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Determinants of the Spanish housing market over three decades and three booms. Long-run supply and demand elasticities

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Abstract:

This paper offers a quantitative analysis of housing supply and demand in Spain. To this end, it formulates a model in line with the traditional models of the literature. Using Spanish data for the period 1975 to 2009, reduced form and structural models are estimated. The results obtained show that faced with situations of disequilibrium prices adjust more rapidly than stock. Similarly, they demonstrate that demand shows low sensitivity to variations in prices and real interest rates. By contrast, it is highly sensitive to demographic changes and the evolution of the labor market. The evidence confirms that permanent income has greater weight than prices as a determinant of demand. Moreover, supply is very sensitive to variations in prices and interest rates.

Keywords: housing booms, demand, supply, elasticities

JEL code: R21, R31

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1. Introduction

This paper analyzes the determinants of housing supply and demand in Spain in the period 1975 to 2009. During this third of a century, the Spanish housing market underwent three housing booms (Naredo, 2004). The first of these began in the early 1970s and ended in 1973, coinciding with the oil crisis. During this period approximately 500,000 dwellings were built annually. The second boom took place between the mid-1980s and the early 1990s. The end of this bubble was partly caused by the successive devaluations of the peseta and the adjustments to correct the foreign deficit of the Spanish economy (Naredo, 1996). At its peak, around 400,000 dwellings per year were constructed, double the figure at the start of the period, and prices increased by 69% (Naredo, 1996, 2004). The latest boom, more intense than the two previous ones, began in 1997 and ended in 2008, coinciding with the onset of the international financial crisis. In those eleven years, the housing stock increased by 50%, with an annual rate of construction of 500,000 dwellings; at its peak in 2006 a figure close to 700,000 was reached. Approximately 40% of all dwellings constructed in the EU in this period were located in Spain, despite the average price per square meter multiplying, in nominal terms, by 2.9, from 694.5 Euros in 1996 to 2,018.50 Euros in 2008.

The bursting of the latest boom is having strongly negative consequences for the Spanish economy, due to the heavy weight which construction has had in GDP, reaching a maximum figure of 12.6% in 2006. Its immediate effect has been a sharp reduction in the gross added value generated by the construction sector, which fell by 6.3%, 17.6% and 5.9% in the years 2008 to 2010. The negative effects produced by this rapid deceleration of the construction sector have spread both to the rest of the real economy and to the financial sector of the Spanish economy; in 2012 the Eurogroup approved help of up to 100 billion Euros to restructure Spanish banks and savings banks in difficulties. As a result, the lack of growth of the Spanish economy, the existence of an unemployment rate of close to 25% -60% of the unemployment produced between 2007 and 2010 originated in the construction sector (Banco de España, 2010)- and the rapid deterioration of public finances (debt rose from 36.3% in 2006 to 69.3% in 2011, while the deficit reached 11.2% in 2009) have, since the summer of 2010, situated Spain in the epicenter of the international economic crisis.

The mid-1990s saw an intensification of the debate regarding the size, causes and possible effects of the property boom in which the Spanish economy was immersed. Initially, the greatest emphasis was placed on the sharp rise in prices. Thus, Ayuso and Restoy (2003) and Martínez and Maza (2003) estimated that housing prices were overvalued by between 8% and 20%, while BBVA Research (2002), García Montalvo (2003) and The Economist (2003a, b) gave this range as between 28% and 50%. Other studies, nevertheless, have offered evidence that expectations of rising house prices, the sharp reduction of interest rates, greater laxity in the access to bank financing or the considerable increase in the immigrant population were behind the origins of the property cycle (García Montalvo, 2006, 2007; Martínez et al., 2006; Rodríguez, 2006; Ferraz, 2006; García Montalvo and Raya, 2012). Much less attention has been paid to the joint study of the determinants of housing supply and demand in the long run. Only Sawaya (2005) and Taltavull (2006) have concentrated on studying supply and Fernández-Kronz and Hon (2006) on demand.

Given this context, this study furthers the empirical literature on the housing market in Spain, jointly analyzing the determinants of supply and demand. The purpose of the research is dual. Firstly, employing the methodological approach of DiPasquale and Wheaton (1994), an estimation is made of the elasticities of supply and demand, paying special attention to prices, income, interest rates and population. Secondly, an analysis is performed of the speed at which housing prices and stock adjust to situations of disequilibrium, such as that existing after the bursting of the bubble in 2008. This is an extremely important question, given that the stock of new housing waiting to be sold is, since 2009, close to 700,000 dwellings (Ministerio de Fomento, 2012a).

The study is developed as follows. The following section offers an overview of the evolution of the Spanish housing stock in the last three decades, and of its determining factors. Section 3 reviews the evidence available regarding housing elasticities. The theoretical framework is presented in Section 4. The fifth section describes the data employed. The results obtained are presented in the sixth and seventh sections. The study ends with a conclusions section.

2. The evolution of housing stock in Spain: stylized facts

Between the years 1975 and 2009 housing stock in Spain increased drastically. In real values[2], this stock multiplied by 2.6 in gross terms and tripled in net terms (Figure 1). To be more precise, the number of dwellings increased by 4.3 million units in the 1970s, 2.4 million in the 1980s, 3.3 million in the 1990s and 5.1 million in the last decade. In other words, the number of dwellings rose from 10.4 million units in 1970 to 25.8 million in 2010 (Tafunell, 2005; Ministerio de Fomento, 2012b). This process of rapid growth in housing stock has taken place in a context of intense price increases. In fact, Spain is among the group of OECD countries (together with the United Kingdom, Ireland, Australia, Norway or Finland, among others) in which prices increased most sharply between 1980 and 2008, with rates exceeding 90% (OECD, 2010). Figure 2 clearly shows the steep rise in housing prices from 1975[3]. Similarly, for illustration, Figure 3 compares the evolution of housing prices and the cost of living, the latter measured by the Consumer Price Index (CPI). As can be seen, housing prices increased by less than the cost of living until the mid-1990s.

The increase in stock and real housing prices from the mid-1990s on is the result of a strong simultaneous pressure of supply and demand factors. One such factor is the increase in population. During the Spanish baby boom, from 1950 to 1975, the population increased on average by 300,000 people annually. In the two following decades the situation became one of low growth; the minimum was reached in 1990, with an increase of 58,300 inhabitants annually. Figure 4 shows that growth intensified strongly from the end of the 1990s onwards. Specifically, a historic maximum of 805,000 was reached in 2007. The Spanish population increased in the 1980s and the 1990s by approximately 1.7 million inhabitants, while in the period between 2000 and 2008 the increase amounted to 5.6 million inhabitants. Behind this strong growth is, without a doubt, the increase in the immigrant population. The percentage of foreigners residing in Spain rose from 0.5% at the end of the 1970s to 12.2% in 2009.

Another of the factors affecting the evolution of the housing stock in Spain has been the improvement in the level of permanent income of Spanish households. As Figure 5 shows, since 1975 a constant increase in the per capita income of Spaniards has taken place, only

[2] Data elaborated by IVIE (see Mas et al., 2007).

[3] The price series employed in the present study has been constructed on the basis of Prados de la Escosura (2003), Uriel et al. (2009) and INE (2012).

checked by the current crisis and that of the early 1990s. Specifically, since the mid-1990s, the increase in per capita income has been accompanied by a significant improvement in the labor market, as reflected in the evolution of the unemployment rate. Between January 2005 and May 2008 the unemployment rate was below 10%, coinciding with a phase of strong economic expansion. Figure 6 shows that this figure is exceptionally low when compared with two recessionary periods of the economy, such as the 21% reached in 1994 or the 25% in 2012. As shall be seen later, the evolution of the unemployment rate has been one of the most important determinants of aggregate housing demand in Spain during the period analyzed.

With regard to the costs of financing housing, Figure 7 displays the evolution of mortgage interest rates, in both nominal and real terms. As can be seen, nominal mortgage interest rates were maintained above 10% between 1975 and 1993, reaching a figure of 16.91% in 1982. However, at the end of the 1990s a rapid and constant fall commenced, from 15.6% in 1990 to 3.2% in 1999. Without a doubt, the adoption of the euro has meant a drastic interest rate reduction for Spain.

Cultural factors must be taken into account in the analysis of housing demand in Spain. Traditionally, Spaniards have preferred purchase to renting, not only as a consumer good but also as an instrument of investment and wealth maintenance. Following Naredo et al. (2009), in 2000 Spanish households held 69% of their wealth in property assets and only 9% in shares. The data available show that 83.2% of Spanish households own one or more dwellings, a figure slightly above that of Ireland (81.2%) and far higher than that of countries with higher per capita income, such as the United Kingdom (70.7%), the United States (68.7%), Germany (41.0%) or Switzerland (38.4%) (see Andrews and Caldera, 2011). Given this context, the objective of this study is to quantify all those effects which the descriptive analysis provided in this section appears to show. The objective is to estimate the determinants of housing stock in Spain, and further to differentiate between supply and demand components.

3. **Literature review**

This section offers a review of the long-term elasticities of housing supply and demand. Table 1 presents evidence obtained with structural models for a selection of developed countries, the majority of the literature available referring to the United States. Following this, Table 2 displays the results available for Spain. A glance at the information contained in Table 1 reveals that the majority of the elasticities present a strong degree of dispersion[4] (for a discussion of the possible causes, see Meen, 2002).

3.1. International evidence: supply elasticities

In the United States, housing supply is more sensitive to price changes than in other developed countries (see Caldera and Johansson, 2011). Riddel (2004) and Ball et al. (2010) have obtained price elasticities lower than unity (0.26 and 0.48), using the housing stock and new construction as dependent variables. Other authors, such as Poterba (1984), Topel and Rosen (1988), DiPasquale and Wheaton (1994) and Blackley (1999) have obtained values exceeding unity with a flow approach. In the case of Topel and Rosen (1988) and Blackley (1999), the values computed have exceeded 2.0. The elasticities obtained for other developed countries have, in the majority of cases, been calculated from flow models. One exception is Mayer and Sommerville (2000) who, as do DiPasquale and Wheaton (1994), employ both approaches. In this case the price elasticity is far greater when the flow approach is used (3.7 compared to 0.08). For Switzerland, Steiner (2010) has obtained an elasticity exceeding unity, while for Ireland Kenny (2003) has obtained a range of values oscillating between 0.72 and 1.03.

The income elasticities of supply obtained for the United States are positive, although lower than unity, oscillating between 0 and 0.7 (DiPasquale and Wheaton, 1994; Malpezzi and Mclennan, 2001 and Riddel, 2004). These values are in line with the review performed by Mayo (1981) for the United States. Following this latter study, the range of elasticities varies from 0.25 to 0.81 when aggregate data are used and between 0.08 and 0.7 in the case of individual data. For the United Kingdom, the income elasticities obtained by Malpezzi and Maclennan (2001) were located between 0.72 and 1.43 in the 1947-1995 period.

Another of the explanatory variables habitually included in housing supply models are production costs (salaries, materials and land). Some studies estimate the elasticity of supply with regard to the joint growth of all these costs. The empirical evidence points to an

[4] A good example of these differences can be found in Lee, Schmidt-Dengler, Felderer and Helmenstein, 2001 for Austria; Kim Lum, 2002 for Singapore or Carreras i Solanas et al., 2004 for Spain.

elasticity lower than unity for such costs (Poterba, 1984; Blackley, 1999; Kenny, 2003; Ball et al., 2010). Nevertheless, there exist exceptions, such as Steiner (2010), who has obtained a value of -2.12 for Switzerland. Similarly, there exists a wide range of studies which find that supply is highly sensitive to increases in interest rates, with elasticities clearly exceeding unity (Topel and Rosen, 1988; Blackley, 1999; Mayer and Sommerville, 2000; Kenny, 2003 and Steiner, 2010). Lastly, the relationship between inflation and housing supply is also negative. Following Topel and Rosen (1988) and Blackley (1999), an increase of 1% in inflation reduces supply by 8%, while Poterba (1984) finds that this variation ranges between 0.93% and -3.13%.

3.2. International evidence: demand elasticities

With regard to demand, price elasticities given in Table 1 show a greater consensus than supply, with values below unity and ranging from -0.09 to -0.46 (DiPasquale and Wheaton, 1994; Knudsen, 1994; Lee et al., 2001; Riddel, 2004 and Steiner, 2010). In the case of the income elasticity of demand, the values obtained range between 0.25 and unity (Knudsen, 1994; Lee et al., 2001; Riddel, 2004 and Steiner, 2010). The evidence shows, therefore, that demand is more elastic to changes in income than to changes in prices. In addition to these variables, the behavior of demand can depend on population growth, the user cost of capital or the price of housing rental. For Austria, Lee et al. (2001) have estimated that housing stock elasticity with regard to the population over 20 ranges between 0.63 and 1.36. Concerning the user cost, Di Pasquale and Wheaton (1994) show that demand elasticity to the user cost of capital is -0.04, while for Riddel (2004) it is not significant. Lastly, Riddel (2004) has found that housing demand is sensitive to changes in rental prices, with an elasticity of 0.3, indicating that the two goods present a certain degree of substitutability. To end the international comparison, Table 1 offers evidence regarding the rhythm at which supply and demand are adjusted in situations of disequilibrium. The results obtained by Poterba (1984) and DiPasquale and Wheaton (1994) reveal that the rhythm of adjustment is very slow (approximately 11 years).

3.3. Evidence for the Spanish case

With regard to the literature available for the Spanish case, only three studies exist which estimate long-run elasticities for housing supply or demand, using structural models.

Employing data for the period 1987 to 2004, Taltavull (2006) estimates a price supply elasticity of 0.46. This value is slightly greater when only the data for the period 1993 to 1998 are used (1.4). This latter value is close to the range of 1.5 to 1.8 obtained for Spain by Sawaya (2005) for the period 1989 to 2000. As for income demand elasticities, the range of values obtained by Fernández-Kranz and Hon (2006) is between 0.75 and 0.95 for the period 1996-2002, coinciding with the onset of the last property boom. To illustrate, Table 2 offers in addition a review of short-term elasticities, computed using cross-section data. As can be observed, short-term income elasticities have progressively increased in recent decades: 0.6 in 1981, approximately unity in 1991 and between 0.9 and 1.3 in 1999 (Jaén, 1994; Manrique and Ojah, 2003 and Barrios and Rodríguez, 2008). The short-term price elasticity of demand ranges between a value close to zero and unity (Jaén, 1994 and Barrios and Rodríguez, 2008). Table 2 reflects the existence of considerable gaps in the long-term response of the Spanish housing market to shocks in prices, income, interest rates or population.

4. Empirical model

The model employed is based on the methodology proposed by DiPasquale and Wheaton (1994). It considers that housing demand (in terms of stock) depends on a set of exogenous variables (X_1), such as demographic variables, permanent income, etc. In addition, it depends on housing prices (P) and user cost (U). Thus:

$$D(X_1, P, U) = S_D \qquad (1)$$

Similarly, housing supply (in terms of stock) is determined following the differential equation:

$$\Delta S_S = C(X_2, P) - \delta S_s \qquad (2)$$

where housing stock depreciates at a rate δ and expands with new construction (C), which depends on the price of housing (P) and on a set of exogenous variables (X_2), such as production costs and financing costs.

For equilibrium to exist in the housing market, supply and demand must be equal, $S^* = S_S = S_D$, such that $P^* = P$. However, the presence of transaction costs and the existence of phenomena typical of this sector, such as the long period of time elapsing between the instant in which housing start decisions are taken and the moment at which they are finalized, mean that the housing market may be far from equilibrium over long periods of time (see DiPasquale and Wheaton, 1994, and Meen, 2002 and 2008). Thus, the prices and housing stock observed (P_O y S_O, respectively) are not generally in equilibrium. Nevertheless, it is to be expected that there exist movements in prices and housing stock towards that equilibrium, so that the disequilibria $\omega_1 = (S^* - S_O)$ and $\omega_2 = (P^* - P_O)$ move towards equilibrium. Consequently, the variations observed in both prices and housing stock are a function of the disequilibria ω_1 and ω_2, although they may also be a function of other exogenous variables, such as the lags in the variations of the distinct variables (X_3) and certain random disturbances (ε_1 y ε_2). Consequently:

$$\Delta S_O = f(S^* - S_O, X_3, \varepsilon_1) \quad (3)$$

$$\Delta P_O = g(P^* - P_O, X_3, \varepsilon_2) \quad (4)$$

The endogenous variables involved in the analysis (P and S) are not generally stationary; however, it is expected that the variables $\omega_1 = (S^* - S_O)$ and $\omega_2 = (P^* - P_O)$ are. Thus, the dynamic of the relationship between these variables and their adjustment, equations (3) and (4), can be tackled from the perspective of error correction models. If the existence of linearity is assumed (see, for example, DiPasquale and Wheaton, 1994, Meen, 2002, Riddel, 2004, or Andrews, Caldera and Johansson, 2011), the following is obtained[5]:

$$\Delta S_O = \alpha_1 + \beta_1 \left(S^*\left(P^*\right) - S_O \right) + \lambda_1 X_3 + \varepsilon_1 \quad (5)$$

$$\Delta P_O = \alpha_2 + \beta_2 \left(P^*\left(S^*\right) - P_O \right) + \lambda_2 X_3 + \varepsilon_2 \quad (6)$$

On the basis of equations (5) and (6), the dynamic of adjustment in the property market can be analyzed. The parameters β_1 and β_2 determine the speed at which the property market adjusts in situations of disequilibrium: β_1 for housing stock and β_2 for prices. The

[5] The formulation is equally valid if it is considered that the variables involved in the analysis are transformed logarithmically (see, for example, Meen, 2002 and Andrews et al., 2011). Obviously, what is indeed modified is the interpretation of the parameters.

empirical model is a linear formulation. On the basis of equations (1) and (2), the model is as follows:

$$S_D = \delta_0 + \delta_1 P + \delta_2 Pop + \delta_3 Income + \delta_4 Wealth + \delta_5 UserCost + \delta_6 Unemployment \quad (7)$$

$$S_S = \mu_0 + \mu_1 P + \mu_2 \, Production\cos ts + \mu_3 Financial \cos ts \quad (8)$$

With the expected signs:

$$\delta_1, \delta_5 \; y \; \delta_6 < 0 \qquad \delta_2, \delta_3 \; y \; \delta_4 > 0$$

$$\mu_1 > 0 \qquad \mu_2 \; y \; \mu_3 < 0$$

Equation (7) shows that demand in real terms for housing stock depends on its real prices (*P*), on population factors (*Pop*), on the evolution of the permanent income of households (*Income*) and on their wealth (*Wealth*), on the user cost (*UserCost*) and on the labor market situation, approximated, for example, through some measure of unemployment (*Unemployment*). Equation (8) shows that supply is determined by price levels, by the costs of the production and rehabilitation of dwellings (*Productioncosts*) and by the costs of financing of housing investment projects (*Financialcosts*). The selection of the variables determining supply and demand are in full accordance with the suggestions of economic theory and the usual assumptions in the empirical literature on the analysis of the housing market (see, for example, DiPasquale and Wheaton, 1994, and Meen, 2002 and 2008). Considering the situation of equilibrium, in which $S^* = S_S = S_D$ and $P^* = P$ and resolving the system, the following equations are obtained:

$$S^* = \pi_{10} + \pi_{11} Pop + \pi_{12} Income + \pi_{13} Wealth + \pi_{14} User\cos t + \pi_{15} Unemployment + \\ + \pi_{16} \, Production\cos ts + \pi_{17} Financial \cos ts \quad (9)$$

$$P^* = \pi_{20} + \pi_{21} Pop + \pi_{22} Income + \pi_{23} Wealth + \pi_{24} User\cos t + \pi_{25} Unemployment + \\ + \pi_{26} \, Production\cos ts + \pi_{27} Finantial \cos ts \quad (10)$$

With the expected signs:

$$\pi_{11}, \pi_{12} \; y \; \pi_{13} > 0 \qquad \pi_{14}, \pi_{15}, \pi_{16} \; y \; \pi_{17} < 0$$

$$\pi_{21}, \pi_{22} \; y \; \pi_{23} > 0 \qquad \pi_{25} < 0 \qquad \pi_{24}, \pi_{26} \; y \; \pi_{27} \leq \geq 0$$

Substituting (9) and (10) into equations (5) and (6), the equations constituting the initial base of the estimations are obtained:

$$\Delta S_O = \gamma_{10} + \gamma_{11} Pop + \gamma_{12} Income + \gamma_{13} Wealth + \gamma_{14} User\cos t + +\gamma_{15} Unemployment + \gamma_{16} \Pr oduction \cos ts + \gamma_{17} Financial \cos ts - \beta_1 S_O + \lambda_1 X_3 + \varepsilon_1 \quad (11)$$

$$\Delta P_O = \gamma_{20} + \gamma_{21} Pop + \gamma_{22} Income + \gamma_{23} Wealth + \gamma_{24} User\cos t + \gamma_{25} Unemployment + \gamma_{26} \Pr oduction \cos t + \gamma_{27} Financial \cos ts - \beta_2 P_O + \lambda_2 X_3 + \varepsilon_2 \quad (12)$$

Moreover, when modeling the adjustment towards the situation of equilibrium it is considered, in line with usual practice in the literature (DiPasquale and Wheaton, 1994, Malpezzi and Mclennan, 2001, or Riddel, 2004) that the process of adjustment is determined by the disequilibrium between $(S_t^* - S_{O(t-1)})$ and $(P_t^* - P_{O(t-1)})$, such that in (11) and (12) S_O and P_O are lagged.

As can be observed, (9) to (12) are reduced forms equations. With the exception of the parameters β_1 and β_2, which determine the speed at which the property market adjusts to situations of disequilibrium, the remaining parameters of equations (9) to (12) have no structural interpretation. The estimation of the elasticities of housing stock supply and demand is obtained on the basis of equation (5), employing in that estimation a consistent approximation of P^*.

5. Data

The variables employed are in full accordance with the empirical model proposed in the previous section. Appendix 1 presents the definition of the variables and their source. With regard to the dependent variable, employment is made of gross housing stock in real terms[6], whose evolution has already been presented in the second section. The sample period covers the years 1975 to 2009, although when the household financial wealth variable is introduced into the analysis it is necessary to restrict the sample to the period 1989-2009, due to lack of data. The total population is employed as the demographic

[6] The model was also estimated on the basis of real net stock (see Appendix III), obtaining results similar to those obtained with gross stock.

variable[7]. To measure permanent income, GDP per capita was considered[8]. The measurement of household wealth employed is real financial wealth, calculated on the basis of the financial wealth elaborated by Banco de España. With regard to the user cost of capital, the measurement proposed in Poterba (1992) was used initially; this incorporates the marginal rate of income tax, but this measurement was not statistically significant. Consequently, it was decided to include a proxy variable of the user cost of dwellings: real mortgage interest rates. To measure the labor market situation the unemployment rate was used[9]. An index of construction materials costs, deflacted by the CPI, and real mortgage interest rates were employed for the production and financial costs of housing supply (see Appendix I).

6. Results of the estimation of the reduced form equations

As a starting point for the empirical study the univariate properties of the variables employed were analyzed. The results of the unit root tests performed (see Appendix II) show clear evidence in favor of the non-stationary character of the processes generating the variables considered in the study, whether in levels or in logarithms. This characteristic conditions not only the econometric analysis performed but also the interpretation of the model summarized in equations (11) and (12). In other words, verification must be made of the possible existence of a long-term equilibrium relationship between prices and housing stock observed and their determinants.

The empirical literature provides models of determination of housing supply and demand not only in levels (DiPasquale and Wheaton, 1994, or Blackley, 1999) but also in logarithms (Riddel, 2004, or Meen, 2002). The present study has opted for a logarithmic formulation[10], which permits the interpretation of the structural parameters estimated in terms of elasticities[11]. In this regard, Tables 3 and 4 show the estimations obtained for equations (11)

[7] The number of annual marriages variable was also considered, as a measure of the creation of households, as it was assumed that the creation of households potentially generates a need for housing. Finally, this variable was not included in the study because it was not statistically significant.

[8] Other possibilities were considered, such as GDP or private consumption. However, the variable which produced the best results was GDP per capita.

[9] Other options were also contemplated, namely employment and unemployment. The most satisfactory result was that obtained using the unemployment rate.

[10] As is habitual in the literature, the logarithmic formulation does not transform the variables expressed into rates such as the unemployment rate or interest rates.

[11] Models with variables in levels were also estimated; these provided good empirical results and are available upon request.

and (12), respectively[12]. As indicated earlier, two sample periods were employed, according to whether the study incorporated (columns III to V of Tables 3 and 4) or not (columns I and II of Tables 3 and 4) a measure of household wealth. Before undertaking the economic interpretation of the results obtained, it would be useful to comment, from the econometric point of view the following results:

(i) Given the non-stationary character of the exogenous variables of the models, the significance of the lag of housing stock and of prices in the respective equations constitutes evidence of the possible existence of a long-term equilibrium relationship between equilibrium stock and that observed and between equilibrium prices and those observed[13].

(ii) Production costs are lagged because they were not contemporaneously significant. This is possibly due to the very nature of the construction industry, where lags are common between changes in costs and in construction activity (see Andrews et al., 2011).

(iii) A simple way of analyzing the possible omission of dynamics in the relationship and, where applicable, modeling it, is to study the existence of autocorrelation in the disturbances of the models estimated and to formulate simple structures of autocorrelation. For that reason, each of the models estimated presents residual autocorrelation tests, and even, as an additional test of possibly poor dynamic specification, the models are overparameterized, incorporating autocorrelation structures. In any case, the results obtained show little evidence to justify in the models estimated the incorporation of lags of the differenced variables.

(iv) The inclusion of a measure of real household financial wealth (columns III to V of Tables 3 and 4) was unsatisfactory for two reasons. Firstly, because this means considerably reducing the sample size, with the implications this has from the point of view of the properties of the estimators. Secondly, because the real financial wealth variable is not always significant. Additionally, when it is significant (column (III) of Table 3), it does not

12 As indicated in the model, stock is expressed in gross terms. Complementarily, estimations were performed with stock in net terms (Appendix III). Results are in full accordance with those obtained when employing gross stock.

13 Cointegration tests were performed between determinants of the reduced form equations and the lags of stock and prices observed. These tests confirmed, at least for the model estimated with the sample 1975-2009, evidence of the existence of a possible long-term equilibrium relationship (see Table II.2 of Appendix II).

appear to display a very different effect to that captured by GDP per capita, which becomes non-significant[14].

Taking all these considerations into account, the final decision was to take as reference models those estimated for the sample period 1975-2009; these appear in column (I) of each table. Thus, and with regard to the economic interpretation of the results, it must be emphasized firstly that, in the context of the equilibrium equations (11) and (12), the signs obtained for the effects of the different variables coincide with expectations. For example, increases in the population, in permanent income and in wealth produce increases in the long-term housing stock, while rises in real interest rates, in production costs and in the unemployment rate reduce gross housing stock (see column I of Table 3). With regard to the models for variations in real housing prices, given in Table 4, the results show that with the exception of the effect of the variable which measures permanent income, the explanatory variables have the expected sign, although in this case GDP per capita is not statistically significant (see column I of Table 4). Nevertheless, the reduced form character of these models does not permit a structural interpretation of these relationships to be given.

Furthermore, it is of great interest to study the parameters which represent the factors of adjustment towards equilibrium, of both gross stock and of prices. A very interesting conclusion, although predictable, is that the adjustment process is much slower for stock than for prices. In this regard, it is useful to measure the average lag which elapses since a change occurs in stock and equilibrium prices until its complete transmission to the stock and prices observed. The stock adjustment period is approximately 13 years, while for prices it is about 2 or 3 years. Behind this result is the rigidity inherent in the production/consumption of dwellings. As is well known, it is impossible to construct a dwelling from one day to the next, and nor can it be made to disappear overnight. Furthermore, as housing is an investment and durable consumption good, it is fitting to expect that agents adjust prices more rapidly than housing stock, anticipating future rises and falls in long-term equilibrium prices to increase or decrease capital gains or losses.

[14] When a measure of wealth is included, the evidence of the existence of a long-run equilibrium relationship diminishes notably (see Table II.2 of Appendix II). It is possible that this result is not unconnected to the small sample size.

7. Structural approximation: estimation of elasticities

As stated, the parameters of equations (11) and (12) have no structural interpretation, except for the parameter which measures adjustment speed. Consequently, to identify and estimate consistently the supply and demand elasticities of the stock of dwellings the following strategy has been followed: 1) A consistent approximation of P^* was obtained on the basis of (10) and with the estimations of the parameters of the reduced form equation (12). Thus, assuming that $\alpha_2 = 0$, the following is obtained:

$$P^* = \frac{1}{\beta_2}(\gamma_{20} + \gamma_{21} Pop + \gamma_{22} Income + \gamma_{23} Wealth + \gamma_{24} User\cos t + \gamma_{25} Unemployment \\ + \gamma_{26} \Pr oduction \cos ts + \gamma_{27} Financial \cos ts) \quad (13)$$

2) The structural parameters of the demand and supply functions are estimated on the basis of equation (5), employing (13) and equations (7) and (8) respectively. In this way, for the demand equation, the following is obtained:

$$\Delta S_O = \gamma_{10} + \beta_1\delta_1 P^* + \beta_1\delta_2 Pop + \beta_1\delta_3 Income + \beta_1\delta_4 Wealth + \beta_1\delta_5 User\cos t + \\ + \beta_1\delta_6 Unemployment - \beta_1 S_O + \lambda_1 X_3 + \varepsilon_1 \quad (14)$$

And for the supply equation it holds that:

$$\Delta S_O = \gamma_{10} + \beta_1\mu_1 P^* + \beta_1\mu_2 \Pr oduction \cos ts + \beta_1\mu_3 Financial \cos ts \\ - \beta_1 S_O + \lambda_1 X_3 + \varepsilon_1 \quad (15)$$

Estimating (14) and (15), and once estimations of β_1 are available, consistent estimations of the structural parameters of demand and supply can be obtained[15].

Table 5 displays the estimations of models (14) and (15), without imposing the estimations of adjustment speed (β_1) obtained previously (columns I and III) and imposing such estimations (columns II and IV). Next to each of the columns are presented the estimations of the respective long-term elasticities. The housing stock demand elasticities

[15] It should be noted that as the approximation of P^* is obtained from the reduced form (12), in equations (14) and (15) there is no problem of simultaneity, and thus the habitual estimators of least squares are consistent.

have the expected signs and are statistically significant, while those of supply, although they always have the expected sign, are only significant when the adjustment speed β_1, obtained from the reduced form, is imposed.

The conceptual framework proposed appears to function better, from the econometric point of view, for demand than for supply. For demand, the estimated values of the parameters are very similar, independently of whether the value of the adjustment speed is imposed, while this does not occur for supply. Furthermore, the autocorrelation tests show no indication of poor specification in the case of demand, while for supply there exist doubts, especially when the value of the adjustment speed is imposed.

The results show that demand is in the long term much less sensitive to prices than is supply. As can be seen in Table 5, the price elasticities for demand have been -0.156 and -0.165, according to whether the adjustment speed is imposed or not. This is close to the -0.16 obtained by Steiner (2010) for Switzerland, but clearly below those estimated in other European countries such as Austria or Denmark (Knudsen, 1994; Lee et al., 2001), which are approximately -0.40. Possibly, this lower sensibility of housing demand to prices in Spain is related to the unusual preference of Spaniards for home ownership, in comparison to its surrounding countries, a circumstance to which allusion was made at the beginning of this paper.

Moreover, the estimations of the price elasticity of supply are considerably different according to whether or not the adjustment speed is imposed; these are 1.309 and 0.433 respectively. The first of these values is very close to the 1.35 obtained for Switzerland in the work of Steiner (2010). Such a value is slightly lower than the estimations of Sawaya (2005) for the Spanish economy, which are in the range of 1.51 to 1.83 for the period 1989 to 2000. The second of the values estimated in the present study is very similar to the 0.46 obtained by Talltavul (2006) for the Spanish economy in the period 1987-2004. Similarly, the price elasticities of supply and demand of the present study are similar to those of DiPasquale and Wheaton (1994) for the United States.

The estimations of the long-run income elasticity of demand were 0.50 and 0.51. Such values are in line with the evidence available for Spain. Specifically, between the 0.46 obtained by Talltavul (2006) and the range of 0.75 to 0.95 obtained by Fernández-Krantz and Hon (2006). One aspect worthy of emphasis is that, as seen in Section 2, both price elasticities and income demand elasticities are lower than unity. However, the results show that demand is more sensitive to changes in income than to changes in prices. A possible explanation of the low income elasticities obtained in the present paper is that the unemployment rate could be capturing part of that effect, due to its strong relationship to the cycle. The semielasticities computed of demand to the unemployment rate were -1.98 and -2.11. Consequently, an increase of one percentage point in the unemployment rate would reduce demand by approximately 2%. The evolution of the unemployment rate acts as a potential lever which increases or reduces housing demand. As seen in Section 2, this is an important question in a country such as Spain, affected by high rates of unemployment.

As in the case of prices, demand is much less sensitive to real interest rates than is supply. Specifically, the semielasticities of demand were -0.356 and -0.358, while in the case of supply the values obtained were -5.732 and -1.167. Supply shows great sensitivity to changes in real interest rates, with a value of -1.167. The existence of semielasticities of supply with regard to changes in interest rates clearly exceeding unity have also been observed in Spain (Sawaya, 2005), and similarly in the United States, Ireland, Switzerland and the United Kingdom (Topel and Rosen, 1988; Kenny, 2003; Steiner, 2010 and Mayer and Sommerville, 2000). Similarly, supply is sensitive to an increase in production costs when adjustment speed is imposed on the estimations. Specifically, the elasticity estimated is -0.69, in line with that obtained for the United States or Ireland (Blackley, 1999; Kenny, 2003).

Lastly, population size exerts considerable pressure upon demand, the elasticities obtained being 0.96 and 0.94. These values, exceeding in absolute value price and income elasticities, show that population increase has been a key factor in the third of the property booms analyzed. The elasticities obtained are in line with the range of 0.36 to 1.63 obtained for Austria by Lee et al. (2001).

8. Conclusions and public policy implications

This research has estimated housing supply and demand elasticities for Spain in the period 1975 to 2009. The results show that demand is in the long run very little sensitive to variations in prices and real interest rates. Conversely, demand is highly sensitive to the labor market situation and, to a lesser extent, to demographic changes. The results also reflect that demand is more sensitive to permanent income than to prices (in absolute values, 0.51 as against 0.16). The evidence therefore shows that the economic cycle effect, measured in terms of changes in income and in the unemployment rate, has a greater weight in the behavior of demand than do prices. Supply shows great sensitivity to variations in prices and interest rates. With regard to the situations of disequilibrium produced by the bursting of the bubbles, the evidence shows that price adjustment is produced at a much faster rhythm than housing stock adjustment, estimated to be a maximum of 13 years.

In the context of the far-reaching economic crisis in which Spain is immersed, these results will be useful for policymakers, to perform estimations of the rhythm at which the housing stock will reduce. In 2010, the number of new dwellings waiting to be sold amounted to 687,523 units, 47% of this stock is located in provinces close to the Mediterranean coast. In fact, the three provinces of the Autonomous Community of Valencia (Alicante, Castellón and Valencia) concentrate 19.3% of this stock. Thus, a large part of the stock is housing aimed at second homes. Given this context, the Management Company for Assets from Bank Restructuring (*SAREB*) will manage the sale of 89,000 dwellings from financial entities nationalized by the Spanish governments in recent years. The average discount for these dwellings (with regard to the original market value) will be close to 55%. Although the amount of this discount is great, the speed at which *SAREB* will reduce housing stock will depend on the response of possible purchasers to prices and income. The results of the present study provide little optimism regarding the rhythm of absorption induced by the purchases of Spanish residents. Firstly, because the rate of unemployment in 2013 will increase, according to the forecasts of the International Monetary Fund, by over 0.2 percentage points. However, other prestigious institutions, such as *FUNCAS*, predict the increase to be over 1 point. Secondly, because GDP will fall by approximately 1.5% in 2013, according to the estimations of the European Commission and the International Monetary Fund. Lastly, because disposable household income displays negative rates of evolution, falling at a rate of 3.2% in 2012.

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FIGURES & TABLES

Figure 1

Real value of housing stock

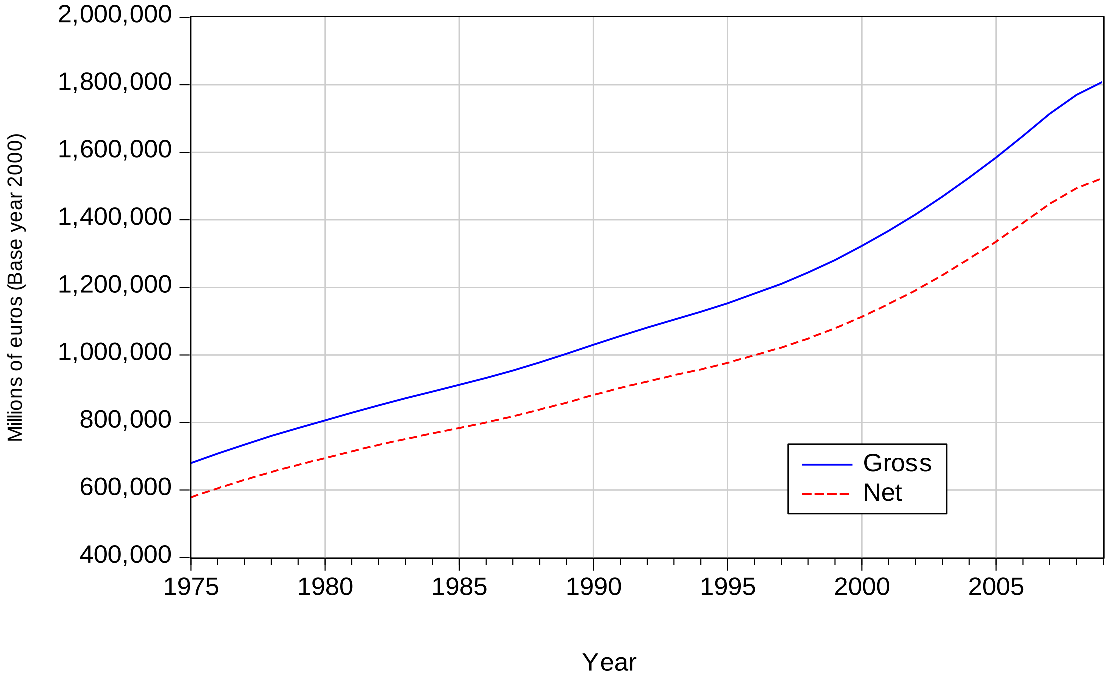

Figure 2

Housing prices

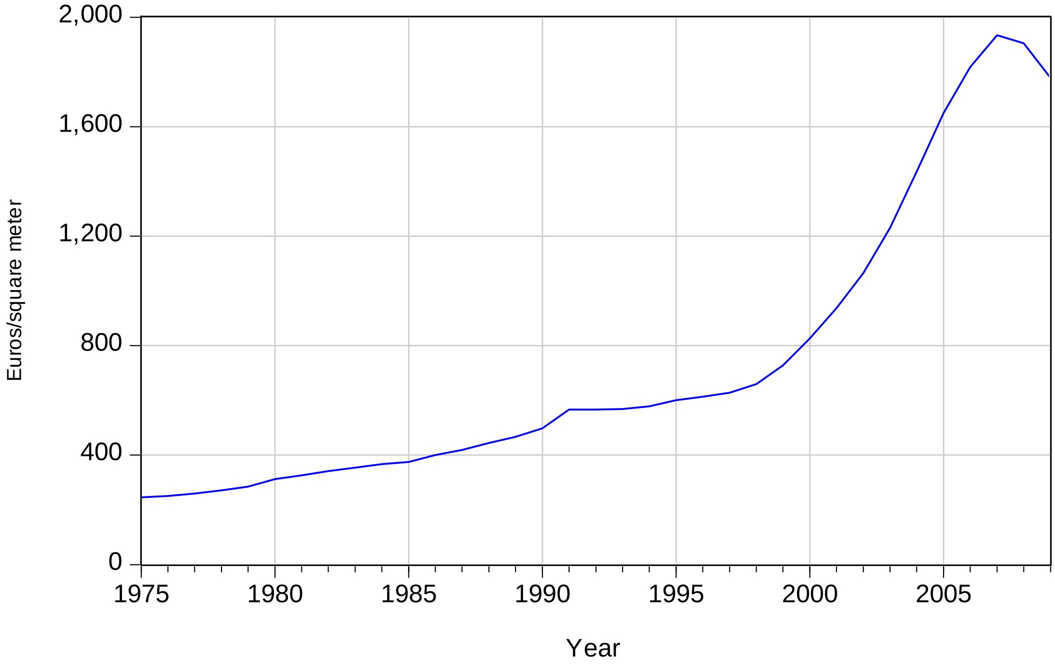

Figure 3

Housing price index deflacted by CPI

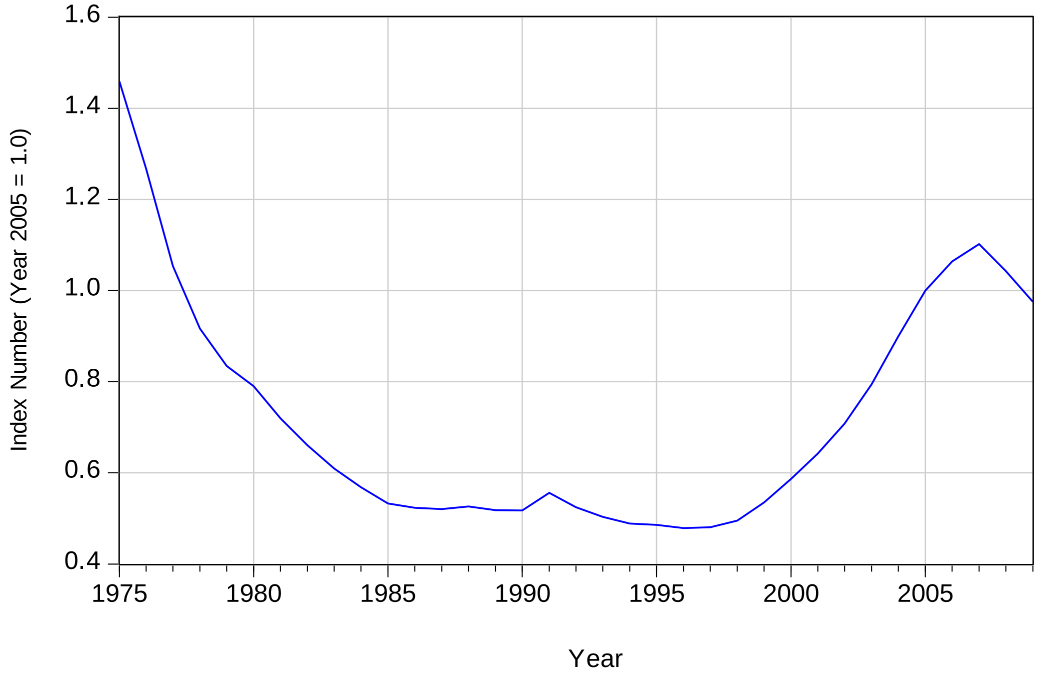

Figure 4

Total population

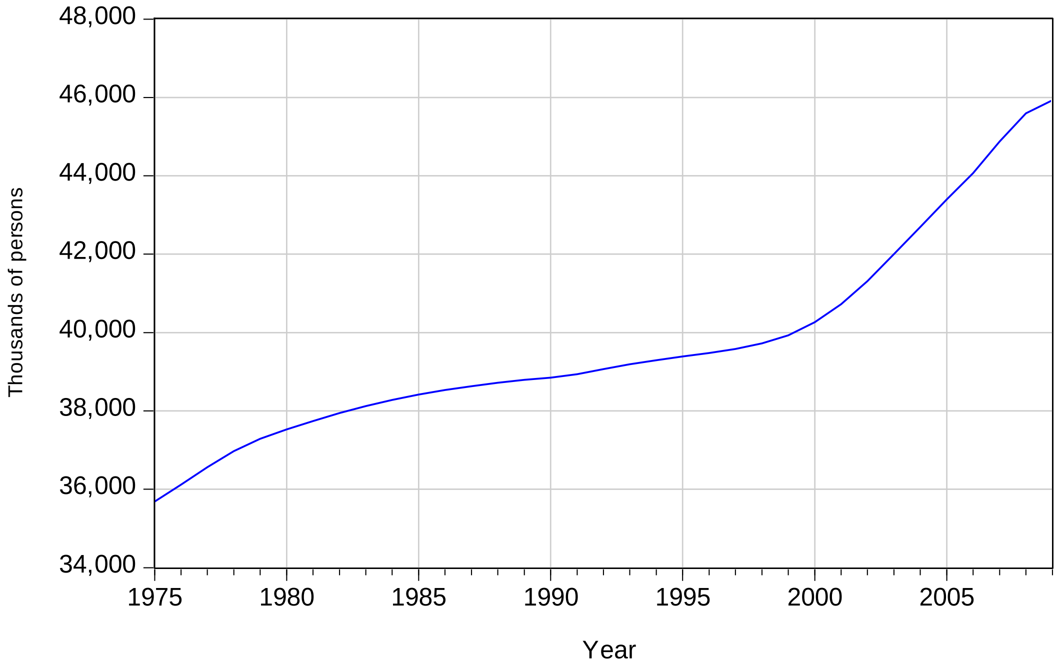

Figure 5

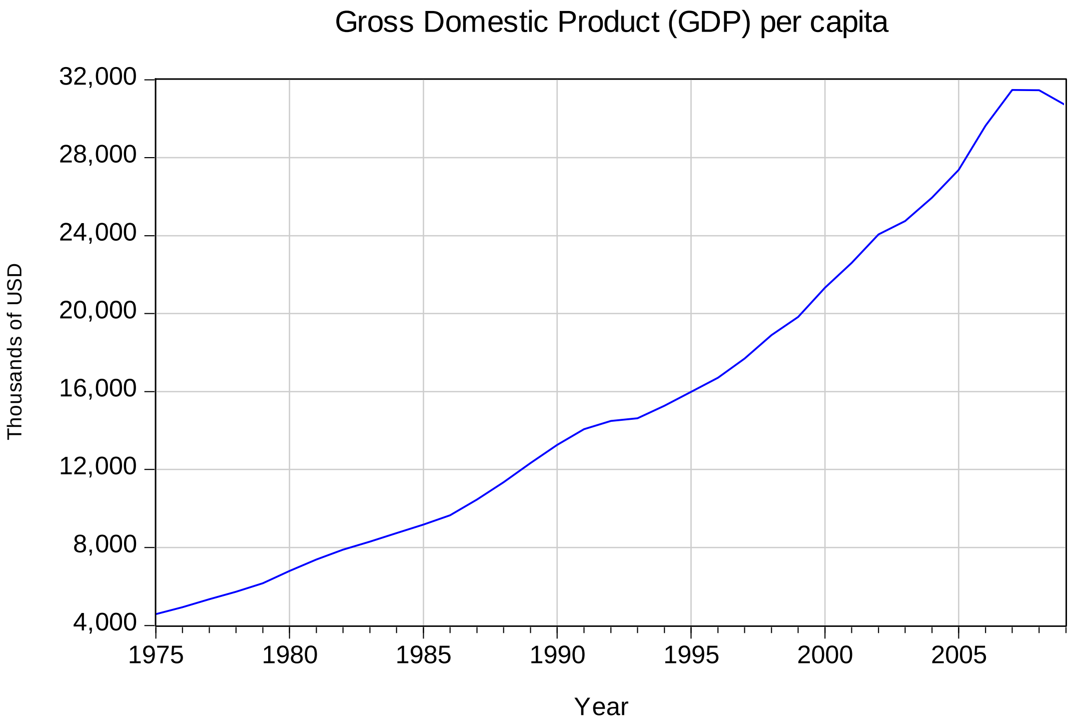
Gross Domestic Product (GDP) per capita
32,000
28,000
24,000
20,000
16,000
12,000
8,000
4,000
Thousands of USD
1975
1980
1985
1990
1995
2000
2005
Year

Figure 6

Unemployment rate

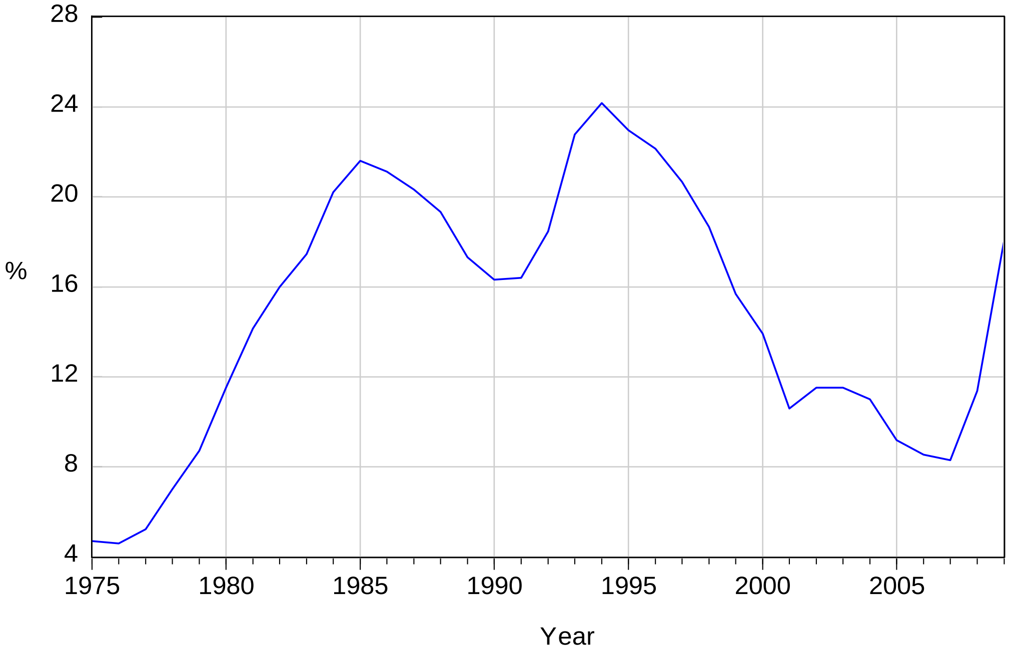

Figure 7

Mortgage rates

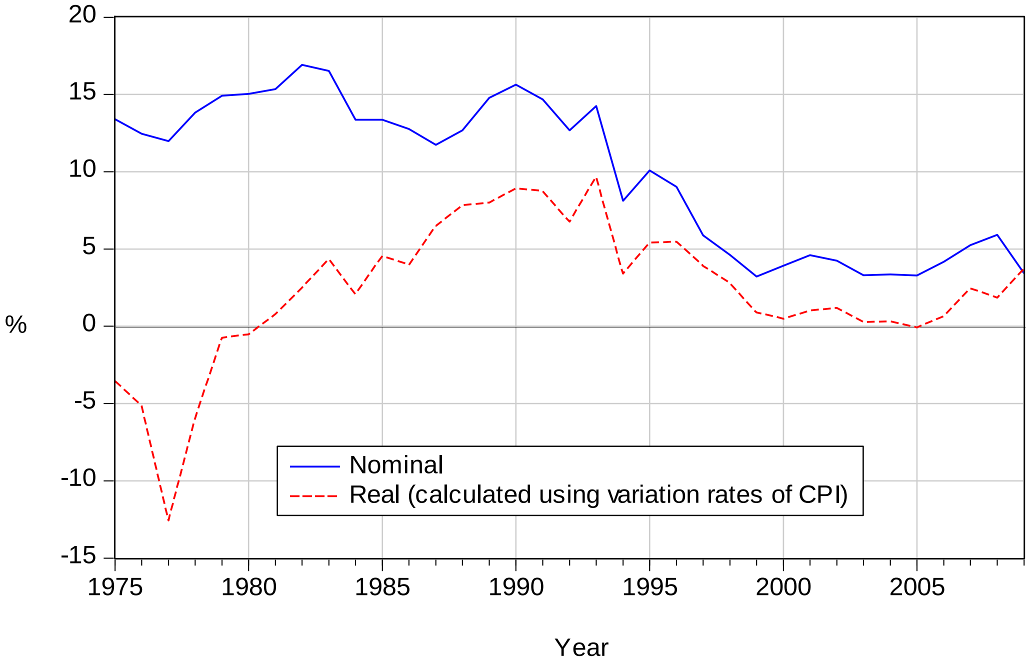

Table 1. International literature review: long-run housing supply and demand elasticities

Authors	Country Data	Elasticities					Stock adjustment process	Dependent variable
		Price		Income		Others		
		Supply	Demand	Supply	Demand			
1. USA								
Poterba (1984)	USA 1964-1982 (Q)	0.52 to 2.96	---	---	---	Non-residential construction deflator: -0.93 to -3.13 Real construction salaries: -0.20	11 years to reach equilibrium	Housing investment
Topel and Rosen (1988)	USA 1963-1983 (Q)	1.4 to 2.2	---	---	---	Annual interest rate: -8.0 Expected inflation rate: -8.0	---	New single family units started
DiPasquale and Wheaton (1994)	USA 1963-1990 (A)	1.0 to 1.2 1.2 to 1.4	-0.09 to -0.19	0.3 to 0.7		user cost of capital: -0.004	Very slow stock adjustment process (2% annually)	Housing starts/stock
Blackley (1999)	USA 1950-1994 (A)	2.0 to 3.3	----	----	----	Materials: -0.5 to -1.37 Real interest: -5.9 to -7.3 Inflation: 8.0	Fairly rapid movement to equilibrium	Residential construction
Malpezzi and Maclennan (2001)	USA 1889 -1994 (A)	(Pre-1947) 4 to 10 (Post-1947) 6 to 13	---	(Pre-1947) 0 (Post-1947) 0 to 0.68	---	----	----	New residential construction
Riddel (2004)	USA 1964-1999 (A)	0.26	-0.27	0.63	0.25	Demand - rental price Demand - user cost: not significant	Price increases reactivates supply, with a lag of two years	Stock of residential units
Ball et al. (2010)	USA 1970-2007 (Q)	0.48	---	----	---	Construction costs: -0.61 Short-term interest rate: -0.03	----	New construction
2. Other developed countries								
Ball et al. (2010)	Australia 1983-2008 (Q)	0.55	---	----		Construction costs: -0.92 Short-term interest rate: -0.01	----	New construction
Lee et al. (2001)	Austria 1969-1996	---	-0.37 to -0.46	----	0.74 to 1.23	Population under 20:	---	Residential capital stock

	(A)					0.63 to 1.36		
Knudsen (1994)	Denmark 1971-1987 (Q)	---	-0.4	---	1.0	---	---	Residential investment
Kenny (2003)	Ireland 1975-1998 (Q)	0.72 to 1.02	---	----	---	Interest rates: -1.16 to -2.19 Construction costs: -0.16 to -0.48	---	New private dwellings completed
Steiner (2010)	Switzerland 1975-2007 (A)	1.35	-0.16	---	0.91	Supply - construction costs: -2.12 Supply - real interest rate: -3.8	---	Housing stock
Mayer and Somerville (2000)	UK 1975-1994 (Q)	3.7 0.08	---	---	---	Interest rates: -3.49 to -4.85	---	Housing starts/stock
Malpezzi and Maclennan (2001)	UK 1850 – 1995 (A)	(Pre-1947) 1 to 4 (Post-1947) 0 to 1	---	(Pre-1947) 0 to 0.558 (Post-1947) 0.72 to 1.43	---	---	----	New residential construction

(A) annual data (Q) quarterly data

Table 2. Housing supply and demand elasticities in Spain

Authors	Data	Elasticities					Stock adjustment process	Dependent variable
		Price		Income		Others		
		Supply	Demand	Supply	Demand			
1. Long-run elasticities								
Sawaya (2005)	January 1989 to April 2000 (Q)	1.51 to 1.83	---	---	---	Interest rate: -1.5	---	Housing starts
Fernandez -Krantz and Hon (2006)	1996-2002 (A)(P)	---	---	---	0.75 to 0.95	---	---	Expenditure on housing
Talltavul (2006)	1987-2004 (Q)(P)	0.46	---	---	---	Interest rate: not significant Construction salaries: -2.26	---	Housing starts
2. Short-run elasticities								
Jaén (1994)	1981 (HS)	---	-0.97	---	0.62	---	---	Expenditure on housing
Manriquea and Ojah (2003)	1991 (HS)	---	---	---	0.88 to 1.0	---	---	Expenditure on housing
Barrios and Rodríguez (2008)	1999 (HS)	---	-0.002 to -0.4	---	0.9 to 1.3	---	---	Expenditure on housing

(A) annual data (Q) quarterly data (P) panel with aggregate data from 50 provinces (S) household survey

Table 3

Reduced form equation for real gross housing stock

	(I)	(II)	(III)	(IV)	(V)
Constant	0,194$^{(*)}$ (0,254)	0,188$^{(*)}$ (0,249)	-0,366$^{(*)}$ (0,664)	0,173$^{(*)}$ (0,711)	-0,137$^{(*)}$ (0,510)
$Stockb_{t-1}$	-0,069 (0,031)	-0,102 (0,030)	-0,110 (0,061)	-0,135 (0,060)	-0,137 (0,047)
Population	0,108 (0,054)	0,163 (0,051)	0,235 (0,071)	0,217 (0,080)	0,248 (0,046)
Real interest rates	-0,040 (0,015)	-0,047 (0,016)	-0,032$^{(*)}$ (0,027)	-0,010$^{(*)}$ (0,026)	-0,015$^{(*)}$ (0,021)
Real construction $costs_{t-1}$	-0,023$^{(*)}$ (0,013)	-0,026 (0,012)	-0,039 (0,017)	-0,050 (0,022)	-0,061 (0,013)
Unemployment rate	-0,106 (0,015)	-0,095 (0,013)	-0,100 (0,033)	-0,088 (0,034)	-0,099 (0,023)
GDP per capita	0,015$^{(*)}$ (0,014)	0,025 (0,012)	0,009$^{(*)}$ (0,037)	0,032$^{(*)}$ (0,037)	0,024$^{(*)}$ (0,028)
Real financial wealth	-	-	0,009 (0,004)	0,005$^{(*)}$ (0,006)	0,005$^{(*)}$ (0,003)
Parameter ρ_1 of an AR(1)	-	0,168$^{(*)}$ (0,205)	-	0,234 $^{(*)}$ (0,287)	-0,092$^{(*)}$ (0,231)
Parameter ρ_2 of an AR(2)	-	-		-	-0,306$^{(*)}$ (0,209)
Durbin-Watson	1,333	1,786	1,916	2,286	2,523
Ljung-Box (p-value). K=1 k=2 k=3	 0,262 0,283 0,371	 - 0,283 0,549	 0,932 0,183 0,321	- 0,019 0,024	- - 0,076
Sample size	34	34	21	21	21

Note: Variables in logarithms, except for interest rates and unemployment rate. Standard errors in parentheses. (*) variable non-significant at 5%.

Table 4

Reduced form equation for real housing prices

	(I)	(II)	(III)	(IV)	(V)
Constant	-13,952 (6,900)	-28,674 (8,638)	-53,780 (24,980)	-54,264 (14,330)	-50,610 (7,575)
Real housing prices$_{t-1}$	-0,297 (0,066)	-0,472 (0,092)	-0,577 (0,240)	-0,547 (0,139)	-0,493 (0,076)
Population	1,567 (0,808)	3,134 (0,968)	6,172 (2,764)	6,463 (1,578)	6,096 (0,833)
Real interest rates	0,077(*) (0,225)	-0,187(*) (0,229)	-0,450(*) (0,527)	-1,397 (0,368)	-1,807 (0,244)
Real construction costs$_{t-1}$	-0,423(*) (0,264)	-0,523 (0,245)	-1,335 (0,445)	-1,447 (0,265)	-1,310 (0,154)
Unemployment rate	-1,651 (0,337)	-1,992 (0,337)	-2,899 (0,702)	-3,084 (0,421)	-2,928 (0,234)
GDP per capita	-0,253(*) (0,187)	-0,448 (0,188)	-1,215 (0,498)	-1,375 (0,498)	-1,343 (0,140)
Real financial wealth	-	-	0,037(*) (0,086)	-0,022(*) (0,041)	-0,026(*) (0,021)
Parameter ρ_1 of an AR(1)	-	0,052(*) (0,180)	-	-0,910 (0,199)	-1,511 (0,211)
Parameter ρ_2 of an AR(2)	-	-	-	-	-0,794 (0,225)
Durbin-Watson	1,645	1,910	2,728	3,005	2,677
Ljung-Box (p-value). K=1 k=2 k=3	 0,431 0,535 0,412	 - 0,618 0,515	 0,046 0,097 0,164	- 0,009 0,013	- - 0,001
Sample size	34	34	21	21	21

Note: Variables in logarithms except for interest rates and unemployment rate. Standard errors in parentheses. (*) variable non-significant at 5%.

Table 5

Structural equations

	Demand				Supply			
	(I)	Elasticities	(II)	Elasticities	(III)	Elasticities	(IV)	Elasticities
Constant	0,469 (0,147)		0,456 (0,143)		0,282 (0,134)		1,492 (0,003)	
$Stockb_{t-1}$	-0,073 (0,029)		-0,069		-0,011(*) (0,006)		-0,069	
Real housing equilibrium prices	-0,011 (0,004)	-0,156 (0,076)	-0,011 (0,005)	-0,165 (0,054)	0,015 (0,002)	1,309 (0,591)	0,030 (0,005)	0,433 (0,048)
Population	0,071(*) (0,041)	0,965 (0,225)	0,065 (0,014)	0,941 (0,170)	-	-	-	-
Real interest rates	-0,026(*) (0,015)	-0,356 (0,160)	-0,025 (0,012)	-0,358 (0,167)	-0,067 (0,013)	-5,732(*) (3,190)	-0,081 (0,029)	-1,167 (0,369)
Real construction $costs_{t-1}$	-	-	-	-	-0,004(*) (0,006)	-0,327(*) (0,398)	-0,048 (0,005)	-0,690 (0,075)
Unemployment rate	-0,146 (0,022)	-1,987 (0,875)	-0,146 (0,027)	-2,116 (0,307)	-	-	-	-
GDP per capita	0,037 (0,010)	0,504 (0,066)	0,035 (0,002)	0,513 (0,031)	-	-	-	-
Durbin-Watson	1,344		1,308		1,256		0,760	
Ljung-Box (p-value). K=1 k=2 k=3	 0,087 0,199 0,227		 0,069 0,168 0,190		 0,411 0,294 0,284		 0,002 0,004 0,013	
Sample size	34		34		34		34	

Note: Variables in logarithms except for interest rates and unemployment rate. Standard errors in parentheses. (*) variable non-significant at 5%.

Appendix I: Summary of variables

Denomination	Content	Observations	Sample available	Source
Stockn	Real value of net housing stock	Millions of euros. Base year 2000	1975-2009	Fundación BBVA-IVIE (Mas et al., 2007 and updates)
Stockb	Real value of gross housing stock	Millions of euros. Base year 2000	1975-2009	Fundación BBVA-IVIE (Mas et al., 2007 and updates)
Housing prices	Linked series of housing prices in Spain 1975-1990 Data Prado (2003) 1990-2007 Data Fundación BBVA-IVIE (Uriel et al., 2009) 2007-2009 Data INE	Euros/m^2. The link is performed by guaranteeing the maintenance of the annual rates of variation of the different linked variables.	1975-2009	Authors' elaboration
Real housing prices	Housing prices deflacted by the CPI	Base year 2005	1975-2009	Authors' elaboration
Population	Total population in Spain	Thousands of persons	1975-2009	Instituto Nacional de Estadística (INE)
Interest rates	Average interest rates of mortgage market	Averages of monthly data	1975-2009	Banco de España
Real interest rates	Interest rates deflacted by the CPI	Per unit basis	1975-2009	Authors' elaboration
CPI	Consumer Price Index	Base year 2005	1975-2009	Instituto Nacional de Estadística (INE)
Construction costs	Index of construction materials costs	Base year 2005	1975-2009	Ministerio de Fomento
Real construction costs	Construction materials costs in real terms (deflacted by the CPI)		1975-2009	Authors' elaboration
Unemployment rate	Unemployment rate	Per unit basis	1975-2009	Instituto Nacional de Estadística (INE)
GDP per capita	Gross domestic product per capita	Thousands of dollars	1975-2009	OECD
Financial wealth	Net financial wealth of Spanish households	Millions of euros	1989-2009	Banco de España
Real financial wealth	Real net financial wealth (deflacted by the CPI)		1989-2009	Authors' elaboration

Appendix II: Unit root and cointegration tests

Table II.1
Unit Root Tests
(p-value)

	ADF T&I	ADF I	ADF	ADF T&I	ADF I	ADF
Variable	Levels			Logarithms		
Stockb	-2,633 (0,267)	0,355 (0,978)	2,506 (0,996)	-2,091 (0,535)	-0,894 (0,778)	2,318 (0,994)
Stockn	-2,542 (0,307)	-0,122 (0,932)	2,216 (0,992)	-2,033 (0,563)	-2,167 (0,221)	1,104 (0,928)
Real housing prices	-0,957 (0,939)	-1,556 (0,496)	-1,569 (0,110)	-2,500 (0,325)	-2,399 (0,149)	-1,419 (0,142)
Population	-2,677 (0,252)	-0,976 (0,750)	1,640 (0,973)	-3,102 (0,139)	-0,855 (0,793)	1,473 (0,963)
Real interest rates	-1,842 (0,663)	-1,944 (0,309)	-1,095 (0,242)	-	-	-
Real construction costs	-1,691 (0,727)	-2,101 (0,244)	-0,437 (0,516)	-0,415 (0,983)	-2,008 (0,282)	-1,572 (0,107)
Unemployment rate	-0,106 (0,640)	-2,498 (0,125)	-2,673 (0,253)	-	-	-
GDP per capita	-1,007 (0,930)	2,874 (0,999)	1,211 (0,939)	-1,746 (0,713)	-2,157 (0,222)	1,430 (0,959)
Real financial wealth	-2,867 (0,194)	-1,001 (0,728)	0,175 (0,726)	-0,929 (0,931)	-2,334 (0,172)	0,727 (0,863)

Note: ADF signifies Augmented Dickey-Fuller test. "T&I" signifies that the model includes trend and intercept, and "I" that only intercept is included.

Table II.2
Cointegration tests (p-value)

		Engle and Granger	Hansen	Engle and Granger	Hansen
Endogenous variables	Exogenous variables	Levels		Logarithm	
Stockb	Population, real interest rates, real construction costs, unemployment rate and GDP per capita.	0,000	>0,200	0,120	>0,200
Stockn		0,000	>0,200	0,220	>0,200
Real housing prices		0,001	>0,200	0,180	>0,200
Stockb	Population, real interest rates, real construction costs, unemployment rate, GDP per capita and real wealth.	0,744	<0,050	0,289	0,032
Stockn		0,771	<0,010	0,225	0,030
Real housing prices		0,553	>0,250	0,271	0,060

Note: In the Hansen cointegration test (Hansen, 1992) the null hypothesis is cointegration, while in the Engle-Granger test (Engle and Granger, 1987) it is non-cointegration.

Appendix III: Models estimated using real net housing stock

Table III.1

Reduced form equation for real net housing stock

	(I)	(II)	(III)	(IV)	(V)
Constant	0,204(*) (0,281)	0,188(*) (0,249)	-0,328(*) (0,717)	0,115(*) (0,293)	-0,096(*) (0,057)
$Stockn_{t-1}$	-0,130 (0,043)	-0,166 (0,040)	-0,174 (0,076)	-0,190 (0,075)	-0,191 (0,057)
Population	0,214 (0,074)	0,275 (0,063)	0,337 (0,091)	0,316 (0,100)	0,346 (0,060)
Real interest rates	-0,055 (0,017)	-0,066 (0,018)	-0,037(*) (0,030)	-0,012(*) (0,030)	-0,019(*) (0,024)
Real construction $costs_{t-1}$	-0,028(*) (0,015)	-0,030 (0,013)	-0,042 (0,019)	-0,054 (0,024)	-0,066 (0,014)
Unemployment rate	-0,117 (0,018)	-0,102 (0,017)	-0,106 (0,037)	-0,098 (0,038)	-0,111 (0,026)
GDP per capita	0,029(*) (0,017)	0,039 (0,016)	0,026(*) (0,042)	0,043(*) (0,042)	0,034(*) (0,031)
Real financial wealth	-	-	0,010 (0,005)	0,006(*) (0,005)	0,006(*) (0,003)
Parameter ρ_1 of an AR(1)	-	0,010(*) (0,210)	-	0,199 (*) (0,293)	-0,124(*) (0,228)
Parameter ρ_2 of an AR(2)	-	-		-	-0,361(*) (0,206)
Durbin-Watson	1,516	1,831	1,955	2,280	2,522
Ljung-Box (p-value). K=1 k=2 k=3	 0,605 0,586 0,695	 - 0,254 0,486	 0,995 0,127 0,204	 - 0,014 0,015	 - - 0,082
Sample size	34	34	21	21	21

Note: Variables in logarithms except for interest rates and unemployment rate. Standard errors in parentheses. (*) variable non-significant at 5%.

Table III.2
Structural equations (using real net housing stock)

	Demand				Supply			
	(I)	Elasticities	(II)	Elasticities	(III)	Elasticities	(IV)	Elasticities
Constant	0,504 (0,159)		0,521 (0,145)		0,345 (0,158)		2,758 (0,003)	
$Stockn_{t-1}$	-0,122 (0,040)		-0,130		-0,015(*) (0,008)		-0,130	
Real housing equilibrium prices	-0,013 (0,004)	-0,105 (0,050)	-0,013 (0,006)	-0,098 (0,033)	0,018 (0,003)	1,230 (0,520)	0,047 (0,006)	0,362 (0,047)
Population	0,149 (0,059)	1,225 (0,134)	0,161 (0,034)	1,238 (0,103)	-	-	-	-
Real interest rates	-0,036 (0,017)	-0,297 (0,109)	-0,039 (0,015)	-0,297 (0,100)	-0,081 (0,016)	-5,475(*) (2,943)	-0,097 (0,047)	-0,743 (0,360)
Real construction $costs_{t-1}$	-	-	-	-	-0,002(*) (0,006)	-0,127(*) (0,378)	-0,086 (0,009)	-0,662 (0,073)
Unemployment rate	-0,163 (0,026)	-1,333 (0,544)	-0,161 (0,034)	-1,238 (0,185)	-	-	-	-
GDP per capita	0,050 (0,013)	0,413 (0,037)	0,053 (0,003)	0,407 (0,018)	-	-	-	-
Durbin-Watson	1,505		1,557		1,263		0,550	
Ljung-Box (p-value). K=1 k=2 k=3	 0,216 0,365 0,472		 0,279 0,422 0,548		 0,418 0,323 0,319		 0,000 0,000 0,001	
Sample size	34		34		34		34	

Note: Variables in logarithms except for interest rates and unemployment rate. Standard errors in parentheses. (*) variable non-significant at 5%

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