The Role of Construction in the Housing Boom and Bust in Spain*

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Abstract

This paper describes a quantitative model developed to account for the change in the level of house prices (boom-and-bust cycle) in Spain. The driving forces behind the housing boom are residential investment, immigration, current account deficits, and the elimination of land regulation. The model emphasizes the interaction of housing supply (determined by the existing stock of residential investment and new construction) with market demand. A calibrated version of the model for the Spanish economy replicates the key aggregate of the economy in 1995. The model predicts that a change in observed fundamentals can rationalize at least 84 percent of the recent boom in the value of housing capital. The model suggests that without large current account deficits and demographic changes the housing boom could have been much smaller. With respect to the housing bust, the model suggests that the combination of increasing mortgage rates, unemployment, and low productivity can have large effects in the value of housing capital. Some conservative predictions quantify adjustments that range between 24 and 29 percent.

Keywords: Residential investment, mortgages rates, immigration

J.E.L. codes: E2, E6

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1. Introduction

In the past two decades, there have been important movements in real estate values and aggregate economic activities in many developed economies. These booms are characterized not only by a rapid increase in house prices, but also by an expansion in the proportion of households who own the house they occupy. The magnitude of these changes is significant. As Table 1 suggests, most countries in the Organisation for Economic Co-operation and Development (OECD) also had double-digit house price appreciation over an extended period. House prices in Spain have shown one of the biggest cumulative growth rates among the OECD countries over the past five years and, indeed, over a more extended period. The increases in house prices have been combined with simultaneous increases in home ownership. In some countries like Spain, Greece, Italy, France, and Sweden the expansion exceeds 800 basis points.

Table 1: House Prices and Ownership Rates in the OECD

	House Prices	**Home Ownership (%)**		
Rank Country	**%△ 1997-2007**	**1996**	**2003**	**Difference**
Spain	13.9	76	85.3	9.3
Greece		70	83.6	13.6
Italy	6.3	67	75.5	8.5
Belgium	9.9	65	72.9	7.9
Luxembourg	NA	66	70.8	4.8
United Kingdom	15.2	67	70.6	3.6
United States	13.3	65	68	3.0
Denmark	9.0	50	65.0	15
France	10.6	54	62.7	8.7
Sweden	9.7	43	59.9	16.9

Data source for ownership: UNECE Environment and Human Settlements Division, Housing database, 2003

Data source for nominal house price appreciation: "Checking the Engine," Economist, June 7, 2007

These recent movements in housing prices have raised many concerns. To what extent are these housing price fluctuations consistent with fundamental conditions? In countries like the United States, part of the boom was fostered by important developments in housing finance that include the introduction of new mortgage products, a reduction in the cost of providing mortgage services, and expansion of subprime lending and private securization. For example, instruments such as piggyback loans and option-adjustable rate mortgages (ARM)

accounted for 12.5 percent of the originations in 2004 and 32.1 percent in 2006. Chambers, Garriga, and Schlagenhauf (2009a, 2009b) use a quantitative model to explore the impact of innovation in housing finance and changes in the demographic structure in the U.S. housing boom. Their findings suggest that these innovations account for roughly two-thirds of the boom in home ownership, whereas demographics account for the remaining one-third. More recently, Bernanke (2010) has discussed the same issues arguing, for the similar importance of mortgage innovations.

In Spain, the driving factors could be somewhat different. Over the past decade, the Spanish economy has experienced by important structural changes. Some of these changes could have made an important contribution to the housing boom. First, the Spanish economy seen major demographic changes. The total population increased roughly 18 percent, and the workforce population increased 25 percent. Most of the growth (98 percent) was due to immigration flows from Eastern Europe, Latin America, and North Africa. Second, the integration into the European Monetary Union was a key factor in lowering the cost of borrowing. In real estate markets, mortgage rates in Spain sharply declined during this period (i.e. nominal mortgage rates were 12 percent in 1995, 3.5 percent in 2005, and 5 percent in 2007). The decline in mortgage rates was fueled by a sizable current account deficit that increased from 0 to 10 percent. This deficit has allowed finance consumption and borrowing without relying on domestic savings. Martínez-Pagés and Maza (2003) find that income and nominal interest rates are pivotal explanatory factors. Another important factor has been the liberalization of constructible land. In 2003, the government voted a to liberalize the real estate sector. The result was a 28 percent increase in the availability of land for construction.

The housing boom could also have been caused by other non-fundamental factors, such as speculators driven by the high yields in the sector, changes in family size, or home purchases by retired households from Northern Europe and the United Kingdom. Although all these factors could be relevant, the focus of this paper is restricted to the role played by the fundamental factors.

The paper's main objective is the development of a quantitative theory that accounts for the change in the level of house prices between 1995 and 2007 in Spain. Some necessary elements need to be formalized to understand the large increase in house prices in Spain. The paper argues that a key element is the evolution of the price of land and its contribution to the value of housing capital. Despite the land deregulation of the sector, most of the increase in the value of housing capital can be attributed to the price of land. This is a key driving force in the modeling strategy. With such a framework, it is also possible to (1) determine the relative importance of the different contributing factors and (2) perform some counterfactual

exercises to determine the magnitude of the housing boom and residential investment had these factors been different. In addition, the model can be used to predict future changes in the levels of house prices when the economy is subject to changes in the same fundamental variables (i.e., higher mortgage rates, declines in employment, and lower productivity). The formal economy considers two productive sectors. One sector produces consumption goods and the other produces residential investment. Housing services are generated by combining structures and land. The quantitative version of the model considers a small open economy to accommodate capital flows. Appendix 8.2, shows some model extensions that consider the introduction of housing policy.[1]

The baseline model can rationalize 84 percent of the increase in the real value of the housing stock and 82 percent of the increase in the real value of land as a response to the change in fundamentals (demographics, liberalization of land use, and lower interest rates). In a decomposition exercise, the contribution of each factor with respect to 1995 values assigns roughly 33 percent to immigration and low rate, respectively, and 7 percent to the elimination of land regulations. However, a single-factor decomposition analysis ignores the interaction of the combined effects essential to understanding the housing boom. For example, the model suggests that the combined effects of low mortgage rate and demographics are larger than the sum of the separate effects. These results are consistent with Gonzalez and Ortega's (2009) empirical estimates. They find that immigration can account for roughly one-third of the housing boom, both in terms of prices and new construction.

The model also is used to perform some counterfactual experiments. The model predicts that a decline in mortgage rates from 9 percent to 6 percent should have generated a housing boom that is 20 percent smaller with respect to fundamentals and 32 percent with respect to the actual data. This experiment suggests that the current account deficits supporting the mortgage rate decline had an important contribution in the housing boom. Without such a flow of funds, the magnitude of the house price increase would have been much smaller.

Most experts seem to agree that house prices in Spain will need to adjust downward to align with income. The model can address the long-run effects of fundamental changes in house prices and the value of housing capital, and it suggests that the combined effects of higher mortgage rates, a decline in unemployment, and lower productivity can have significant effects in the value of housing capital. Some conservative predictions suggest declines between 24 and 29 percent. The current adjustment in house prices in Spain is still far from these magnitudes. However, it is not clear whether the current values will be sustainable in

[1] López-Garcia (2004) studied the impact of housing policy on house prices in Spain. The model predictions suggest that the removal of housing subsidies implicit in the personal income tax would entail a substantial decline in the real price of housing and in the stock of housing. However, the quantitative results depend on the assumptions about the nature of land prices.

the long run.

This is not the first study to consider the impact of land or demographics on house prices. Several papers highlight the potential importance of the supply side of the market in understanding fluctuations in housing prices. For example, Kiyotaki, Michaelides, and Nikolov (2008) develop a quantitative general equilibrium model to study the interaction between housing prices and aggregate production. In their economy, land and capital are used to build residential and commercial real estate. They find that when the share of land in the value of real estate is large, housing prices react more to an exogenous change in expected productivity or the world interest rate, causing a large redistribution between net buyers and net sellers of houses. Davis and Heathcote (2006) document that the dynamics for the prices of residential land and residential structures are substantially different. They find that the real price index for residential land almost tripled between 1975 and 2005, whereas the real price of structures increased by only 24 percent. Green, Malpezzi, and Mayo (2005) find that housing supply regulations are a key factor in explaining differences in housing supply elasticities across U.S. metropolitan areas. Van Nieuwerburgh and Weill (2006) argue that the increase in the dispersion of housing prices across regions can be quantitatively generated from an increase in the dispersion of earnings in the presence of planning restrictions.

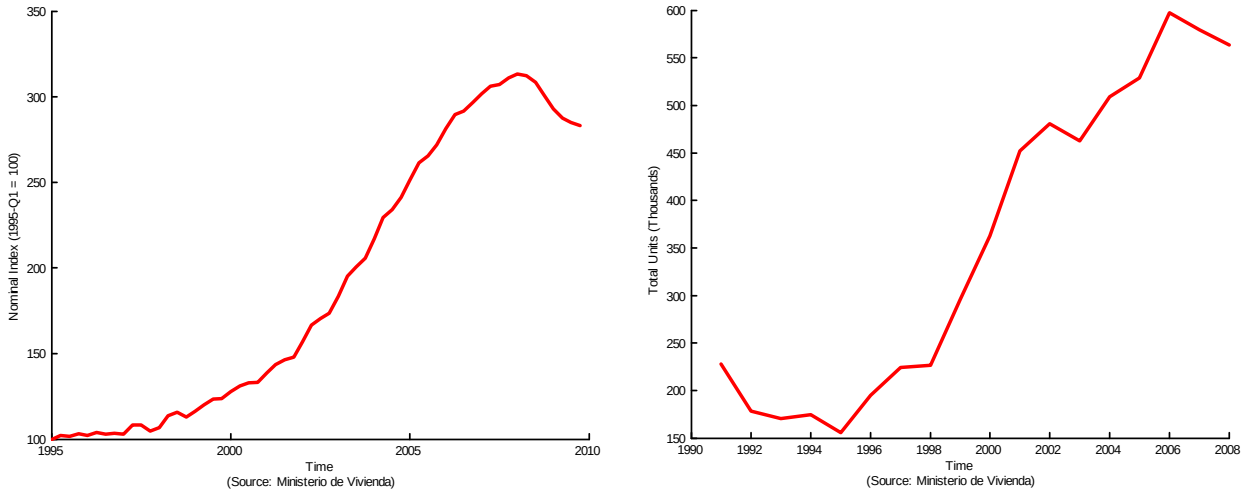
In principle, changes in the demographic structure can have important effects on the demand for housing and ultimately on house prices. In a classic paper, Mankiw and Weil (1989) explore the connection between the baby boom in the United States and house prices. They argue that a demographic boom generates a level effect on demand because more individuals demand homes, but the boom also has a composition effect because the group of individuals purchasing also matters (i.e., young vs. middle-aged). Their findings suggest that the level effects should drive prices up in the short run, but as the baby boomers retire, home prices should be expected to fall because of insufficient demand to purchase all the housing units from retired individuals. Although this argument is attractive, their predictions for the U.S. housing market and the baby boom generation (1978-85) proved to be incorrect. They predicted a large effect of the baby boomers on the housing market, but they had only a very small effect on home ownership and house prices, certainly less than the boom predicted by these economists. However, the model presented herein suggests a different contribution of demographics to the housing boom.

2. Empirical Evidence

This section describes the evolution of the key variables in housing markets for the Spanish economy. The series for house prices and construction of new dwellings are collected from

the Spanish Housing Ministry (http://www.mviv.es/es/). The house price data are available at a quarterly frequency. The data measure the nominal value of a square meter and include the sales of new and existing units. The data for residential investment include the total number of dwellings completed in a given year. Figure 1 shows an impressive boom in house prices and residential investment.

Figure 1: House Prices and Residential Investment in Spain (1995-2009)



Between 1998 and 2008, the house price index per square meter in Spain roughly tripled (345 percent) in nominal terms and more than doubled in real terms (221 percent).[2] This rapid increase implies an average annual appreciation of 11.5 percent in nominal terms and around 6.3 percent in real terms. These magnitudes are large both in nominal and real terms, especially from a historical perspective. The housing boom in Spain makes the boom in the United States appear small. In the case of the U.S. economy, the estimates of the different price indices suggest that the implied annual nominal appreciation ranged between 4.2 and 6.1 percent (see Freddie Mac Conventional Mortgage Home Price Index (http://www.freddiemac.com/finance/cmhpi/) and Case-Shiller House Price Index (http://www.standardandpoors.com)). These are clearly different orders of magnitude.

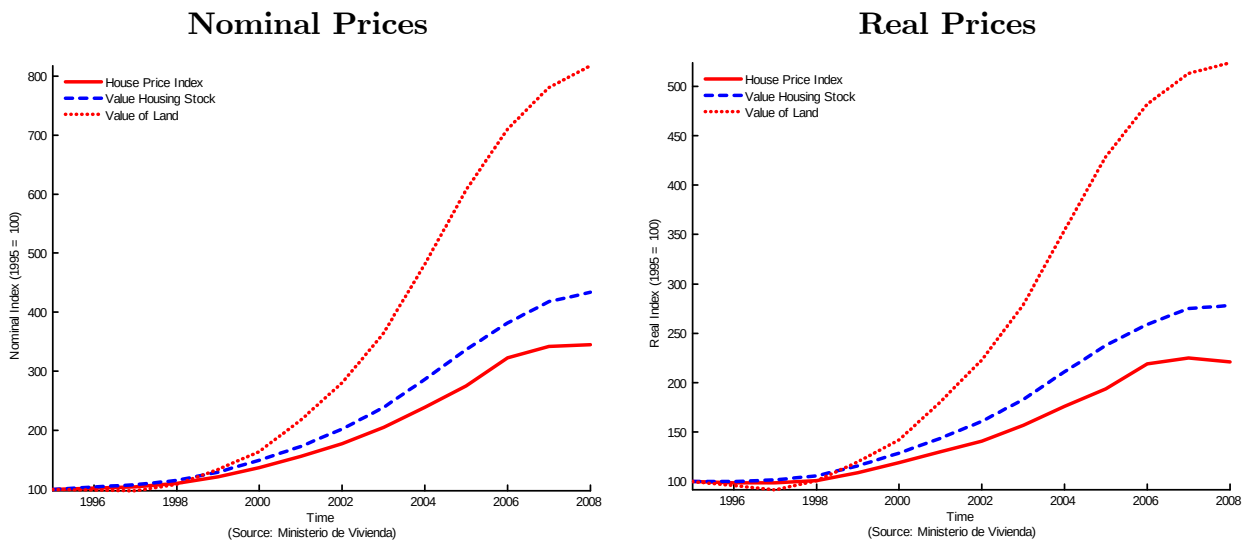
The housing boom in Spain is even more surprising given the large increase in residential construction activity during the period. The number of new units put in place between 1998 and 2007 doubled, and the share of construction in Spain's Gross Domestic Product (GDP) increased by 4 percentage points, attaining 10.7 percent in 2008. For example, in the U.S.

[2] This aggregate number has some dispersion because some coastal areas such as Andalucia (243%), Cataluña (214%), and Valencia (227%) had larger increases than inland locations such as Castilla-Léon (138%) and Madrid (178%). The nature of the dispersion of prices is not discussed here, but the model could be extended to price the amenities from coastal areas.

the share of residential investment over GDP during the same time period grew from 4 to 6 percent (see Fisher and Quayyum, 2006).

Between 1995 and 2007, the increased value of the price per square meter and the expansion of the housing stock generated an increase in the nominal value of the housing stock by a factor of 4.3 and 2.78 in real terms. This increase is mainly due to an important component in the value of housing capital: the value of land. In Spain, Uriel et al. (2009) show that the share of land in house prices was 25 percent in 1995,but increased to 46 percent in 2008. They argue that during this period 84 percent of the increase in house prices is due to land costs. Figure 1b summarizes the evolution of the value of the housing stock, the value of the structures, the value of land, and the house price index in real terms.

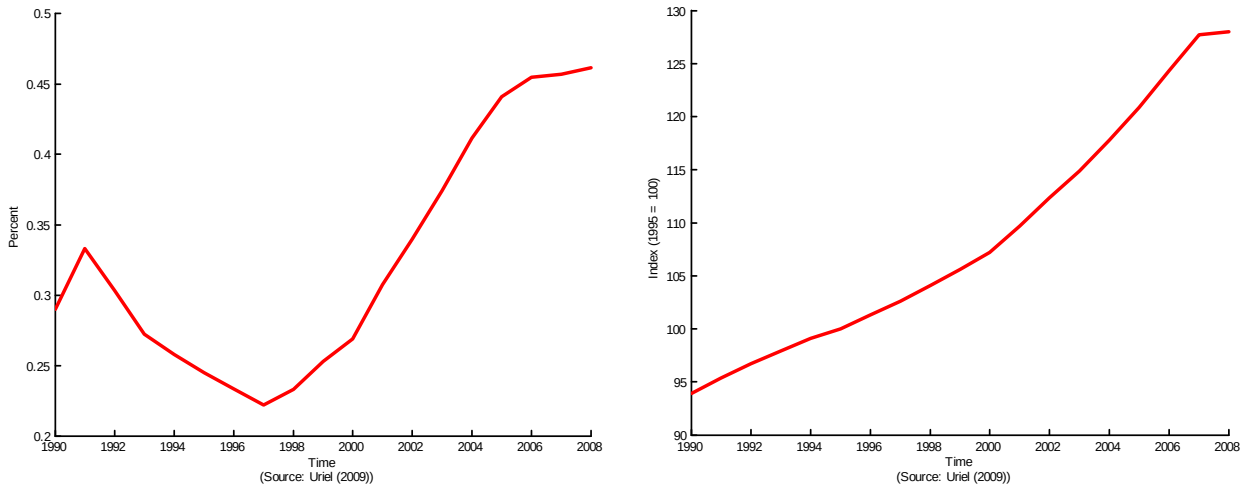
Figure 1b: Components of the Value of Housing Capital in Spain (1995-2009)



The figure suggests that the increase in the value of housing capital is higher than the house price index. The difference is the expansion of the housing stock that resulted from the boom in residential investment as a fraction of GDP. Uriel et al. (2009) estimated that the value of land increase by a factor of 8.2 in nominal terms and 5.25 in real terms. The increase in the value of land is even more surprising considering that government liberalization of land use expanded the land available for construction by roughly 30 percent. The evolution of

these two variables is summarized in Figure 2.

Figure 2: The Role of Land in the Housing Boom in Spain (1995-2009)

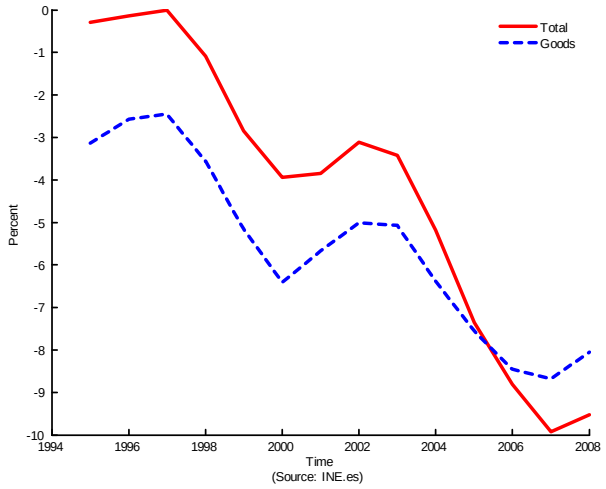


Two important forces in housing finance fueled the housing boom. In Spain, the housing market is very sensitive to mortgage rates. The rates are quite relevant since more than 80 percent of homeowners use ARM's to finance the purchase of a house. This number is much larger in contrast with the 15 percent who use ARMs in the U.S. economy. According to the Bank of Spain, the average mortgage rates in Spain have steadily declined from 17 percent in 1991, to 10 percent in 1996, to 3.5 percent around 2004-05. An important factor lowering interest rates was the integration of Spain into the European Monetary Union. Nevertheless, the global financial crises that started in the summer of 2007 affected credit conditions across developed economies. In Spain this was reflected in an increase in mortgage rates to levels around 6 percent in 2009, which is particularly important given the majority of homeowners holding ARMs.

The expansion in housing finance has been sustained by a large current account deficits as a fraction of GDP (Figure 3). The deficit has made it possible to finance consumption

and the purchase of homes without relying on domestic savings.

Figure 3: Current Account Deficits over GDP (1995-2009)

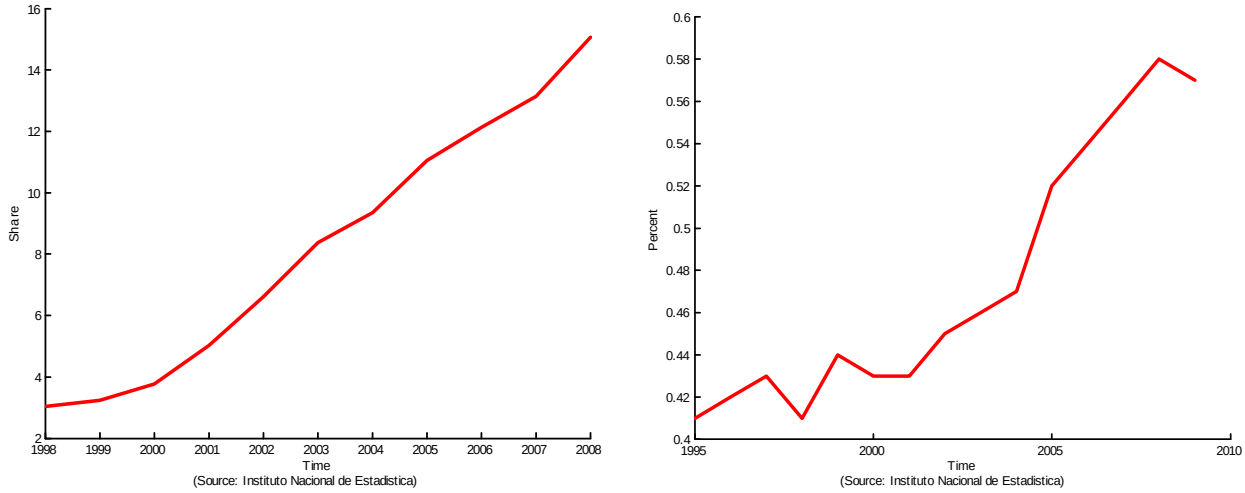


The lower rates and capital flows can be explained by the liberalization of the mortgage market. For example, the fraction of outstanding mortgage debt over GDP grew from 14 percent in 1990, to 29 percent in 2000, to more than 61 percent in 2007. The 2007 figure is closer to the aggregate leverage ratio of the U.S. economy roughly 97 percent of GDP.

The important changes in housing finance have been accompanied by important changes in the demand side. In the past decade, the Spanish economy has experienced a large influx of immigrants, particularly in the workforce. In absolute terms, the number of foreign-born population increased from 1.2 to 6 million in only 10 years. This change is very significant, given that the total number of native-born residents in the same period has only increased from 38.7 to 40.1 million. The relative importance of the foreign-born population is summarized in Figure 4.

Figure 4: Demographic Changes in Spain

Immigration Flows **Workforce**



In the past decade, the share of immigrants among the total population increased from 3 to 15 percent. Immigration accounts for most of the increase in total population. The flow of immigrants has had an important effect in the labor markets. In particular, the total working-age population has increased from 26.7 to 31.3 percent; however, 98 percent of that growth is due to immigrants. The magnitude of immigration flows can be important to reconcile the simultaneous increase in house prices and residential investment during this period. The addition of new workers increased the demand for housing goods and provides more workers for new construction. The combined effect is an increase in the level of effective workers from 41 percent to 56 percent of total population in 2008 — a 37 percent increase in the size of the labor force. The change of the population structure in the workforce is summarized in the right panel in Figure 4. As a result, the reallocation of resources from the production of consumption goods into housing could be a contributing factor in the housing boom.

3. The Economy

The choice of the model is driven mainly by the goal of reconciling the change in the levels of house prices and the boom in residential investment. The model has two sectors. One sector produces consumption goods using a linear technology where labor is the only input, whereas the other produces residential investment. Housing services are generated by combining structures and land. The baseline formulation considers a closed economy. Later this

assumption is relaxed to accommodate capital flows and discuss additional extensions.

3.1. House Price Fluctuations and Residential Investment

In this section a simple equilibrium model is developed to determine house prices. The model provides some basic intuition and is useful in understanding two ideas. The first is the connection between interest rates and house prices, whereas the second reflects the challenges faced in the literature to simultaneously understand the boom in house prices (the boom-bust cycle) and residential investment (changes in the housing supply). The model has limitations but is helpful in illustrating these key ideas.

Consider an economy where two investment opportunities are available. Individuals can either invest resources in (1) a riskless technology (i.e. bank deposit or savings accounts) earning a return denoted by r or (2) housing This second alternative requires the purchase of a house, which generates an income flow of housing services Rs, where R represents the market value of selling/renting one unit of space (i.e., m^2). The house can be sold in the market the following period without incurring any transaction costs. In the absence of frictions, the rate of return from both investments (bank and housing) must be the same. Formally,

$$1 + r_t = R(1 + r_t) + \frac{p_{t+1}}{p_t}, \tag{3.1}$$

where $p_t is$ the purchase price and p_{t+1} is the selling price. This expression states that the rate of return of investing one dollar (\$1) and earning \$1 $\times$ $(1 + r_t)$ tomorrow must be equivalent to purchase a house today, receive some rental payments from the house that can be deposited in the bank, $R(1 + r_t)$, and then sell the house tomorrow. Selling the house generates a capital gain (loss) that depends on the difference between the purchase price, p_t, and the selling price, p_{t+1}. The return from purchasing a house has two components: the service flow from the property and the capital gains (losses). The expression can be used to determine the price to pay per unit of housing today. Formally,

$$p_t = \underbrace{R_t}_{\text{User Cost } = R_t} + \underbrace{\frac{p_{t+1}}{1 + r_{t+1}}}_{\text{Resale Value}}. \tag{3.2}$$

The new expression decomposes the price paid for a unit of housing (this concept is different than the rate of return) as a function of the rental price and the expected discounted resale value tomorrow. This expression ignores the presence of bubbles in the pricing equation that would cause the price to deviate from the asset fundamentals, transaction costs associated with the purchase and sale of the property, and any asymmetry in the tax treatment of tenant versus owner-occupied housing. In addition, when housing acts as collateral, the

pricing equation should also include an additional term that captures the benefits and costs of changes in the value of the housing in the collateral constraint. Thus, it is useful to illustrate the key determinants of housing valuation. This expression can be iterated forward to compute the price in the event of sale in period $t = 2$.

$$p_t = R_t + \frac{R_{t+1}}{1 + r_{t+1}} + \frac{p_{t+2}}{(1 + r_{t+1})(1 + r_{t+2})}, \tag{3.3}$$

and the same procedure can be used to determine the current price for different buy, hold, and sell strategies. Two things become obvious: The longer you hold the property the more you should be willing to pay, whereas if the resale value is expected to decline, the current price should be lower. The expression encompasses most of the important elements that determine house prices: the value of the rental flow, expected appreciation, and the discount rate (i.e. opportunity cost of alternative investments). Consider a special case: when the house is viewed as an infinite console (where the growth rate of rental income is zero, $g = 0$). In this case, the pricing expression can be written as

$$p = \frac{R(1 + r)}{r - g} \approx \frac{R}{r}. \tag{3.4}$$

According to this expression house prices can rise (decline) as a result of two factors: a change in the rental prices and/or interest rates. A permanent increase in the market value of rental income should increase by more than one for one the house prices, $\partial p/\partial R = 1/r > 1$ since $r \in (0, 1)$. Similarly, a decline in the interest rate should generate an increase in the house price, $\partial p/\partial r = -R/r^2 < 0$. A simple way to test the model is to regress the log of prices against the log of rental rates and interest rates. This regression presents several problems. First, data estimates for rental prices are difficult to obtain. In addition, houses have different attributes and characteristics that are not captured by house size as the model predicts. A second problem with this analysis is that rental value is not independent of the interest rate. Changes in the interest rate are likely to modify the intertemporal allocation of consumption, which changes the implied user cost. Therefore, the final effect on house prices depends on the relative strength of both effects, $p = R(r)/r$. To understand the joint determination of rental prices and interest rate it is necessary to impose additional structure on the economy.

Let's now assume that there exists a fixed supply of house, H_t, and each unit of housing generates a flow of housing services that depends on the size of the units purchased that period, $s_t = A_H H_{t+1}$. Individual's value consumption of goods, c_t, and housing services, s_t, and use a utility function, $u(c_t, s_t)$, to rank different bundles of goods. The utility function

satisfies the standard properties $u', -u'' > 0$, and the Inada conditions. These properties suggest that consuming either more consumption goods or housing services increases the individual well-being. However, each additional unit of consumption has diminishing returns, or decreasing contributions to the total level of utility, u.

In this economy, the consumer faces a trade-off between consumption goods and housing services. The optimal decision equates the marginal rate of substitution of these goods to the relative price, R_t, since the price of consumption goods has been normalized to 1. The price of one unit of housing is tight to consumer preferences:

$$p_t = \underbrace{\frac{u_2(c_t, s_t)}{u_1(c_t, s_t)}}_{\text{User Cost } = R_t} + \underbrace{\frac{p_{t+1}}{1 + r_{t+1}}}_{\text{Future Value}} . \tag{3.5}$$

To illustrate the nature of changes in the level of house prices it is useful to make some additional assumptions about the model. Assume that preferences are characterized by $u = [c^\rho + \gamma s^\rho]^{1/\rho}$, where $\gamma > 0$ and $\rho \in (-\infty, 1]$. In a representative agent economy without capital, the optimal level of consumption is determined by labor income $c = wN$. In this case, the pricing equation becomes

$$p \approx \frac{\gamma}{r} \left[\frac{wN}{A_H H} \right]^{1-\rho} . \tag{3.6}$$

The formula relates house prices to fundamentals and not bubbles. According to expression (3.6), house prices should increase (decrease) with wages, employment (or hours worked), a change in the relative importance of housing in the utility function, or a decline in interest rates. Therefore, each factor can be an important contributor to the housing boom and bust. For example, the U-shaped pattern of labor income and mortgage rates between 1998 and 2009 would be consistent with the boom-bust cycle observed in the Spanish economy.

One important challenge in a model based on economic fundamentals is rationalizing the simultaneous increase in house prices and residential investment. Equation (3.6) suggests that an increase in the stock of homes, H, should decrease the house prices, p. In the case of positive residential investment, prices and quantities work in opposite directions. An excess of supply can be an important factor in explaining the housing bust, the challenge is to explain the boom while the supply is expanding. To reconcile house price movements with sizable changes in residential investment it is necessary to introduce an additional fixed factor: land. In the presence of land, a house becomes a composite good that depends on the price of the structure, qH, and the market value of that land, vL. The next section develops a more complex economy to explore the role of residential investment in the boom-bust cycle

in Spain.

3.2. Closed Economy

In the economy the size of total population at a given time point is N_t. Since the focus of the paper is the change in the house price index between 1998 and 2009, it is useful to normalize the population of the initial time period, $t = 0$, to unity, $N_0 = 1$, and assume that the total level of the population remains constant in the long run, $N > N_0$.[3] Following Martin (2005), the demographics in a representative agent are introduced by assuming that the time endowment varies through time, $N_t^w \in (0, N_t]$. This variable can be interpreted as either a time-varying endowment or as the number of individuals in the total population who are available to work. A change in the time endowment or the fraction of individuals who can work is equivalent to a change in the workforce due to demographics. In particular, the flow of immigrants will be modeled as a combined increase in total population, $\triangle N_t$, and the time endowment, $\triangle N_t^w$.

As in the previous section, individual preferences are defined by a time-separable utility function, $u(c_t, s_t)$. The sequence of utilities is discounted at a rate $\beta \in (0, 1)$. In addition to goods consumption and housing services, the representative consumer chooses a sequence of housing structures or housing capital, H_{t+1}, bond holdings, B_{t+1}, and land holdings, L_{t+1}. A house in the model is complex object. Housing services are produced according to a technology $\overline{s}_t = g(H_{t+1}, \chi_t L_{t+1})$, that combines the physical structure (or building) and the land on which the structure sits. The technology has constant returns to scale and satisfies $g_i' > 0$, $g_i'' < 0$, but $g_{ij}'' > 0$. The term $\chi_t \in (0, 1)$ is a reduced form of capturing the presence of land regulations that can limit the utilization of the existing stock of land over time.[4] With this specification, homes in the model have two dimensions. One is the size of the dwelling or the livable space. The other element is the size of the lot (or land) where the structures are located. The ratio of land over structures, H/L, can be interpret as density.[5] Formally, the representative consumer chooses the relevant variables $\{c_t, s_t, H_{t+1}, L_{t+1}, B_{t+1}\}_{t=0}^{\infty}$ for all

[3] Since the stock of land is fixed, assuming a constant level of population in the long run eliminates the problem of having the share of land converges to zero. The purpose of the paper is to understand the change in house prices between different time periods, not to define the stationarity properties of an economy with a fixed factor.

[4] This parameter is determined outside the model and is taken as given by the consumer.

[5] Formally, a "house" in the model is defined as a combination of infrastructures, h_{t+1}, and land, L_{t+1}, that produces a given amount of housing services. For simplicity and interpretation, the notion of a house is normalized to a single unit of housing services, $s_t = 1$. This notion can be interpreted as the price per square meter. The price of a house can be computed by solving $g(h, L) = 1$ such that $p = qh + vL$. Any combination of infrastructures and land can be priced using the above expression.

the individuals in the economy, N_t. Formally,

$$\max \sum_{t=0}^{\infty} \beta^t u(c_t, s_t) N_t,$$

$$\begin{aligned} s.t. \qquad & N_t c_t + B_{t+1} + q_t H_{t+1} + v_t(L_{t+1} - L_t) = w_t N_t^w + ... \\ & (1 + r_t)B + q_t(1-\delta)H_t + R_t(g(H_{t+1}, \chi_t L_{t+1}) - s_t N_t), \\ & H_0, L_0, B_0 \geq 0 \end{aligned} \tag{3.7}$$

where q_t is the price of infrastructures, v_t, is the land price, w_t, represents the wage rate, r_t, is the rate of return from bonds and, R_t, is the rental price of housing. Some features of the consumer deserve further explanation. The current specification allows land trading, L_{t+1}, and rental markets for tenant-occupied housing. In equilibrium, there is no trade in either market, but its formalization determines the implied equilibrium prices necessary to price the value of the stock of housing. In particular, formalizing the market of rental services makes explicit the opportunity cost of owner-occupied housing. When the production of housing services at the household level equals the level of consumption, the term $R_t(g(h_{t+1}, \chi_t L_{t+1}) - s_t)$ drops from the budget constraint. In addition, labor income is expressed as a combination of total hours worked at market wage, but this term can be expressed as the labor income earned in each sector, $w_t N_t^w = \sum_i w_{it} N_{ct}$ for $i = h, c$.

The first-order conditions of the consumer problem are derived in Appendix (8.1), but the optimality conditions that result are characterized by expressions that determine the rental price and the interest rate as functions of allocations:

$$R_t = \frac{u_2(c_t, s_t)}{u_1(c_t, s_t)}, \qquad \forall t, \tag{3.8}$$

$$\frac{1}{(1 + r_{t+1})} = \frac{\beta u_1(c_{t+1}, s_{t+1})}{u_1(c_t, s_t)}, \qquad \forall t, \tag{3.9}$$

Equation (3.8) states that the rental price is determined by the ratio of marginal utilities between consumption goods and housing services. As usual, the interest rate is determined by the ratio of marginal utilities between consumption in periods t and $t+1$. The model predicts no arbitrage between land investment opportunities and housing capital or infrastructures. Formally, the rate of return of both types of investments need to equalize:

$$\frac{q_{t+1}(1-\delta)}{q_t - R_t g_1(H_{t+1}, \chi_t L_{t+1})} = \frac{v_{t+1}}{v_t - R_t g_2(H_{t+1}, \chi_t L_{t+1})}. \tag{3.10}$$

This expression is consistent with the ideas developed in the previous section. It is worth

noting that the rate of return needs to be adjusted by the market value of the contribution of each input in the production of housing services. Using the implied (and endogenous) interest rate, it is possible to compute via recursion the value of housing capital and land:

$$q_t = R_t g_1(H_{t+1}, \chi_t L_{t+1}) + \frac{q_{t+1}(1-\delta)}{1+r_{t+1}}, \tag{3.11}$$

and

$$v_t = R_t g_2(H_{t+1}, \chi_t L_{t+1}) + \frac{v_{t+1}}{1+r_{t+1}}. \tag{3.12}$$

These expressions state that the current cost of purchasing a unit of housing structures (land) equals the contemporaneous return of housing services derived from the housing capital (land) valued at market prices, and the discounted selling price next period. In the case of structures, it is necessary to net out the depreciation cost of that particular unit. The formal expression for the prices are detailed in Appendix 8.1.

The production of consumption goods and houses is endogenous in the model. There are two different types of firms in this economy. The first type is a representative firm that uses a linear technology to produce consumption goods, $c_t^s = A_{ct} N_{ct}$. The firm's optimization problem is characterized by

$$\max_{N_{ct}} A_{ct} N_{ct} - w_{ct} N_{ct}, \qquad \forall t,$$

where the price of consumption goods is normalized to 1. The constant returns to scale assumption implies zero equilibrium profits and marginal cost pricing for the labor input

$$w_{ct} = A_{ct}. \tag{3.13}$$

The other type of firm produces residential investment, $x_t = A_{ht} N_{ht}$. This investment is combined with the existing undepreciated housing capital to produce the new level of structures. This technology is subject to irreversibility constraints, $x \geq 0$. The market value of residential investment is determined by p_{ht}. Then, the optimization problem is given by

$$\max_{(N_{ht}, x_t) \in R_+} p_{ht} x_t - w_{ht} N_{ht},$$

$$s.t. \qquad x_t = A_{ht} N_{ht},$$

Let μ_t represent the Lagrange multiplier of the irreversivility constraint in period t. The

first-order condition of the optimization problem implies

$$w_{ht} = (p_{ht} + \mu_t)A_{ht}. \tag{3.14}$$

The consumer time allocation problem, $N_t = N_{ct} + N_{ht}$, implies $w_{ct} = w_{ht}$. For this condition to hold the price of new structures must equate

$$p_{ht} = \frac{A_{ct}}{A_{ht}} - \mu_t. \tag{3.15}$$

This specification assumes that this price depends on the path of effective productivities of each sector, and the multiplier of the irreversivility constraint. When the constraint binds, the price of residential investment declines. When the constraint does not bind, the wage rate of both sectors equates to $w_{ct} = w_{ht} = A_{ct}$. This result allows redefinition of the notion of labor income, $w_t N_t = w_{ct} N_{ct} + w_{ht} N_{ht} = A_{ct} N_t$, and it also simplifies the number of prices that need to be solved in equilibrium. It is worth emphasizing that p_{ht} reflects the cost of producing new structures. However, the price of a house differs from this value since it depends on the relative value of structures and land.

Definition (Competitive Equilibrium): *Given* $\{A_{ct}, A_{ht}, \chi_t\}_{t=0}^{\infty}$, *equilibrium comprises allocations* $\{c_t, s_t, B_{t+1}, H_{t+1}, L_{t+1}, N_{ct}\}_{t=0}^{\infty}$, *and prices* $\{q_t, v_t, R_t, r_t, p_{xt}, w_t\}_{t=0}^{\infty}$ *that solve i) consumers solve the optimization problem, ii) firms producing consumption goods and housing capital maximize profits; and iii) all markets clear: a) Labor markets:* $N_t \geq N_t^w = N_{ct} + N_{ht}$; *b) Goods markets:* $N_t c_t = A_{ct} N_{ct}$; *c) Land markets:* $L_{t+1} = L_t = \overline{L}$; *d) Bond market:* $B_{t+1} = 0$; *e) Rental market:* $N_t s_t = g(H_{t+1}, \chi_t L_{t+1})$; *f) Market for structures:* $H_{t+1} = x_t + (1-\delta)H_t$.

The objective of the paper is understanding the change in the level of house prices between 1998 and 2007, and the bust cycle in 2007-09. Therefore, it is useful to define and characterize the steady state of the economy. In this equilibrium prices, allocations, and expectations over future variables are constant over time.

Definition of Steady-State Equilibrium: *For a given level of productivities* $\{A_c, A_h\}$, *a steady-state equilibrium is characterized by allocations* $\{c, s, B, H, L, N_c\}$ *and prices* $\{q, v, R, r, p, w\}$ *that solve the equilibrium conditions.*

The steady-state conditions are used to determine the levels of house prices. In this case, the equilibrium interest rate is determined by the rate of time preference, $r^* = 1/\beta - 1$. The rental price by the marginal utility is

$$R = u_2(c, s)/u_1(c, s). \tag{3.16}$$

The equilibrium prices for housing capital and land are determined by

$$q = \frac{(1+r)}{(r+\delta)} R g_1(H, \chi L), \tag{3.17}$$

and

$$v = \frac{(1+r)}{r} R g_2(H, \chi L). \tag{3.18}$$

In steady-state, there is no net investment in housing capital. All residential investment replaces the depreciated structures,

$$x = \delta H = A_h(N^w - N_c). \tag{3.19}$$

This expression is used to determine the steady-state level of structures, $H = A_h(N^w - N_c)/\delta$, as a function of the employment allocation across sectors. Substituting the expression in the market-clearing condition for consumption goods,

$$A_c N^w - q\delta h = A_h(N^w - N_c), \tag{3.20}$$

determines the steady-state price of structures

$$q^* = \frac{A_c}{A_h}, \tag{3.21}$$

as a ratio of the productivity levels in each sector. To determine the value of land, v, rental prices, R, and employment, N_c, it is necessary to solve a system of nonlinear equations.

3.3. Small Open Economy

In a small open economy, households have access to international borrowing by accessing capital flows. A simple approach to formalize the access to the global credit market is to assume that consumption of goods is tradable, whereas housing services, housing capital, and land are non tradable goods and inputs. In this case, households can import consumption goods from abroad by borrowing, $D_{t+1} = C_t^* = N_t c_t^*$, where the term C_t^* represents imported goods. To simplify matters, the model considers capital flows with countries that use the same currency (i.e. European Monetary Union, EMU); therefore, the exchange rate between Spain and their counterparts is set to 1, $e^* = 1$. The consumption goods market clearing condition needs to be modified accordingly,

$$N_t c_t = A_{ct} N_{ct} + D_{t+1} - (1 + r_t^*) D_t.$$

In this class of economies, any deviation in the implied interest rate determined by the rate time preference, β, and the world interest rate, r_t^*, generates permanent increasing deficits or surpluses. One way to solve the problem, ignoring default issues, it to bound the long-run level of sovereign debt, $D_{t+1} \leq \phi_t$, and consumption. The parameter ϕ sets the long-run level of indebtness and it can be determined to match the levels of the current account deficits. The introduction of capital flows and bounds on current account deficits modifies the intertemporal decision with respect to consumption

$$\frac{u_1(c_t, s_t)}{\beta u_1(c_{t+1}, s_{t+1})} \geq (1 + r_{t+1}^*), \qquad \forall t.$$

This condition holds with inequality when $D_{t+1} = \phi_t$. The relevant long-run case for the Spanish economy implies permanent current account deficits, $D = \phi$, where the above expression becomes $1/\beta \geq 1 + r^*$. In the open economy, the relevant discount rate is given by r_t^*; hence, the pricing equation must be evaluated at the EMU borrowing and lending rate. This rate is the relevant one to discount the future flows in the pricing equations.

4. The Housing Boom-and-Bust Cycle in Spain

4.1. Parameterization of the Model: 1995

The quantitative evaluation of the model requires specifying parameter values and functional forms. These are determined to match key properties of the Spanish economy before the housing boom. Some key parameters have a directly observable counterpart in the data. The remaining parameter values are determined using an exactly identified method of moments approach. Once the economy is parameterized, it can be used to address the key forces driving the housing boom.

Three parameters that are determined directly are the size of total population, $N_{95} = 1$; the share of the workforce in the population, $N_{95}^w = 0.41$; and the current account position. In 1995, the current account of the Spanish economy was balanced. A simple way to capture the absence of deficits is to assume that the world interest rate coincided with the rate of time preference, $r^* = 1/\beta - 1$. An alternative specification would imply that Spain had no access to credit markets, $\phi = 0$.

The choice of functional forms is relatively standard. The utility function is consistent with unitary income elasticity, $\rho = 0$

$$U(c, s) = [\gamma c^\rho + (1 - \gamma) s^\rho]^{1/\rho},$$

where the term $\gamma \in (0,1)$ represents the relative share of goods consumption in utility. The production of housing services is given by

$$g(H, \chi L) = H^{\alpha}(\chi L)^{1-\alpha}.$$

where $\alpha \in (0,1)$ represents the relative weight of each input.

In the model, housing structures depreciate at a constant rate δ, and the flow of utility is discounted at a rate β. The model key parameters $(\beta, \delta, \gamma, \alpha)$ are determined to match four targets in the data. The model targets are defined to be consistent with their data counterpart (i.e, output, value housing stock). For example, the model definition of GDP includes the production of consumption goods, residential investment, and the market value of housing services. The data used to determine the targets are from three sources. The National Income and Products Accounts data are from the Instituto Nacional de Estadistica. The estimates of the real mortgage rate are from the Banco de España, and the share of land in the housing stock is derived from the estimated series of Uriel et al. (2009). The parameters are determined to match a 9 percent interest rate (12 percent nominal minus 3 percent inflation), an 83 percent ratio between consumption and output, a 25 percent contribution of land in the value of the housing stock, and a 2.05 ratio between housing capital and GDP. Table 2, summarizes the results of the model parameterization

Table 2: Parameterization of the Model —1995

Variable	**Target**	**Model**
Real mortgage rates (%)	9	9
Consumption-output (%)	83	83
Share land in housing stock (%)	25	25
Housing capital/output	2.05	2.05
Non targeted values		
Value of land/output	0.66	0.68
Value of housing/output	2.71	2.73
	Parameters	
Subjective discount rate	$\beta =$	0.91
Share of goods consumption	$\gamma =$	0.84
Share of structures	$\alpha =$	0.67
Depreciation rate	$\delta =$	0.08

The targets generated by the model solution along with the market-clearing equations are within less than 1% error in each target. The model can be evaluated in terms of housing characteristics that have not been targeted. The model predicts that the value of land relative to output is 68 percent, whereas the data predict 66 percent. Similarly, the value of housing relative to output is 2.73 in the model and 2.71 in the data.

4.2. Sources and Decomposition of the Housing Boom: 1995-2007

The objective of the paper is to understand the sources driving a housing boom of the magnitude experienced in Spain. A model capable of generating booms of sizable magnitude also can be used to decompose the quantitative impact of each variable. Before addressing any of these issues it is important to explore the change in the magnitude of the relevant housing variables in this period. Table 3 summarizes the change in house prices and the composition of value of housing capital relative to GDP observed in the data.

Table 3: Changes in House Prices and Value in Spain: 1995-2007

			$\triangle$1995 – 2007	
Variable	**1995**	**2007**	**Total**	**Annualized (%)**
Nominal house prices index (m^2)	601	2,056	1,470	10.0
Real house prices index (m^2)	601	1,327	726	6.3
Value of housing stock over GDP (p^h/GDP)	2.71	4.63	171	4.6
Value of housing structures over GDP(qH/GDP)	2.05	2.51	122	1.7
Value of land over GDP(vL/GDP)	0.66	2.11	318	10.2

Source: Uriel et al. (2009)

The house price index data show that prices more than doubled (tripled) in real (nominal) terms. The appreciation during the 12-year period is 6.3 percent in real terms and 10 percent nominal. The value of the housing stock relative to GDP was 2.71 in 1995 and 4.63 in 2007. Despite the extended period of growth, the appreciation of the housing stock (land plus structures) was much more rapid than output. The change in the value can be decomposed with changes in the values of structures and changes in the value of the land.

$$\frac{p^h}{GDP} = \frac{qH}{GDP} + \frac{vL}{GDP}.$$

In 1995, the contribution of structures to the total value was 75 percent. Surprisingly, this contribution declined by 28 percent to account only for 54 percent of the value. The mirror

image is the importance of land in the formation of value, which increased from 25 percent to 46 percent. Land not only had an increasing weight in value, but it also had a much larger increase (318 percent) than the value of structures (122 percent). These facts are important because a model that captures a sizable magnitude in the value of housing capital should also be consistent in its composition (land vs. structures).

Three fundamental changes are used to understand the change in the value housing stock in 2007 (peak boom). These include demographic changes, the ability to borrow and better lending terms due to current account deficits, and relaxation of land restrictions.

1) Demographics: The demographic changes associated with the housing boom involve two terms: the total population and the size of the workforce relative to total population. In Spain, the total population increased roughly 18 percent, whereas the workforce increased 25 percent. Most of the growth (98%) is due to immigration flows. The combined effect is an increase in the level of effective workers from 41 percent to 56 percent of total population in 2008, which is a 37 percent increase in the size of the labor force.

2) Borrowing ability and better lending terms: In the past years homeowners in Spain were able to borrow with much better terms. The real mortgage rate was reduced from 9 percent to roughly 4 percent. Because it is difficult to determine the precise value of the discount rate with capital flows, the paper also presents estimates for different values for this rate. What is clear from the data is that part of the decline has been sustained with a large increase in the current account deficit. The deficit peaked after 2005 with values around 9 to 10 percent of GDP. A simple way to capture the decline in mortgage rates in the open economy requires reducing the world interest rate, r^*, to 4 percent. In addition to the interest rate decline, it is necessary to increase the access to credit markets by setting the term $\phi > 0$ to values consistent with current account deficits.

3) Relaxation of land restrictions: During this period the Spanish government opted to deregulate the sale of existing land. The result of this deregulation process was an increase in the supply of land (measured in square meters) of 28 percent. The index of land use was summarized in Figure 2.

Table 4 summarizes the baseline model prediction to a change in fundamentals (demographic structure and the reduction of land restrictions) with different assumptions about the mortgage rate and the cost of structures. The first two columns represents the change with respect to baseline values normalized to 100. The last column captures the change in

the rental price with respect to the baseline economy in 1995.

Table 4: Contribution to House Prices: Joint Effects

Experiment	Value Housing $\triangle \mathbf{P}^h$	Value Land to Output $\triangle \mathbf{vL/Y}$	Rental Price $\triangle \mathbf{R}(\%)$
Data $\triangle$1995-2007	275	318	-
Model (No-change cost structures)			
Demographics, Liberalization, r = 4.0%	230	260	-25
Demographics, Liberalization, r = 3.5%	246	293	-27
Demographics, Liberalization, r = 3.0%	267	337	-29
Model ($\triangle$10% cost structures)			
Demographics, Liberalization, r = 4.0%	253	260	-17
Demographics, Liberalization, r = 3.5%	271	293	-19.8
Demographics, Liberalization, r = 3.0%	294	337	-22.4

It is clear from Table 4 that the model makes different predictions depending on the assumed mortgage rates. For a conservative estimate of 4 percent, the baseline economy suggests that the change in fundamentals can rationalize 84 percent of the increase in house prices (230/275), and 82 percent of the contribution of land value to output (260/318). Following the intuition of the simple model presented in the previous section, the increase in house prices is accompanied by a decline in the rental price or dividend payment of the house. Without this decline, the increase in house prices would have been larger. Therefore, the model is consistent with the idea that rental prices are not independent of interest rates because these change the relative price of present and the future consumption. Given the model specification a decline in consumption implies a decline in the rental price as well. For lower interest rates the magnitude of the housing booms increases and the model can rationalize 90 percent of the increment of the housing capital value. The model also captures the fact that most of the increase in the value of housing is associated with the increase in the price of land. The contribution of this factor can be decomposed by an increase in the price, v, which triples, and the expansion of available land, L, which increases 30 percent. The combined effect adjusted by the increase in output explains the change in the ratio.

Table 4 also includes the same simulations under the assumption that the relative price of structures, $q = A_c/A_h$, increases 10 percent. The price increase could be due to the cost of materials, time cost of hiring workers, or any factor that increases the cost of production

unrelated to land. The objective is not to provide a precise estimate of a change (if any) but to understand how prices respond to such change. The model suggests that the same changes in fundamentals can be magnified with increasing costs of structures. Even though q increases only 10 percent, the final contribution of higher costs translates to an approximate increase in the value of housing capital of 10 percent. In the case of a 4 percent mortgage rate, the model accounts for 85 percent of the increase in value instead of 77 percent. Other factors not included in the model could be important (i.e., bubbles, speculation, change in the value of housing preferences), but the results suggest that theories based on rationality should not be abandoned.

To understand the total effects of the change in fundamentals it is necessary to solve the model isolating the contribution of each factor. It is important to understand that each simulation is performed under the assumption that the households perceive the change in the fundamentals as permanent. The results of the decomposition are summarized in Table 5.

Table 5: Decomposition of the Housing Boom by Factors

Price Change with Respect to Baseline $\mathbf{P}^h = 100$	**Value Housing $\triangle\mathbf{P}^h$**
Data $\triangle$1995-07	275
1) $\triangle$ Demographics	143
2) $\triangledown$ Mortgage rates	
r = 4.0%	145
r = 3.5%	155
r = 3.0%	167
3) $\triangledown$ Land restrictions	107
4) $\triangle$ Demographics, $\triangledown$ mortgage rates	
r = 4.0%	209
r = 3.5%	223
r = 3.0%	240

The index of house prices in 1995 has been normalized to 100. Compared with the baseline model, the decomposition exercise suggests that the largest effects can be attributed to the decline in the interest rate (145 percent) and the change in the demographic structure brought about by immigration (143 percent). In relation to the total increase, each of the changes

individually accounts for roughly one-third. Table 5 shows, decomposing contributions in a general equilibrium model is complicated because the contribution of two simultaneous factors is usually different than the sum of these factors separately. In general equilibrium, some of these effects can either reinforce or cancel. The model suggests that the combined effects of demographics and low mortgage rate would increase 91 percent from the baseline period, and the contribution with respect to the total change in house prices is 67 percent. However, the sum of the separate contribution for immigration and low mortgage rates is 55 percent (33%+32%). This suggests that the general equilibrium effects generate a reinforcing effect of 22 percent. The increase in the supply of land should produce a decline in the value of land (v) of 21 percent, but the decline in the price does not compensate for the increase in the quantity of land ($\triangle L = 30\%$), so the contribution associated with thr elimination of land restrictions is quite small.

The model seems to make some strong predictions about the key forces driving the increase in the value of the housing stock in Spain. The flow of immigrants and the decline of interest rates account for the majority of the housing boom. These two factors seem to reinforce each other. Whether the housing boom was driven by bubbles or irrational behavior remains to be proved. Nevertheless, the approach in this paper suggests that a parsimonious model with clear and testable assumptions can generate sizable housing booms such as the ones observed in the Spanish economy.

These results are consistent with those of Gonzalez and Ortega (2009) who find a sizable causal effect of immigration on both prices and quantities in the housing market. Their estimates suggest that the immigrant inflow increased house prices by about 52% and is responsible for 37% of the total construction of new housing units during the period. Overall, immigration can account for roughly one-third of the housing boom in terms of both prices and new construction.

One assumption in the model — the existence of complete markets — merits further attention. Some papers in the literature argue that the housing boom is partially due to innovations in housing finance that relaxed down payment constraints and reduced the cost of purchasing a home. Although this paper abstracts from financial frictions, a direct implication of using complete markets is that any household that wants to purchase a home and can afford to do so will indeed buy a house. In some sense, the complete market paradigm eliminates all frictions and maximizes the access of the population to the housing market. This is particularly important in a framework where the total population and the workforce increase dramatically. That situation suggests that in a model with financial frictions, there would still be some individuals who cannot finance their house purchases, thereby making the effect on house prices much smaller.

4.3. Counterfactual Experiments: 1995-2007 — An Alternative Story?

This section uses the model to perform some counterfactual experiments. In particular, it considers the effects of the relaxation of credit markets on house prices. The exercise takes the flow of immigrants and relaxation of land regulations as given and asks what would have happened with 6 percent interest rates instead of the 4 percent observed.

Table 6: Counterfactual Experiments

Experiment	Value Housing $\triangle \mathbf{P}^h$	Value Land to Output $\triangle \mathbf{vL/Y}$	Rental Price $\mathbf{R}(\%)$
Data $\triangle$1995-07	275	318	-
Demographics, Liberalization, r = 4.0%	230	260	-23
Demographics, Liberalization, r = 6.0%	187	182	-15
No Demographics, Liberalization, r = 6.0%	131	182	-19

The results in Table 6 suggest that the increase in the value of housing capital (structures and land) would have been much smaller. How much smaller? The model states 187 instead of 230, which is 20 percent less. The model suggests that the current account deficits supporting the mortgage rate decline had an important contribution in the housing boom. Without such a flow of funds, the house price increase would have had a different order of magnitude. The model also predicts that without the immigration flows ($\triangle \mathbf{N} = \triangle \mathbf{N}^w = \mathbf{0}$), the housing boom would been much smaller. These findings reinforce the idea that a combination of low mortgage rates with important changes in the demographic structure can be responsible for large changes in the level of house prices.

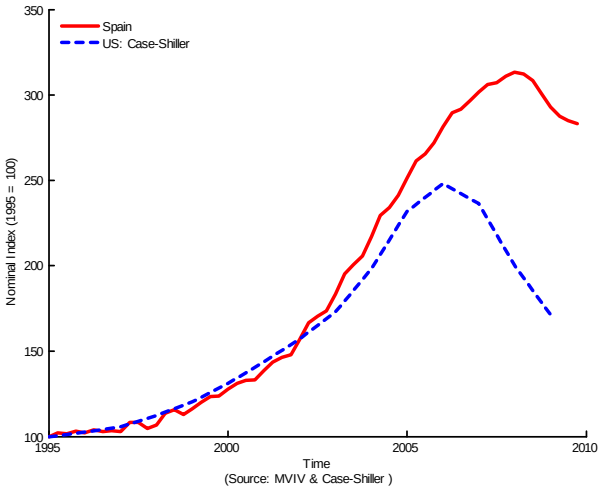
4.4. Housing Bust: 2007-09

Although the model is relatively stylized, it can be used to make predictions about the downward response of house prices to changes in economic fundamentals. It may still too early to fully understand the nature and the impact of the financial crises in the Spanish economy. However, it is certainly important to be aware of the magnitude of the economic adjustment when conditions are deteriorating. For example, Martínez-Pagés and Maza (2003) found that house prices in Spain were already above their long-term equilibrium level in 2003. However, their model does not allow them to make an estimate of the correction of future house prices.

The goal in this section is to derive predicted magnitudes using the model. Before proceeding further in the analysis, it is important to compare the evolution of house prices in Spain with the house prices in the U.S. The comparison is important because many economic

commentators suggest that the U.S. economy already has had a severe adjustment in the housing market.[6] In the case of the Spanish economy, it is not clear that the housing market has had a significant correction. Figure 6 compares the evolution of nominal house prices in Spain and the United States between 1995 and 2009. Both indices have been normalized to 100 in 1995.

Figure 6 House Prices in Spain and the United States (1995-2009)



Ssome of the features in Figure 6 are dramatic. Until 2005, the housing boom in both countries had similar magnitudes. However, in the United States this period represented the peak of nominal house prices, whereas in Spain prices continued to grow well into the first quarter of 2008. Not only the timing but the magnitudes of the peak differ. In Spain the peak of house prices was 3.12 times larger than the 1995 counterpart, but it was only 2.5 times larger in the United States. In addition, the timing and magnitudes in the downward adjustment of prices also differ. In the United States, house prices declined 30 percent, whereas in Spain prices continued to grow 25 percent more until 2008, but the decline has been much more modest — between 8 and 10 percent at the national level. If the adjustment in Spain is of magnitude similiar to that of the United States (30 to 40 percent), the index still has to decline from 2.87 to somewhere between 1.87 and 2.18. Other estimates based on consumer price index (CPI) adjustment would suggest a further adjustment to 1.56.

[6] There is still some disagreement in markets. Recently, Moody's agency revised upward its loss forecasts on option-ARM residential mortgage-backed securities (RMBS) issued between 2005 and 2007 in the U.S. The rating agency is now projecting cumulative loss rates of 20%, 41%, and 51% for 2005, 2006, and 2007 securitizations, respectively. The increasing losses are partially due to the expectation that the overhang of impending foreclosures is likely to adversely affect home prices going forward. As a result, some analysts generally expect another 10% decline in U.S. home prices, bringing the peak-to-trough drop to roughly 37%.

The final adjustment of house prices will depend on the length of the financial crises and other factors. However, it is possible to use the model to make some predictions about the sensitivity of house prices to various factors.

Altough many combinations of factors can be considered, this section concentrates on only a few. In particular, it is interesting to explore the model response to increases in the mortgage rate (from 4 to 5 percent), declining employment (5 and 10 percent), and negative productivity shocks in the production of consumption goods (5 and 10 percent). The numbers are compared with the model predicted-peak based on fundamental variables. Of note, the baseline model with 4 percent mortgage rates accounts for only 84 percent of the run-up in the value of the housing stock. Table 7 summarizes the percentage change with benchmark predictions for 2007 levels (see Table 4).

Table 7: Model Predictions for House Price Declines

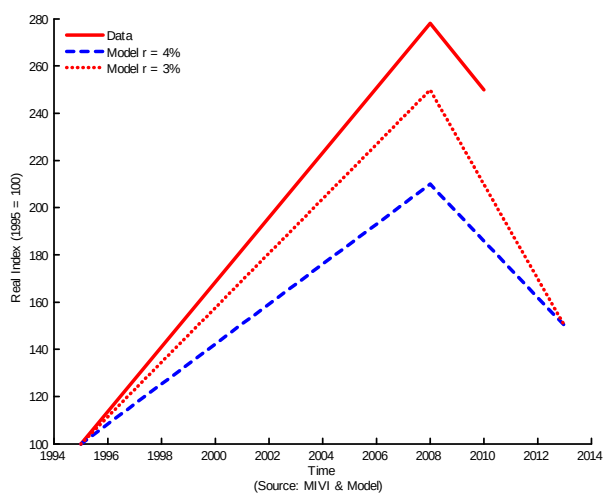
Mortgage Rate (%)	**Employment** (N_t^w) (%)	**Productivity Goods** (A_c) (%)	**Value Housing** $\triangle \mathbf{P}^h$	**Rental Price R**
5	=	=	-10.6	6.12
5	$\nabla 5$	=	-15.7	5.23
5	$\nabla 10$	=	-20.9	4.24
5	=	$\nabla 5$	-15.0	0.79
5	=	$\nabla 10$	-19.6	-5.23
5	$\nabla 5$	$\nabla 5$	-24.1	-5.63
5	$\nabla 10$	$\nabla 10$	-28.8	-6.22

All the experiments share a common feature. The interest rate increases from 4 to 5 percent. There are different ways to rationalize the increase in mortgage rates. One could be an increase in the cost of borrowing abroad, due to country-specific risk premia (fiscal deficits that crowded private savings), liquidity shortages, or the credit crunch. The model predicts that an increase in the mortgage rates should decrease the long run value of the housing stock by roughly 11 percent. The decrease occurs despite the 6 percent increase in the market value of housing services; this suggests that the link between house prices and interest rates (i.e. $p = R(r)/r$) is weak given that the rental price is an endogenous variable. The findings from Table 7 shows two different cases where rental prices and house prices move in opposite directions. The higher interest rate increases the level of current consumption relative to housing services that are ultimately responsible for the increase in R.

Changes in the level of employment in the economy can be analyzed by reducing the size of the active population. The model predicts that declines in employment have important effects on the value of housing capital. A decline of 5 percent (in conjunction with higher mortgage rates) implies a 16 percent decline in value, whereas a 10 percent decline generates a 21 percent drop. The model suggests an almost one-for-one relationship between employment and house prices, but lesser relationship for rental prices.

In the traditional business cycle literature the sources of economic fluctuations are shocks to total factor productivity. A simple way to integrate some of these features is to consider an unexpected and permanent decline in the productivity of consumption goods, A_c. Declines of 5 and a 10 percent in productivity generates a declines similar declines in house values. The model linearity also suggests a one-for-one decline. However, in this case the response in the rental market is very different than the case of employment. Figure 7 compares the levels of the value of housing capital for the data and the model predictions for different scenarios.

Figure 7 Housing Boom-and-Bust Cycle: Data and Model Predictions



Depending on the assumption, it is clear that the model can generate boom-and-bust cycles of similar magnitude as the data. With respect to the bust cycle, the model also suggests that the combined effects of higher mortgage rates, lower levels of employment, and reduced productivity can have large and devastating effects on the value of housing capital. Some conservative predictions suggest declines between 24 and 29 percent. The current adjustment in house prices in Spain is still far from these magnitudes. However, it is not clear that the current values will be sustained in the long run.

5. Conclusions

The paper develops a quantitative model to account for the change in the level of house prices in Spain. An important element in understanding the increase in the value of the residential capital stock is the existence of a fixed factor — land — that interacts with residential investment. The proposed model can rationalize 84 percent increase in the value of the housing stock and an 82 percent in the increase in the value of land. The contribution of each factor with respect to 1995 prices assigns rougly 33 percent to demographics and low interest rates, respectively, and 7 percent to land restrictions. However, these single contributions ignore the interaction of the combined effects that is essential to understanding the housing boom. The model is used to perform some counterfactual exercises to determine the magnitude of the housing boom and residential investment had these factors been different. The model suggests that the housing boom would have been 25 percent lower if mortgage rates had been 200 basis point higher.

One of the challenges going forward is understanding the housing bust. That process requires identifying the relevant sources that changed around 2007 and consequently modified households' expectations about the path of future prices. Some preliminary findings suggest that the combined effects of higher mortgage rates, unemployment, and low productivity can have large effects on the value of housing capital. Some conservative predictions suggest adjustments that can easily range between 24 and 29 percent.

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7. Appendix

7.1. First-Order Conditions of the Consumer Problem and Pricing Functions

Let λ_t represent the Lagrange multiplier of the budget constraint. The first-order conditions of the consumer problem with respect to $\{c_t, s_t, B_{t+1}, H_{t+1}, L_{t+1}\}$ imply in the case of an

interior solution:

$$\beta^t u_1(c_t, s_t) = \lambda_t, \tag{7.1}$$

$$\beta^t u_2(c_t, s_t) = \lambda_t R_t, \tag{7.2}$$

$$\lambda_t = \lambda_{t+1}(1 + r_{t+1}), \tag{7.3}$$

$$q_t \lambda_t = \lambda_t R_t g_1(H_{t+1}, \chi_t L_{t+1}) + q_{t+1}(1 - \delta)\lambda_{t+1}, \tag{7.4}$$

$$v_t \lambda_t = \lambda_t R_t g_2(H_{t+1}, \chi_t L_{t+1}) + v_{t+1}\lambda_{t+1}. \tag{7.5}$$

The characterization of the prices for structures and land requires substituting the values of the Lagrange:

$$q_t = \frac{u_2(c_t, s_t)}{u_1(c_t, s_t)} g_1(H_{t+1}, \chi_t L_{t+1}) + q_{t+1}(1 - \delta)\frac{\beta u_1(c_{t+1}, s_{t+1})}{u_1(c_t, s_t)}, \tag{7.6}$$

$$v_t = \frac{u_2(c_t, s_t)}{u_1(c_t, s_t)} g_2(H_{t+1}, \chi_t L_{t+1}) + v_{t+1}\beta\frac{u_1(c_{t+1}, s_{t+1})}{u_1(c_t, s_t)}. \tag{7.7}$$

Iterating forward

$$q_t = \textstyle\sum_{\tau=0}^{\infty}(1 - \delta)^\tau m_{t+\tau}\dfrac{u_2(c_{t+\tau}, s_{t+\tau})}{u_1(c_{t+\tau}, s_{t+\tau})} g_1(H_{t+\tau+1}, \chi_{t+\tau} L_{t+\tau+1}), \tag{7.8}$$

and

$$v_t = \textstyle\sum_{\tau=0}^{\infty} m_{t+\tau}\dfrac{u_2(c_{t+\tau}, s_{t+\tau})}{u_1(c_{t+\tau}, s_{t+\tau})} g_2(H_{t+\tau+1}, \chi_{t+\tau} L_{t+\tau+1}). \tag{7.9}$$

Let $m_{t+\tau} = \beta^\tau u_c(c_{t+\tau}, s_{t+\tau})/u_c(c_t, s_t)$ represent the pricing kernel or the consumer-adjusted discount rate. In this economy, the equilibrium interest rate for any time period, $r_{t+\tau}$, is endogenously determined by the path of consumption over time:

$$\frac{1}{1 + r_{t+\tau}} = \beta^\tau \frac{u_c(c_{t+\tau}, s_{t+\tau})}{u_c(c_t, s_t)}.$$

Since the model prices housing services (or rents), $R_{t+\tau}$, the current market value of these assets is

$$q_t = \textstyle\sum_{\tau=0}^{\infty} Q_{ht+\tau} R_{t+\tau} g_1(H_{t+\tau+1}, \chi_{t+\tau} L_{t+\tau+1}),$$

$$v_{t+\tau} = \textstyle\sum_{\tau=0}^{\infty} Q_{Lt+\tau} R_{t+\tau} g_2(H_{t+\tau+1}, \chi_{t+\tau} L_{t+\tau+1}),$$

where $Q_{it+\tau} = 1$ and $Q_{it+\tau+1} = Q_{it+\tau}(1 - I_i\delta)(1 + r_{t+\tau+1})^{-1}$ represent the Arrow-Debreu discount prices for $i = h, L$. The depreciation term has been embedded in the term that

represents the discount rates, where the indicator takes two values $I_h = 1$ and $I_L = 0$.[7]

7.2. Equilibrium with Housing Policy

The baseline economy does not consider the role of housing policy. However, the basic model can easily accommodate the introduction of tax subsidies for consumers and producers.

Definition (Competitive Equilibrium with Housing Policy): *Given a sequence of productivity* $\{A_{ct}, A_{ht}, \chi_t\}_{t=0}^{\infty}$, *and housing policy* $\pi = \{T_t, \theta_t, , s_{xt}, , \tau_t^{IVD}, \tau_t^{L}, \tau_t^{LS}, \tau_t^{HS}\}_{t=0}^{\infty}$, *an equilibrium comprises allocations* $\{c_t, s_t, B_{t+1}, H_{t+1}, L_{t+1}, N_{ct}\}_{t=0}^{\infty}$ *and prices* $\{q_t, v_t, R_t, r_t, p_{xt}, w_t\}_{t=0}^{\infty}$ *that solve the following conditions:*

1. *The consumer's optimization problem,*

$$\max \textstyle\sum_{t=0}^{\infty} \beta^t u(c_t, s_t) N_t,$$

$$\begin{aligned} s.t. \qquad & N_t c_t + B_{t+1} + (1+\tau_t^{IVD}) q_t H_{t+1} + v_t(L_{t+1}(1+\tau_t^{L}) - L_t(1-\tau_t^{LS})) = w_t N_t^w + ... \\ & (1+r_t)B + q_t(1-\delta)H_t(1-\tau_t^{HS}) + R_t(g(H_{t+1}, \chi_t L_{t+1}) - (1-\theta_t)s_t N_t) + T_t, \quad (7.10) \\ & H_0, L_0, B_0 \geq 0. \end{aligned}$$

2. *Firms' producing consumption goods optimize profits,*

$$\max_{N_{ct}} A_{ct} N_{ct} - w_{ct} N_{ct}, \qquad \forall t.$$

3. *Firms' producing housing capital maximize profits,*

$$\max_{N_{ht} \in R_+} (1+s_{xt}) p_{ht} A_{ht} N_{ht} - w_{ht} N_{ht}.$$

4. *Government budget constraints*

$$T_t + \theta_t s_t N_t + s_{xt} p_{ht} x_t = \tau_t^{IVD} q_t H_{t+1} + \tau_t^{L} v_t L_{t+1} + \tau_t^{LS} v_t L_t + \tau_t^{HS} q_t (1-\delta) H_t.$$

5. *All markets clear*

   1. *Labor markets:* $N_t \geq N_t^w = N_{ct} + N_{ht}$,
   2. *Goods markets:* $N_t c_t = A_{ct} N_{ct}$,

[7] In a closed economy, the sequences for $R_{t+\tau}$ and $r_{t+\tau}$ are simultaneously determined.

3. *Land markets:* $L_{t+1} = L_t = \overline{L}$,

4. *Bond market:* $B_{t+1} = 0$,

5. *Rental market:* $N_t s_t = g(H_{t+1}, \chi_t L_{t+1})$,

6. *Market for structures:* $H_{t+1} = x_t + (1 - \delta)H_t$.