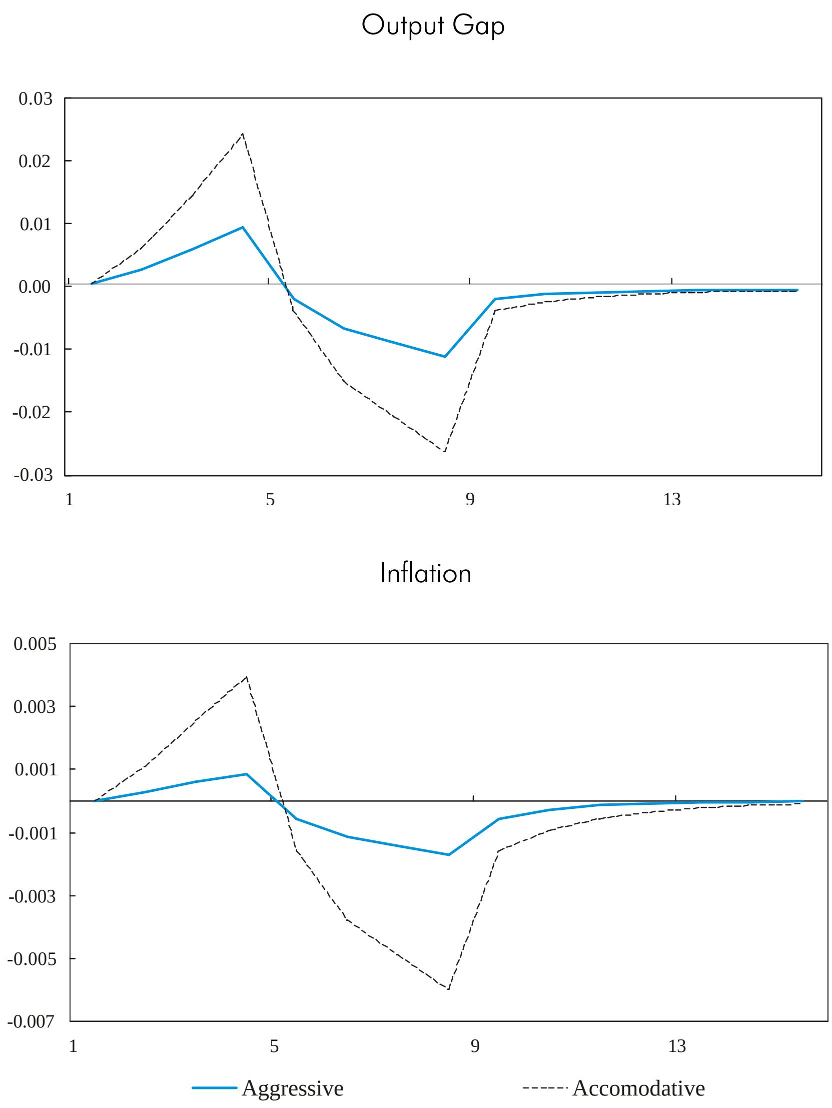
Table 4

Output and Inflation Variability under Alternative Policy Rules

	Bubble shock	
	Output gap	**Inflation**
$R_t^n = 0.9\, R_{t-1}^n + 0.25\hat{p}_{t+1}$	0.27	1.00
$R_t^n = 0.9\, R_{t-1}^n + 1.25\hat{p}_{t+1}$	0.23	0.89
$R_t^n = 0.9\, R_{t-1}^n + 0.25\hat{p}_{t+1} + 0.1S_{t-1}$	8.48	11.11
$R_t^n = 0.9\, R_{t-1}^n + 1.25\hat{p}_{t+1} + 0.1S_{t-1}$	2.52	3.07

Graph 3

Effects of an Asset Boom Followed by an Asset Bust



Same exercise as in Graph 2 except that the positive bubble shock is followed by a symmetric negative bubble shock that last from period 6 through 9. Monetary policy responds only to expected inflation.

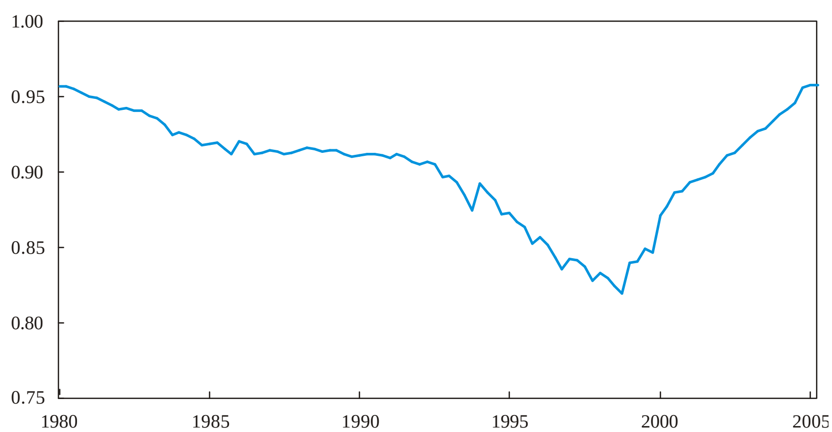
C. THE EFFECT OF LEVERAGE ON THE RESPONSES TO ASSET PRICE

In an effort by the government to alleviate the social and economic problems originated during the nineties, the Colombian government introduced a new Law of Housing (Law 546 from 1999). Some of the modifications that the Law introduced to confront the finance housing sector crisis were for example that the interest could not be capitalized, that debtors would be allowed total or partial pre-payments to the stock of debt on housing without penalties and that banks should request a higher deposit on loans to finance housing, among others. On the other hand, given the severity of the crisis in the housing sector, households seem to be more averse to engage in very high debts to finance purchases of their houses. All this has resulted in important changes in the quality of the balance sheet of households. The ratio net worth to capital has returned to the levels that it presented before the nineties (Graph 4).

In our model, this effect can be captured by evaluating the effects of a bubble in the housing sector under alternative levels of steady-state leverage ratio. Graph 5

Graph 4

Ratio Net Worth/Housing Capital Stock

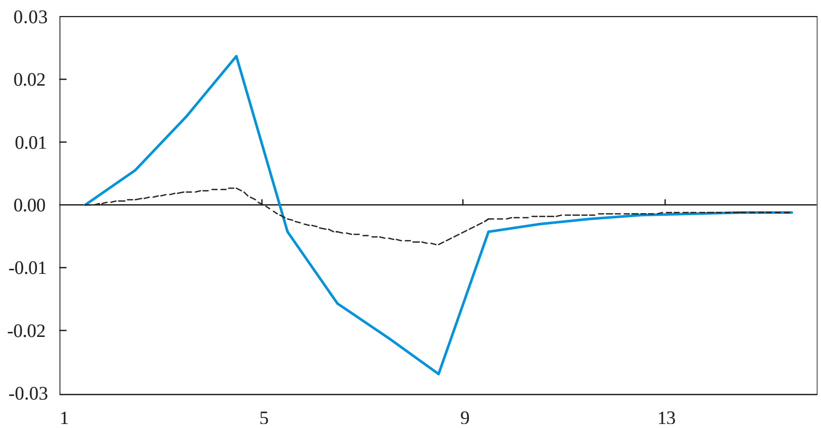


Source: author´s calculations, based on Greco (2002), DNP, and Superintendencia Bancaria.

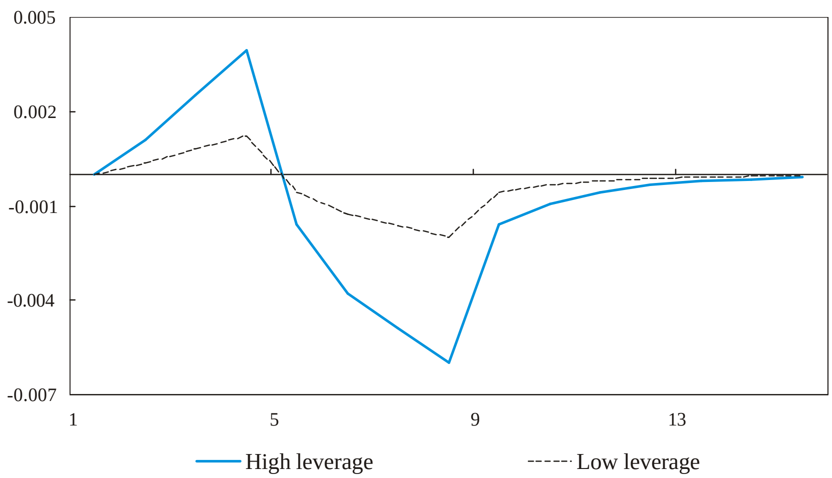
Graph 5

The Effects of Leverage on Responses to a House Prices Boom and Bust

Output gap



Inflation



Same excercise as in Graph 3, comparison of high steady-state leverage (net worth-capital of 0.65, as in the base line simulations) and low steady-state leverage (net worth-capital ratio of 0.7). Monetary policy is assumed to be accomodative and it reacts only to expected inflation.

shows that the reduction in steady-state leverage (from 0.7 to 0.6) significantly moderates the business cycle. Therefore, prudential regulation may have an important role to prevent very strong economic cycles.

VI. FINAL REMARKS

Asset prices bubbles and housing prices bubbles remain as some of the most important challenges of monetary policy. Even though many inflation targeting countries have been able to stabilize inflation in low levels during the last decade, the possibility of asset prices bubbles emerges as a threat to economic and financial stability. In this paper we have shown that inflation targeting provides an effective framework for achieving macroeconomic stability. As in Bernanke and Gertler (1999) model, given a strong commitment to stabilizing expected inflation, it is not desirable for monetary policy to respond to changes in housing prices. Monetary policy may contribute to moderate the business cycle when it reacts aggressively to inflation; this, somehow, guarantee that monetary policy will not over-react (for example in the face of an asset price bubble) causing a recession in the economic activity. Moreover, a combination of monetary policy and prudential regulation may be used to encourage mechanisms that may help to contain inflated speculations in asset prices and to send signals to the markets about potential vulnerabilities.

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APPENDIX

MODEL EQUATIONS USED IN SIMULATIONS

In this appendix we present the functional form of the first order conditions and other equations used in the simulations of the model. We refer the readers to Aoki *et al*. (2004) for the complete description of the main characteristics and assumptions of the model. The model has been expanded to introduce deviations of asset prices from fundamentals as in Bernanke and Gertler (1999).

PREFERENCES

(1) $$\ln C_t^i + \partial \ln(M_t^i/P_t) + x\ln(1 - L_t^i)$$

(2) $$C_t^i = \left[g^{1/h}(c_t^i)^{(h-1)/h} + (1 - g)^{1/h}\,(h_t^i)^{(h-1)/h}\right]^{h/(h-1)}$$

(3) $$c_t^i(z) = (p_t(z)/P_{c,t})^{-e}c_t^i$$

AGGREGATE DEMAND

(4) $$Y_t = c_t + I_t + G_t$$

(5) $$(1/C_t^p) = bE_t(1/C_{t+1}^p)R_{t+1}$$

(6) $$C_t^R = W_t L_t^R + \tilde{O}_t$$

(7) $$\tilde{O}_t = c(N_{t+1}/q_t h_{t+1});\ c` > 0$$

(8) $$C_t = nC_t^p + (1 - n)C_t^R$$

(9) $$c_t = g\,(P_{c,t}/P_t)^{-h}C_t$$

(10) $$h_t = (1 - g)(P_{h,t}/P_t)^{-h}C_t^i$$

(11) $$P_t = \left[gP_{c,t}^{1-h} + (1 - g)P_{h,t}^{1-h}\right]^{1/(1-h)}$$

(12) $q_t = F`(I_t/h_t)P_{c,t}/P_t\,;\; q_t = Q_t/P_t$

(13) $E_t((s_{t+1} - q_{t+1})/R^q_{t+1}) = a(s_t - q_t)$

(14) $E_t[R^q_{t+1}] = [(P_{h,t+1}/P_t) + (1 - d)q_{t+1}]/q_t$

(15) $E_t[R^S_{t+1}] = [(P_{h,t+1}/P_t) + (1 - d)s_{t+1}]/s_t$

(16) $R^S_{t+1} = R^q_{t+1}[b + (1 - b)q_t/s_t]$

(17) $E_t[R^S_{t+1}] = W\,(N_{t+1}/s_t\,h_{t+1})R_{t+1} \qquad W`_t < 0$

AGGREGATE SUPPLY

(18) $y_t(z) = A_t\bar{K}^a L_t(z)^{(1-a)}$

(19) $W_t = x\,C_t/(1 - L_t)$

(20) $0 = E_t\sum_{s=t}^{\infty}(qb)^{s-t}\,l_s\left[(P_{c,t+k}/P_{t+k})(p_t(z)/P_{t+k})^{-e}\,Y_{t+k}\{(p_t(z)/P_{c,t+k}) - (e/(e - 1))mc_{t+k}\}\right]$

(21) $\hat{p}_{c,t} = k_1\hat{mc}_t + bE_t\hat{p}_{c,t+1}$

(22) $mc_t = (W_{t+k}/P_{c,t+k})(y_{t+k}(z)/A_{t+k})^{1/(1-a)}$

EVOLUTION OF STATE VARIABLES

(23) $N_{t+1} = (R^q_t q_{t-1}h_t - W\,(N_t/s_{t-1}h_t)R_t d_{t-1}) - \tilde{O}_t$

(24) $h_{t+1} = dI_t\,(1 - d)h_t$

SHOCK PROCESSES AND MONETARY POLICY RULE

(25) $\hat{R}^n_t = p_R\hat{R}^n_{t-1} + r_p\hat{p}_t + e_{R,t}$

(26) $R_{t+1} = R_{t+1} + E_t p_{t+1}$

(27) $\widehat{G}_t = p_G \widehat{G}_{t-1} + e_{G,t}$

(28) $\widehat{A}_t = p_A \widehat{A}_{t-1} + e_{A,t}$

The expectations given information known as of period of the value of variable X_t are written $E_s X_t$. Equation (1) is the period-utility function of household *i*. Equation (2) denotes a CES consumption aggregator between consumption goods c_t^i and housing services h_t^i. (3) is the demand for each of the consumption good.

Equation (4) is the economy resource constraint. (5) is the usual Euler condition for consumers of the type PIH. (6) and (7) describes the (composite) consumption of the ROT consumers. These equations embodies the assumption that ROT consumption depends on labor income $W_t L_t$ and the ratio of net worth to market value of capital (leverage), $(N_t / s_t\ h_t)$. The composite aggregate consumption is given by (8), where *n* is the fraction of consumers PIH in the economy. (9) and (10) are the demands for each of the consumption goods and housing services, respectively. Equation (11) is the composite price index.

Equations (12)-(17) characterize housing investment demand including the bubble. (12) relates investment, I_t to the fundamental value of capital, q_t, with one period delay for planning investment. Equation (13) describes the expected evolution of the bubble. Equation (14) defines the fundamental return to capital as the sum of the current return to capital and the increase in fundamental value. Similarly, (15) describes the returns on market value of capital. (16) illustrate the relationship between the market return and the fundamental return, which depends on the bubble. Equation (17) is the financial accelerator equation which links the spread between safe returns and stock returns to household leverage.

Equation (18) is a Cobb-Douglas production function for the producers of consumption goods. (19) is the first order condition for labor in the household intertemporal optimization problem. (20) reflects the assumption that prices of consumption goods are sticky. More specifically it is the first order condition for optimal pricing of the seller indexed (*z*). (21) is a Phillips curve that can be derived from (20) using the Calvo (1983) staggered price setting. Equation (22) is the real marginal cost of the firm in terms of the consumption goods.

Equations (23) and (24) are transition equations for the two state variables, capital and net worth. (23) denotes the evolution of the Net worth of households. The first term is the ex-post return housing times the housing investment, the second term is the ex-post cost of debt and the third one are the transfers that homeowners give to ROT consumers. Equation (24) denotes the evolution of capital stock in housing. (25) is the monetary policy rule; the short-term nominal interest rate is the instrument of monetary policy. Equation (26) is the real interest rate. Finally, equations (27) and (28) impose that the exogenous disturbances to government spending and technology obey stationary autoregressive processes.

Parameter values used in the simulations were calibrated for the Colombian economy based on López (2004). A summary is presented in Table A.1.

Table A.1

Parameters

b	Discount factor	**0.980**	M. López (2001)
$\boldsymbol{r}$	Steady state real interest rate	**4.120**	M. López (2001)
g	Share of consumption goods in aggregate consumption	**0.670**	Average data from the 1980-1990s.
h	Elastisity of substitution between housing and consumption goods	**1.000**	Calibrated
x	Inverse elasticity of labor supply	**0.330**	Literature
$\boldsymbol{n}$	Portion of rule of thumb consumers	**0.400**	A. López (1994)
a	Share of capital in production function	**0.350**	Greco (2003, Ch 3)
d	Depreciation of housing	**0.025**	Greco (2003, Ch 3)
y	elasticity of fundamental price of capital w.r.t. *Investment / Capital ratio*	**0.550**	Chirinko (1993)
q	Probability of not adjusting price	**0.800**	J. Bejarano (2003) (five quarters)
$(\hat{R}_h, - \hat{R})$	Steady state premium (annual)	**4.000**	Data from the 1990s.
f	Steady state leverage ratio	**0.700**	According to new regulation
r_R	Interest rate smoothing	**0.750**	R. Bernal (2002)
G/Y	Government spending/Output ratio	**0.200**	Data from the 1990s.
$\boldsymbol{v}$	Elasticity of premium with respect to leverage ratio	**0.600**	Calibrated-Based on estimation
S	Speed of adjustment in dividend rule	**3.000**	Calibrated-Based on estimation