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House Price Determinants: Fundamentals and Underlying Factors

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This study examines the key drivers of real house prices in the five main Euro area countries (Germany, France, Italy, Spain, and the Netherlands) and the Anglo-Saxon economies (the United Kingdom and the United States) from 1970 to 2010. Estimating the determinants of house prices is very important, as they significantly influence economic activity and financial stability. Therefore, a multivariate unobserved component model, introduced by Harvey, has been used to model house price fluctuations. This technique allows us to catch those price movements that are not fully explained by economic fundamentals. The empirical results, in fact, indicate that in addition to changes in real income, long-run interest rates, stock prices and inflation, the latent component has a significant role in explaining real house prices. The latent component reflects those factors that are not specifically observed, such as structural changes in markets and changing preferences.
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INTRODUCTION

The determinants of house prices have attracted much attention in recent years, because of the increasing role played by the house sector in the global economy[1] and the global boom and bust in house prices in several countries.

[1] For many countries, house activities, including construction, renovation and bank and trading services, are estimated to be between 5% and 10% of GDP (Hilbers *et al.*, 2008).

From 2000 to 2006, house prices rose in most advanced countries. For example, they soared in the United States and other Anglo–Saxon systems, fuelled by financial innovations. In Spain, house prices were buoyed by easy credit conditions, namely, extended mortgage periods and record-low interest rates resulting from monetary easing and fierce inter-bank competition, increasing household incomes, strong employment growth, high foreign real estate investments, and demographic factors (explicitly record levels of immigration and the Spanish baby boom that increased household formation) (IMF, 2009). In the Netherlands, the rise in house prices was triggered by robust income growth and the pro-cyclical lending standards of the banks. In 2007, house prices started to fall, first in the United States and then elsewhere. It seems that house prices in many industrial countries follow trends in the United States, with a lag of at least 6 months and up to 2 years (Deutsche Bank, 2010). Rollercoaster house prices are often seen as a major cause of the current global financial crisis and recession and have been commonly considered a threat to global prosperity since the Great Depression (Loungani, 2010). It is, therefore, important to understand the drivers of real estate prices, as doing so would contribute to the preservation of macroeconomic and financial stability, and facilitate household consumption and saving/investment decisions.

In this context, the present study examines real house price dynamics in two groups of industrialized countries: one belonging to the Euro area, the other to the Anglo–Saxon group. In particular, the analysis focuses on the five largest Euro countries (Germany, France, Italy, Spain, and the Netherlands) and on the two largest Anglo–Saxon economies (the United Kingdom and the United States). This would help to investigate common features and broad differences in house price dynamics across countries.

In the two country groups, real house prices have shown peculiar trends. Looking at their development from a historical perspective, four striking aspects appear from a graphical inspection (Figure 1). First, there have been periodic run-ups in the real house prices of these countries during the past 40 years. This means that real house prices show cyclical movements. Second, the size of real price increases during the period from 1997–2007 was impressive. Afterward, the global recession induced significant price drops. Third, price hikes and falls occurred simultaneously across countries. Put differently, real house prices have a tendency to co-move and to be highly synchronized. Fourth, Germany is a special case: real house prices have been rather stable; in particular, modest price movements and even drops have been observed over time. The pattern of declining real house prices in Germany can be ascribed to the interaction of several factors. These include the excessive supply of houses that resulted from the construction boom that followed German unification (Terrones and Otrok, 2004), slowdowns in

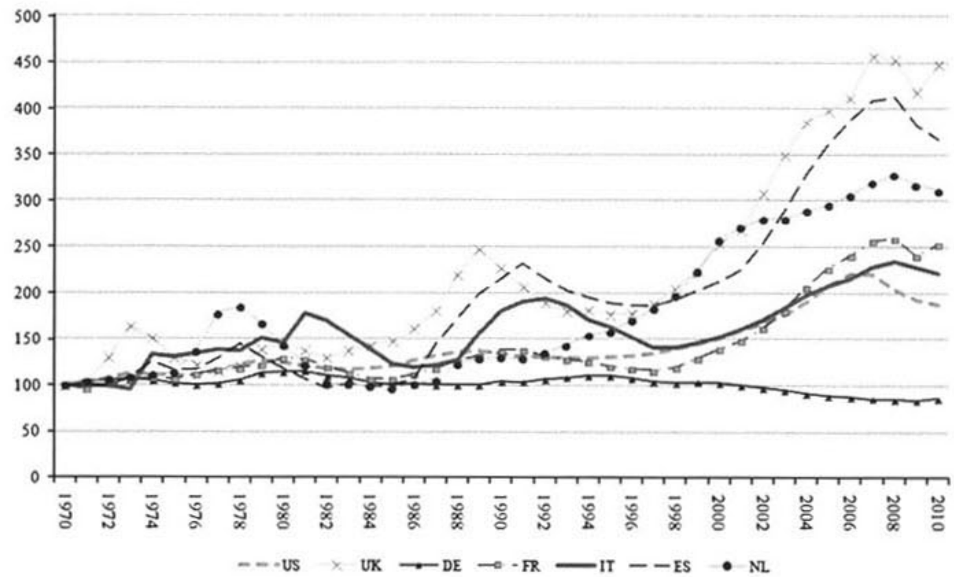

Figure 1: Evolution of real house prices 1970 = 100
Note: House prices are deflated by CPI and then normalized to equal 100 in 1970.
Source: Elaborations on Bank for International Settlements

Table 1: Real house prices. Year-on-year percentage change. Average for the period

	United States	United Kingdom	Germany (DE)	France	Italy	Spain (ES)	Netherlands
1970–1980	2.29	4.60	1.39	2.68	4.50	2.07	4.37
1981–1990	0.80	5.01	−0.85	0.74	2.88	7.01	−0.55
1991–2000	1.17	1.39	−0.17	0.26	−1.57	−0.03	7.20
2001–2007	5.63	8.85	−2.50	9.10	5.95	9.84	3.07
2008–2010	−5.33	−0.51	0.05	−0.38	−0.82	−3.53	−0.80

Source: Elaborations on Bank for International Settlements

population growth (Ahearne *et al.*, 2005), restrictive financing conditions including the absence of 'innovative' mortgages product, which contributed to hold back demand for houses (Westerheide, 2010), and the moderate growth in real disposable income (Kholodilin *et al.*, 2010).

Table 1 offers more evidence on real house price variations at an average annual rate. The Anglo-Saxon countries registered real price growth from 1970 to 2007. The same trend holds true for France. Italy and Spain have instead registered a real price contraction during the decade 1991–2000, while the Netherlands experienced a small drop in 1981–1990. During the years 2001–2007, house price growth was particularly strong in the United Kingdom, France, and Spain, with an average annual growth rate, in real terms, of 8.8%, 9.10% and 9.84%, respectively. Lesser increases have been registered in the Netherlands, Italy, and the United States, with average annual growth rates of about 3% and 6%. The fact that the United States belongs to the latter group is significant, given that the financial storm, which first struck the United States in August 2007, has its roots in the biggest house and credit bubble in history (*The Economist*, 11.10.2008). Nevertheless, the gap between the first and second group narrows if we consider the percentage price increase between 2005 and 2007. Germany is the only country to show counter-cyclical price developments.

In general, the synchronization of price movements across most of the countries has induced some observers to believe that the house price boom is a bubble (Hilbers *et al.*, 2001; Klyuev, 2008; Girouard *et al.*, 2006). Thus, the house price run-ups may partly be driven by factors that are unrelated to economic fundamentals, especially the record-low interest rates registered in the new millennium.

This study thus tries to shed light on fundamentals and underlying factors that cause price fluctuations within an error correction mechanism. Technically, it introduces, in addition to the traditional triggers of real house prices, such as interest rates and disposable income, an unobserved component in the form of a time-varying trend, in order to pick up on the stochastic un-modeled behaviors of the series. Underlying factors could include economic elements that are unknown, unobservable, unquantifiable, or not easy to compute, such as structural changes in markets (eg land use restrictions) or in the level of government interventions in markets that are difficult to measure (eg home-owner's interest deducibility from taxes, grants for first time home buyers, and cuts in rental properties' taxes), and those factors of 'irrational exuberance' or changing tastes. Most studies have estimated equilibrium prices for house and their deviation from fundamentals without providing information with respect to the underlying unobserved drivers. This study goes one step further than other studies by capturing the veiled factors that influence price development in the form of stochastic trends. This is done to characterize unmodeled long-run real house price movements, reduce the residuals in estimations, and better gauge the elasticity of the fundamentals. If stochastic trends are appropriate, but are not explicitly modeled, their effects will be picked up indirectly by time trends and lags on the variables. This can lead to a proliferation of lags that have no economic meaning, and which are subject to common factors and problems of inference associated with unit roots (Harvey and Shephard, 1993). In addition, the omission of important long-run information implies that the long-run equation is misspecified, thus raising the problem of spurious regression and omitted variables or measurement errors. The inclusion of the unobserved time series components adds an extra dimension to the interpretation and specification of certain aspects of the price dynamics.

The rest of this article is organized as follows. The next section presents a literature review of the determinants of house prices. The section 'Econometric methodology' describes data and methodology. The section after that, 'Estimation of House Prices', presents the results, and the final section concludes.

THE LITERATURE ON HOUSE PRICE DETERMINANTS

Houses can be regarded as both an investment and consumption goods. This distinguishes them not only from financial assets (eg shares), the simple possession of which does not originate any utility, but also from other real assets (eg land, machinery, gold, coins, stamps, art and antiques) that require a sufficiently developed secondary market to be included in an investment portfolio (Banco de España, 2003). Moreover, houses have long average lives – they are durable goods – and can be subjected to long construction processes because of cumbersome building regulations and slow administrative procedures,[2] which implies that, in the short term, their supply is relatively rigid. Likewise, a house is linked to a specific location and, therefore, to a limited land supply (including zoning restrictions), even over the very long term. Owing to the high acquisition value, in relation to average household income, the house market is also closely linked to the mortgage financing market. Changes in the supply of mortgage lending are, therefore, a significant determinant of the demand for houses. Other fundamentals driving the demand for houses are household wealth, population growth, inflation, credit availability, interest rates, and unemployment. As the supply side of the market is more rigid, both because of the shortage of land for houses and the time needed for new construction to be completed, most empirical literature focuses on the demand side when estimating house price determinants. Put differently, the existence of supply-side constraints and other market imperfections make house prices chiefly demand driven, above all in the short run.

It should be noted that although there is a broad consensus among researchers regarding the direction of the impact of each house price determinant, there is less agreement regarding the size, the explanatory power, and the relative explanatory importance of the variables to be added to the main house price drivers, namely, household incomes and interest rates.

[2] In Spain, for instance, the average time between building permit and house completion is around 2 years (IMF, 2009).

A summary of the literature review is reported in the Appendix. Table A2 shows that some authors only consider interest rates and disposable income as real price drivers (Hofman, 2005; Hunt and Badia, 2005), while others add such explanatory determinants as unemployment (McCarthy and Peach, 2004; Schnure, 2005), house stock supply (McCarthy and Peach, 2004; Verbruggen *et al.*, 2005, Wagner, 2005), inflation (Annett, 2005; Almeida *et al.*, 2006; Davis and Zhu, 2004; Iossifov *et al.*, 2008; Tsatsaronis and Zhu, 2004), house stock and/or stock market and real credit (Ayuso *et al.*, 2003; Annett, 2005; Bessone *et al.*, 2005; Fitzpatrick and McQuinn, 2004; OECD, 2004; Sutton, 2002), and population growth (OECD, 2004; Terrones and Otrok, 2004; Wagner, 2005). Reported elasticities differ widely. For instance, real interest rates vary by −7.7% to −0.02%, and real per-capita income varies by 0.3–8.3%. This could be because of the types of empirical techniques adopted (time series *versus* panel estimates), the inclusion of additional explanatory variables, or the databases used. Panel analyses generally tend to report more contained interest rates and income elasticity than time series analyses. For instance, Hilbers *et al.* (2008), using a panel data approach, uncovered differences in house price developments between three distinct groups of European countries: those with rapidly increasing house prices, called the 'fast lane', including Spain, Belgium, Ireland, the United Kingdom, the Netherlands, and France; those showing a closer-to-average development – the 'average performers' – comprised of the Nordic countries, Italy, and Greece; and those with relatively stagnant house prices – the 'slow movers' – including Germany, Austria, Switzerland, and Portugal. For these groups, income elasticity was about or less than 1. In his panel approach, Schnure (2005) also found a small income elasticity of 0.2–0.3. Iossifov *et al.* (2008) investigated residential property prices in 20 advanced countries in Western Europe and Asia and found that house prices are related to some economic fundamentals, and that more than half of price adjustments take place within a quarter with small income and interest rate elasticity. Higher elasticity is found in the analyses based on the Johansen procedure by Bessone *et al.* (2005), McCarthy and Peach (2004), and Gattini and Hiebert (2010), and in the error correction model (ECM) models by the OECD (2004), Meen (2002) and Ayuso *et al.* (2006). Another interesting result is that transition countries tend to have higher income and interest rate elasticity than industrialized countries (Égert and Mihaljek, 2007).

Against this background, the present study proposes a novel methodology that sheds light on observable and unobservable factors that influence house prices, with the aim of more accurately assessing each variable's elasticity and explaining an important part of price increases that remains unexplained by existing empirical analyses.

ECONOMETRIC METHODOLOGY

The unobserved component model

To evaluate the factors that push price movements over time, a structural time series framework, developed by Harvey (1989), has been adopted. In a structural time series model the explanatory variables enter into the model side by side with the unobserved components, which slowly evolve over time. Several applied economists assume that the variables have strong deterministic trends. Therefore, they incorporate a time-invariant trend with constant level and slope parameters to variables when estimating autoregressive models. In contrast Harvey (1997, p. 192), pointed out that '… unless the time period is fairly short, these trends cannot be adequately captured by straight lines. In other words, a deterministic linear time trend is too restrictive …'. He suggested that time series models should add in gradually evolving stochastic instead of deterministic trends.

The basic structural time series framework can be expressed as:

$$y_t = \phi x_t + \mu_t + \varepsilon_t \tag{1}$$

where x_t is a $k \times 1$ vector of exogenous regressors, ϕ_t is a $k \times 1$ vector of coefficients, μ_t is the time-varying trend or unobserved component and ε_t is the irregular disturbance term or transient component. The x_t vector includes the lagged values of the dependent variable, as well as the lagged values of exogenous variables. The trend component μ_t assumes local linear specification, as given by:

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t \quad \eta_t \approx NID(0, \sigma_\eta^2) \tag{2}$$

$$\beta_t = \beta_{t-1} + \xi_t \quad \xi_t \approx NID(0, \sigma_\xi^2) \tag{3}$$

where equation (2) defines the level of the trend and equation and (3) defines its slope (β), that is, its growth rate. The stochastic disturbances ε_t, η_t and ξ_t are normally distributed and mutually uncorrelated at all lags and leads. The local linear trend specifies both the level and the slope as stochastic, but the trend can also be a random walk with drift (local level with drift) when $\sigma_\xi^2 = 0$ and $\sigma_\xi^2 > 0$ or random walk without drift (local level) when $\sigma_\xi^2 = 0$, $\sigma_\eta^2 > 0$ and $\beta = 0$. A trend has a smooth specification when the level is fixed ($\sigma_\eta^2 = 0$) and the slope is stochastic ($\sigma_\xi^2 > 0$). The model reduces to a global or deterministic trend when $\sigma_\xi^2 = \sigma_\eta^2 = 0$, in which case the level does not vary over time. It is worth noting that to have a stationary disturbance term, it is necessary to difference twice for local linear trends and once for the local level, regardless of whether there is drift and a deterministic trend (Harvey and Scott, 1994). In the latter case, equation (1) becomes:

$$\Delta y_t = \phi \Delta x_t + \delta x_{t-1} + \mu_t + \varepsilon_t \tag{4}$$

where the lagged variables constitute the long-run dynamics and the differenced variables (Δ) represent the short-run dynamics.

The error correction specification

As it is possible to envisage a wide range of demand and supply fundamentals underlying the evolution of house prices, a specification that uses six variables and an unobserved component has been adopted to explain the evolution of house prices. In particular, the choice of explanatory variables mirrors the consensus in the literature that house prices are primarily determined by factors affecting aggregate demand in the short run – *in primis* interest rate and income – and in the long run, namely demographic factors. The model includes two financial variables, namely stock market prices to capture the impact of equity prices on house price via wealth effects caused by equity price variations or as an investment alternative to real estate (Égert and Mihaljek, 2007), and the rate of inflation as proxy for uncertainty as well as the real depreciation of non-indexed financial assets (Poterba, 1984; Iossifov *et al.*, 2008). Finally, private residential investments have been included to take the supply side into account. The error correction house price specification is expressed as follows:

$$\begin{aligned}\Delta \ln hp_t = {} & \partial_1 \Delta \ln y_t + \partial_2 \Delta\, r_t + \partial_3 \Delta \ln \pi_t + \partial_4 \Delta \ln share_t + \partial_5 \Delta \ln pop_t \\ & + \partial_6 \Delta \ln gfcf_t - \gamma_1 \ln hp_{t-1} + \gamma_2 \ln y_{t-1} + \gamma_3\, r_{t-1} + \gamma_4 \ln \pi_{t-1} \\ & + \gamma_5 \ln share_{t-1} + \gamma_6 \ln pop_{t-1} + \gamma_7 \ln gfcf_{t-1} + \mu_t + \varepsilon_t\end{aligned} \tag{5}$$

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t \quad \eta_t \sim NID(0, \sigma_\eta^2) \tag{6}$$

$$\beta_t = \beta_{t-1} + \xi_t \quad \xi_t \sim NID(0, \sigma_\xi^2) \tag{7}$$

where *hp* is the country's real house price, *y* is real income per capita, *r* denotes the real long-term interest rate, π is the inflation rate, *share* is the stock market price, *pop* is population change, and *gfcf* refers to residential investments. Δ is the difference operator and *ln* is the logarithm. The latent component, μ, reflects different phenomena embedded in house prices' trends and cycles, components that have a stochastic nature. ε, η and ξ are normally distributed random disturbances with means of zero and a constant variance of σ^2. As before, the lagged variables in the levels represent the long-run equilibrium equation, whereas the differenced variables define the short-run equilibrium. Data on house prices (*hp*) were obtained from DataStream and the Bank of International Settlements, which compiles data from national sources. The variable *hp* was deflated by countries' consumer price index (CPI) so as to have real value. There is a caveat: each country compiles house price figures using different definitions; therefore, data are not always homogeneous and strictly comparable. Some data refer, for instance, to the average price for all types of dwellings, others to average price per square meter, whereas still others are focused on whole countries or main cities. A log of real per capita gross domestic product (GDP) has been used as a proxy for wealth. The variable y is expected to be positively related to house prices because income growth improves house affordability. This generates more demand for living and recreation space, which drives up the price of construction land. In addition, the positive influence of income on house price could be caused by the Baumol–Bowen effect and the Balassa–Samuelson effect.[3] Like other asset prices, house prices are influenced by interest rates (r). Specifically, real long-term interest rates are used as a proxy for the cost of mortgage financing.[4] As houses are predominantly financed with borrowing, a decline in real long-term interest rates translates into a reduction in mortgage rates, thereby boosting liquidity, demand for houses, and house prices. Put differently, changes in interest rates are expected to be negatively linked to real house prices because higher real mortgage rates increase the cost of homeownership and push prices down. Expectations of higher inflation (π) are likely to be associated with higher demand for houses used as shelters against inflation. This leads to soaring house prices. In other terms, on the economic side, the inclusion of the rate of inflation reflects the fact that houses serve as a store of purchasing power; therefore, if the

[3] The Baumol–Bowen effect (1966) and the Balassa–Samuelson effect (1964, 1964) are closely related but distinct from each other. The main idea behind the Balassa–Samuelson effect is that, in a given economy, a higher productivity growth in the tradable sector than that in the non-tradable boosts up wages in all sectors. This in turn increases the prices of non-traded goods relative to the prices of traded goods. The Balassa–Samuelson effect is purely a 'supply side effect'; demand does not have any role in the formation of relative prices, whereas the Baumol–Bowen effect provides an explanation for the rise in relative prices of non-tradable goods by introducing the consumer demand (Coudert, 2004). As the income elasticity of the demand for services is greater than that of the demand for goods, the share of services in total demand increases during the process of development. Thus, the rise in the relative prices of services derives not only from smaller productivity increases, as the Balassa–Samuelson effect predicts, but also from growing demand during the development process.

[4] Data on loan-to-value ratio, mortgages, and household credit growth are not available for all the considered countries. In addition, the series do not always go back to 1980 and sometimes they are not available on quarterly frequency.

inflation rate increases, people are more prone to buy houses to hedge again the risk that inflation may erode their wealth. Besides, higher uncertainty about future expected returns on investment in bonds and equities associated with high inflation also contribute to the attractiveness of real estate as a vehicle for long-term savings. On the econometric point of view, the issue of likely endogeneity is smoothed by considering past values of the inflation rate. The inclusion of the rate of inflation is in line with the studies by Zhu (2003), Tsatsaronis and Zhu (2004), Iossifov *et al.* (2008). The inflation rate is computed using changes in the CPI. Share price indices (*share*), normally based on a selection of shares, represent share price movements in stock markets. Share price indices generally relate to common shares of companies traded on national or foreign stock exchanges, other manipulation, and adjustments. The expected sign of the variable *share* is uncertain because it depends on substitution and wealth effect and which of the two prevails. The substitution effect predicts a negative relationship between the price of two assets (eg equities and houses), as the high return in one market tends to cause investors to leave the other market. The wealth effect instead postulates a positive relation because the high return in one market will increase the total wealth of investors and their capability of investing in other assets (Koivu, 2012). The demand for houses is also influenced by demographic changes, thereby the population between 15–64 years old (*pop*) has been included. A higher growth rate in the working age population is likely to be associated with higher house demand and hence higher prices. Finally, to account for supply side variables[5] (ie factors influencing the available house stock), private residential investments (*gfcf*) in real terms have been considered for all countries. The expected sign is negative as prices lessen when residential supply increases. A detailed data description is reported in the Appendix.

ESTIMATION OF HOUSE PRICES

Unit root tests

As a preliminary step, the degree of integration of the series involved has been computed. Two univariate unit root tests were carried out, the augmented Dickey-Fuller test (1979) and the Phillips-Perron test (1988). Table A3 (Appendix) reports the results from the tests. Overall, the picture that emerges indicates that the variables are integrated of order one ($I(1)$), that is, the series becomes stationary after the first differences.

[5] Data on house starts and construction costs were not considered because the series were not available for all the countries and the entire period of the analysis.

Structural model estimation

A number of specifications were estimated for real house prices.[6] The analysis is based on quarterly data ranging from 1970:1 to 2010:2.[7] All estimations and test statistics were produced with the econometric software STAMP 8 (Koopman *et al.*, 2007), which maximizes likelihood functions using the Kalman Filter, with diffuse initial conditions. Specification of the components was based on the series' salient features. Starting from the Basic Structural Model[8], the variances of disturbances in the components were evaluated. When a parameter was found to be equal to zero, its corresponding component was fixed. When the slope and seasons of the series were estimated to be not null, trends were modeled on a local linear level,[9] and when the slope and seasons were found to be null, trends were treated on a local level (Koopman *et al.*, 2007). Interventions, in the form of irregular and level[10] components, were introduced, where the residuals of house prices revealed the presence of an outlier. To explore the appropriateness of the stochastic specification, the model was estimated into two different scenarios. The first is less restricted and allows for a stochastic trend according to the state equations (6) and (7); the second scenario corresponds to the conventional model, with fixed dummies and a deterministic time trend. A report on these estimations is presented in Table 2 and 3 and gives information about the maximized value of the log-likelihood function, the convergence (ie weak or strong) and the prediction error variance. In addition, Table 2 and 3 provide a set of diagnostic statistics for the estimated residuals, which should satisfy three important properties: independence, homoscedasticity and normality. The assumption that the residuals are independent is checked using a classical Durbin Watson test, which is

[6] An advantage of the unobserved component model is that it does not need the real house price to be cointegrated with macroeconomic fundamentals as a prerequisite to obtain non-spurious long-run relationships and estimates of the price equation. The approach facilitates the estimation of the long-run relationship between the integrated variables using maximum likelihood, and the use of the likelihood ratio test to identify the significance of the long-run coefficients, even if cointegration is rejected. If the standard deviation of the innovation to the random walk process is approximately zero, the unobserved random walk component will reduce to a constant and the real house price is said to be cointegrated with the fundamentals (Chen and MacDonald, 2010; Nyblom and Harvey, 2000).

[7] As many series for Germany starts from 1991, the sample period goes from 1991:1 to 2010:2.

[8] $hp_t = \mu_t + \gamma_t + \Psi_t + \varepsilon_t$ where μ_t is the trend level, Ψ_t is the stochastic cycle, γ_t is the stochastic season and ε_t is the irregular.

[9] This is, in fact, reflected in the non-zero estimates of the trend level and slope in the final state vector.

[10] Level interventions accommodate permanent step shifts in the series; they resemble structural breaks.

Table 2: House price equations estimated[a] with stochastic components

1970:4–2010:2	France	Germany 1991:1–2010:2	Italy	Netherlands	Spain	United Kingdom	United States
Fundamental part[b]							
Lagged house price	−0.58 (0.06)	−0.18 (0.05)	−0.98 (0.04)	−0.20 (0.03)	−0.97 (0.07)	−0.36 (0.05)	−0.27 (0.06)
Lagged per capita income	0.47 (0.15)	0.12 (0.06)	0.73 (0.20)	0.17 (0.09)	1.48 (0.53)	0.61 (0.25)	0.20 (0.10)
Lagged real long-run interest rate	−0.008 (0.003)	−0.001 (0.0003)	−0.01 (0.0003)	−0.036 (0.01)	−0.003 (0.001)	−0.006 (0.002)	−0.031 (0.004)
Lagged inflation	0.37 (0.16)	0.024 (0.01)	0.126 (0.06)	0.32 (0.16)	0.28 (0.13)	0.71 (0.21)	0.16 (0.08)
Lagged share prices	0.016 (0.01)	0.005 (0.002)	0.01 (0.004)	0.046 (0.01)	0.04 (0.01)	0.077 (0.02)	0.03 (0.01)
Lagged change in population	0.26 (0.14)	0.13 (0.08)	0.65 (0.09)	0.30 (0.16)	2.36 (1.38)	1.14 (0.22)	0.79 (0.29)
Lagged residential investment	−0.13 (0.07)	−0.09 (0.03)	−0.09 (0.04)	−0.052 (0.01)	−0.17 (0.04)	−0.81 (0.03)	−0.04 (0.02)
Differenced per capita income	0.01 (0.12)	0.04 (0.08)	0.11 (0.05)	0.09 (0.06)	1.03 (0.44)	0.26 (0.35)	0.22 (0.07)
Differenced real long-run interest rate	−0.003 (0.08)		−0.003 (0.001)		−0.001 (0.001)	−0.71 (0.21)	−0.002 (0.001)
Differenced inflation		0.027 (0.01)	0.03 (0.04)	0.55 (0.28)	0.12 (0.08)	0.04 (0.37)	0.36 (0.11)
Differenced share prices	0.01 (0.008)		0.01(0.002)	0.02 (0.012)	0.01 (0.006)		
Differenced change in population	0.01 (0.00)	0.09 (0.05)			0.98 (0.74)		
Differenced change in residential investment					−0.001 (0.03)		−0.01 (0.02)
Trend decomposition, standard deviations of disturbances (10^2)							
σ_η Trend	0.000	0.000	0.000	0.438	0.070	0.289	0.251
Slope	0.295	0.000	0.573	0.127	0.823	0.185	0.000
Seasonal	0.000	0.000	0.000	0.127	0.085	0.113	0.028
σ_ε Irregular	0.498	0.137	0.000	0.783	0.264	0.845	0.000
Cycle	0.280	0.000	0.002	0.001	0.359	0.002	0.570
Level q ratio	0.000			0.559	0.085	0.342	0.441
Slope q ratio	0.593	0.000	1	0.162	1	0.219	0.000
Seasonal q ratio	0.000	0.000	0.000	0.163	0.103	0.134	0.049
Irregular q ratio	1	1	0.000	1	0.321	1	0.000
Cycle q ratio	0.562		0.004	0.001	0.501	0.002	1
Dumping factor	0.92		1	1	0.93	1	0.53
Growth rate per year	5.50%	−0.70%	3.43%	1.73%	3.13%	2.65%	1.18%
Residuals tests[c]							
Standard error (10^2)	0.9	0.1	0.5	1.3	1.2	1.3	0.66
Normality	5.01	3.66	3.76	4.58	2.29	1.68	0.51
$H(h)$	1.44 $H(46)$	0.33 $H(20)$	0.41 $H(43)$	0.57 $H(45)$	1.32$H(39)$	0.62$H(24)$	0.72 $H(43)$
$r(1)$ (10^2)	−0.3	2.5	−0.7	−1.6	5.9	−0.8	3.3
$r(q)$ (10^2)	− 0.5	−4.6	−5.4	1.4	−3.1	−10.3	−1.6
DW	2.01	1.94	2.01	1.99	1.88	1.99	1.91

$Q(q,q\text{-}p)$	10.8	13.4	12.0	9.07	12.6	9.71	12.6
Rd^2(10^2)	66.3	55.6	71.0	61.8	66.9	63.8	78.5
Goodness-of-fit results for residuals[d]							
Prediction error variance (p.e.v.)	0.0000849	0.000021	0.000029	0.000175	0.000134	0.000184	0.000044
Ratio p.e.v./ (prediction error mean deviation)^2	1.14	1.40	1.87	1.09	1.50	1.06	1.28
AIC	−9.12	−12.57	−10.19	−8.43	−8.52	−8.38	−9.76
Convergence	Very strong	Very strong	Very strong	Very strong	Very strong	Very strong	Very strong
Stability	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[a] Dependent variable: Δ ln hp, real house price. All variables except the real interest rate are in logs. Standard errors are given in brackets. The method of estimation is Maximum Log-likelihood. The State is estimated through a Kalman filter.

[b] Outliers were detected by looking at the graphs of the auxiliary residuals, that is, the smoothed estimates of the irregular and level disturbances. Five outliers relative to 1981:4, 1988:3, 1989:4, 2000:4, and 2002:4 were inserted in the house price equation for United Kingdom. Their values are −0.03, 0.06, −0.04, 0.03, and 0.03, respectively and their standard error are all 0.01. Four outliers relative to 1976:1, 1980:1, 1980:2, and 2004:1 enter the house price equation for the United States. Their values are −0.02, −0.03, −0.04, and −0.02 with all standard error equal to 0.006.Three outliers were added for France, their values referred to 1993:1, 1996:1, and 1997:1 are −0.03, −0.02, −0.02 with standard errors equal to 0.01 for all of them. Two outliers relative to 1981:1 and 1982:1 were added to Italy's equation: their values are 0.08 and −0.06 with standard errors equal to 0.01. An outlier relative to 1998:2 was added to Spain, its value 0.12 with standard error equal to 0.01. An outlier relative to 2008:3 was added to Germany, its value and standard error are 0.012 and 0.004, respectively. Two outliers relative to 1976:1 and 2008:2 were added to the hp equation for the Netherlands. Their respective values are 0.03 and −0.03 with standard errors all equal to 0.01.

[c] Normality is tested according to the Doornik–Hansen correction to the Bowman–Shenton statistic. The latter has a χ^2 distribution with two degrees of freedom under the null hypothesis of normally distributed errors. We reject the null if the calculated probability exceeds the tabulated ones equal to 5.99 at 5% significance level and 9.21% at 1% significance level. $H(h)$ is the heteroskedasticity test statistics distributed as a $F(h,h)$ with (h,h) degrees of freedom. Under the null of no heteroscedasticity and for h=33–36, the 5% critical value is 1.75. For h=37–41 the 5% critical value is 1.70. For h=42–47 the 5% critical value is 1.64. $r(1)$ and $r(9)$ are the serial correlation coefficients at the 1st and 9th distributed as a $N(0;1/T)$, T being the number of observations. Rho $<$ 0.02 at 5%. DW is the classical Durbin Watson test distributed as $N(2, 4/T)$. $Q(P,d)$ is the Ljung Box statistics based on the sum of the first P autocorrelations and it is tested against a χ^2 distribution with d degrees of freedom. The null hypothesis of no autocorrelation is tested against the alternative of autocorrelation. The critical value for eight degrees of freedom is 15.51 at 5% significance level.

[d] The prediction error variance (p.e.v) is the variance of the one-step ahead prediction errors in the steady state. It gives a measure of the precision of a model's predictions. A low p.e.v. (tending to zero) means that good predictions are obtained at that point. A ratio p.e.v./ prediction error mean deviation in squares near to 1 means that the model is correctly specified. AIC is the Akaike Information criterion used to select the proper model estimation.

Table 3: House price equations estimated with deterministic trend

1970:4–2010:2	France	Germany	Italy	Netherlands	Spain	United Kingdom	United States
Fundamental part							
Lagged house price	−0.104 (0.04)	−0.18(0.05)	−0.043(0.013)	−0.08 (0.02)	−0.036 (0.01)	−0.14 (0.02)	−0.03(0.01)
Lagged per capita income	0.092 (0.02)	0.12(0.06)	0.048 (0.05)	0.34 (0.07)	0.035 (0.02)	0.21 (0.04)	0.09(0.05)
Lagged real long-run interest rate	−0.014 (0.004)	−0.001(0.0003)	−0.004(0.0007)	−0.039(0.01)	−0.021(0.011)	−0.008(0.003)	-0.013(0.004)
Lagged inflation	0.006 (0.002)	0.024(0.01)	0.038 (0.05)	0.21(0.02)	0.18(0.10)	0.47(0.07)	0.02(0.008)
Lagged share prices	0.011 (0.003)	0.005(0.002)	0.02 (0.003)	0.03(0.004)	0.01(0.005)	0.028(0.01)	0.001(0.006)
Lagged change in population	0.028(0.016)	0.13(0.08)	0.169 (0.033)	0.05(0.01)	0.07(0.03)	0.44(0.11)	0.07(0.03)
Lagged residential investment	−0.099(0.07)	−0.09(0.03)	−0.10 (0.03)	−0.052(0.01)	−0.07(0.03)	−0.11(0.03)	-0.04(0.006)
Differenced per capita income	0.419 (0.19)	0.04 (0.08)		0.06 (0.13)	0.97(0.24)	0.85 (0.45)	0.41(0.10)
Differenced real long-run interest rate	−0.003(0.08)		−0.007(0.004)	0.02(0.01)	−0.002(0.001)	−0.02(0.01)	−0.002(0.001)
Differenced inflation		0.027(0.01)		0.38(0.30)			
Differenced share prices					0.01(0.006)		
Differenced change in population		0.09(0.05)					
Differenced change in residential investment							-0.07(0.02)
Standard deviations of disturbances (10^2)							
σ_ε Irregular	1.2	0.137	1.41	1.76	1.83	1.81	0.872
Seasonal	0.000	0.000	0.002	0.008	0.000	0.113	0.000
Trend analysis							
Fixed Level	0.00897		0.03759	0.0449	0.0121	0.86523	0.01825
Residuals tests							
Standard error (10^2)	1.1	0.1	1.3	1.6	1.7	1.7	0.83
Normality	2.50	3.66	3.76	0.39	5.35	0.19	2.83
$H(h)$	2.16 $H(46)$	0.33 $H(20)$	0.11 $H(46)$	0.34 $H(47)$	1.06 $H(47)$	0.61$H(27)$	0.50 $H(47)$
$r(1)$ (10^2)	4.6	2.5	6.8	2.9	−3.9	0.3	2.5
$r(q)$ (10^2)	9.2	−4.6	13.5	14.6	4.7	−10.3	−5.6
DW	1.06	1.94	1.62	1.40	1.91	1.89	1.68
$Q(q,q\text{-}p)$	12.0	13.4	12.0	12.07	10.10	12.89	11.00
Rd^2(10^2)	54.3	55.6	45.5	37.46	56.9	57.6	61.5
Goodness-of-fit results for residuals							
Prediction error variance (p.e.v.)	0.00013	0.000021	0.00018	0.00028	0.00031	0.00030	0.000544
Ratio p.e.v./ (prediction error mean deviation)^2	1.15	1.40	1.19	1.01	1.06	1.01	1.11
AIC	−8.73	−12.57	−8.42	−7.97	−7.91	−7.95	−9.38
Convergence	Strong	Very strong	Strong	Strong	Strong	Strong	Strong
Stability	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Dependent variable: ln hp, real house price. All variables except the real interest rate are in logs. Standard errors are given in brackets.

distributed as $N(2, 4/T)$ and the Ljung Box statistics[11] $Q(P,d)$. The assumption that the residuals display homoscedasticity is evaluated using the $H(h)$ test which is distributed as a $F(h,h)$ with (h,h) degrees of freedom.[12] The normality of the residuals is tested using the Doornik-Hansen correction to the Bowman-Shenton statistic.[13] The baseline specification for each setting and for each country has been chosen on the basis of its robustness and, thus, on the minimization of the Akaike information criterion (AIC), Bayesian information criterion (BIC), and error prediction. In the first setting (Table 2), all of the estimated coefficients display the expected signs. Diagnostic checking rejects the presence of serial correlation, heteroskedasticity, and non-normality. The estimates show good explanatory power for all countries, as highlighted by the R^2 values. The correct specification of the model is shown by the low values of the prediction error variance, that is, the variance of the one-step-ahead prediction errors in the steady state, and by the ratio of the prediction error variance and the mean deviation in squares, which is close to 1. Finally, the model strongly converges to the steady state, which is an indication of good results (Koopman *et al.*, 2007). In the second setting (deterministic trend), there are some problems of autocorrelation in the residuals for France as testified by the Ljung–Box statistics, and the coefficient of the inflation rate is not significant for Italy (Table 3). The traditional model specification displays a lower R^2 than the one with an unobserved component. Besides, it appears that stochastic trends ameliorate the evaluation of the real house price equations when compared with the deterministic trend, on the basis of specification and misspecification tests and of goodness-of-fit criteria. The components' graphics with stochastic trend plus regression effects, in fact, more accurately explain real house prices than a traditional deterministic trend plus regression effects.[14] The long-run parameters for the baseline setting are given in Table 4.

The results show that real house prices are positively driven by per capita income, stock prices, population changes, and inflation. They are

[11] The latter is based on the sum of the first P autocorrelations and is tested against a χ^2 distribution with d degrees of freedom. The null hypothesis of no autocorrelation is tested against the alternative of autocorrelation. The critical value for eight degrees of freedom is 15.51 at a significance of 5%.

[12] Under the null of no heteroskedasticity and for $h = 33$–36, the 5% critical value is 1.75; for $h = 37$–41, the 5% critical value is 1.70. For $h = 42-47$, the 5% critical value is 1.64.

[13] The Bowman–Shenton statistic has a χ^2 distribution with two degrees of freedom under the null hypothesis of normally distributed errors. The null is rejected if the calculated probability exceeds the tabulated probabilities that are equal to 5.99 at a significance of 5% and 9.21 at a significance of 1%.

[14] Graphical presentations of these results have been reported for reasons of space, but they are available upon request.

Table 4: Long-run house price relationship. Baseline setting

	France	Germany	Italy	Netherlands	Spain	United Kingdom	United States
Ln *y*	0.81	0.67	0.74	0.82	1.52	1.69	1.61
Ln *r*	−0.01	−0.01	−0.01	−0.18	−0.003	−0.03	−0.28
Ln π	0.64	0.13	0.13	1.60	0.29	1.97	1.14
Ln *share*	0.03	0.03	0.01	0.23	0.04	0.22	0.12
Ln *pop*	0.45	0.73	0.66	1.49	2.43	3.16	5.52
Ln *gfcf*	−0.22	−0.51	−0.11	−0.26	−0.18	−0.22	−0.57
Unobserved component	1.72		1.02	5.00	1.03	2.77	7.69

Dependent variable: ln hp, real house price. All variables except interest rates are in logs (ln). *y* = per capita income, π = inflation rate, *share*=share price, *pop*=population growth, *gfcf*=residential investments.

negatively driven by interest rates and residential investments (Table 4). More specifically, income, population and inflation rate are the core long-run determinants among the observable factors in terms of magnitude for the two groups of countries. The long-run per capita income elasticity is bigger than the unity for the United Kingdom, the United States, and Spain, and varies between 0.67 and 0.82 for the remaining countries. According to IMF (2003), the high sensitivity of real house prices to income is linked to high loan-to-value rates. In addition, income elasticity larger than unity may mirror increased access to credit following financial deregulation and a higher household propensity to borrow. Countries that have more conservative financing systems, that is, a smaller degree of financial sophistication such as Germany and Italy, have lower income elasticity.

Population growth have a strong role in the United States, United Kingdom, Spain, and the Netherlands, where a 1% increase results in 5.5%, 3.2% 2.2%, and 1.50% higher house price growth, respectively. The highest values for the United States and the United Kingdom is likely linked to the increasing growth rate in the working-age population – including immigrants – recorded in these countries, which boosted the demand for houses and, thus, prices.

A 1% increase in inflation rate, keeping constant other factors, produces a rise in house price of 1.60% in the Netherlands, 1.97% in the United Kingdom, 1.1% in the United States, 0.64% in France, 0.30% in Spain, and 0.13% in Germany and Italy. This implies that uncertainty tends to make the portfolio of investors shift toward more traditional investments. As regards real interest rate elasticity, it is significant and exerts a dampening effect on house price. The magnitude differs across countries, ranging from 0.003 in Spain to 0.28 in the United States. The interest rate that determines the effective mortgage rate thus has an impact on homebuyers' decisions. In any case, it turns out that countries with a higher financial liberalization of mortgage markets show a higher sensitivity of house prices to interest rates. This result is in line with Muellbauer and Murphy (1997) and Iacovello and Minetti (2003).

The stock market variable is positively related to real house prices, suggesting that the wealth effect dominates the substitution effect during the sample period. This finding corroborates the results by Sutton (2002) and Borio and McGuire (2004). The stock market has a much bigger role in the Netherlands, the United States, and the United Kingdom than in Germany, France, and Italy. Moreover, the results show that price reacts less than proportionately to changes in supply (ie the elasticity is smaller than one) for all countries. Put differently, higher residential investments make house supply shift outward, leading to lower house prices. Interestingly, Germany has the highest residential investment value, with falling real house prices. This is in line with the study by ECB (2003).

The stochastic trends, which indicate the general direction in which the series are moving, have long-run elasticity greater than one for all the countries considered; their value is greatest in the United States and the Netherlands. This implies the presence of substantial unobserved long-run effects, which are effectively captured by the stochastic trend (Table 4). The stochastic trend encompasses all the unobserved factors that affect real house prices but cannot be directly measured or are simply overlooked. Such latent factors can include consumer preferences, structural changes, and local market specificities difficult to quantify. Table 2 provides further information on the trend's components. Specifically, the extent to which the trend's components evolve over time is specified by the parameters σ_η^2 and σ_ξ^2, which have been estimated by the maximum likelihood in the time domain. Table 2 reports the estimated standard deviations and the signal-to-noise ratio of the residuals driving the unobserved components. When the signal-to-noise ratio is not zero, the permanent component is stochastic. If the signal-to-noise ratio were equal to zero, the time series model that represents a decomposition into permanent-plus-transient components would have contained a deterministic trend. Moreover, as the proportion that is not explained by the model, that is, the transitory noise, is minimized, the model is well specified. It is worthwhile noting that house prices are modeled differently across countries. For instance, for the United States the specification with the best fit consists of a stochastic trend and a fixed slope. For the Netherlands, Spain and the United Kingdom the specifications present a stochastic trend and a stochastic slope. For France and Italy the local linear model shows a somewhat smoother trend, being the trend fixed and the level stochastic. For Germany the finest specification consists of a deterministic trend, likely because of the smooth house price patterns. The trend's contribution to the annual rate of increase in house prices within the sample is positive for all the countries considered, with the exception of Germany, where the trend reduces house prices by 0.7% per year. A negative time trend indicates secular declines in house prices, as confirmed by Figure 1, which shows that Germany's property prices performed unimpressively from the mid-1990s to the mid-2000s, when most European countries were experiencing house booms. Among the economies in which there was an underlying trend improvement in real house prices, the largest effect at the end of each year can be seen in France, Italy, Spain and the United Kingdom. The values for these countries would explain the large price increases observed there. In a nutshell, the estimated values of the slope parameter indicates that at steady state, the median price appreciated by 5.50% a year in real terms in France, 3.13% in Spain, 3.43% in Italy, 2.65% in the United Kingdom, 1.73% in the Netherlands, and 1.18% in the United States.

The cycle component has a global feature and is relevant to all countries, with the strongest role in the United States, followed by France and Spain. Except for Italy and France, the results also reveal changes in the seasonal patterns with house prices generally being higher in the second and third quarter compared with their values in the first and fourth quarter of a year. This result supports the findings of other studies on seasonality in house price (Kajuth and Schmidt, 2011; Ngai and Tenreyro, 2009; Hosios and Pesando, 1992; Case and Shiller, 1989).

CONCLUSIONS

Real house prices in many industrial countries have soared extraordinarily rapidly in recent years, and in some cases these upsurges do not seem to be fully explained by economic fundamentals. For this reason, the present article has extended the analysis to include underlying factors that drive real house price fluctuations into two groups of advanced economies: the main five Euro area countries, and the big two Anglo–Saxon countries. Although previous studies have considered long-run interest rates and per capita income as the main determinants of price behavior, this article introduces a hidden factor and constructs an unobserved component approach to modeling house price equations. The methodology adopted enables observers of house markets to pick up on underlying changes in real house prices after controlling for the impact of interest rates, income, inflation, population growth, residential investments, and stock prices. If latent information is, in fact, overlooked, long-run price equations may be misspecified, and spurious regressions may occur. The adopted approach overcomes any misspecification by proxying any long-run variations with a latent component in the form of a time-varying trend.

Differently from the mainstream approach, based on the unit root tests and estimating cointegrating equations using deterministic trends, this study has treated trends as a stochastic variable because of the effects of several unobservable shocks to the economy.

Subject to the usual caveats concerning the comparability of house price data across countries, the model shows how significant time stochastic trends are when explaining the performance of real house prices.

Indeed, the elasticity of the estimated stochastic trends is well above the unity, showing how this effectively captures the changes that occurred in recent years in the Euro area, the United Kingdom and the United States. The only exception is Germany. As the variances of the disturbances of the level and slope of trend were found to be equal to zero, the structural time series model implies that a deterministic trend is preferable to a stochastic trend. This finding likely mirrors the smooth pattern in the country's house prices. In addition, the econometric results confirm that real house prices in industrial countries show dependence on economic fundamentals and underlying factors. The latter are more relevant for the United Kingdom, Italy, France, and Spain. The cycle component has the utmost role in the United States.

Furthermore, the investigation reveals that there are some common elements to the two groups of countries, namely the following: 1) the estimated per capita income elasticity and population changes in the set of real house price equations generally represent the main observed fundamentals to influence real house price patterns; 2) the stock market variable drives up real house prices, suggesting that the wealth effect dominates the substitution effect; 3) overheating is associated with sustained growth of inflation-adjusted real house price – this result points to the fact that a house could be a shelter for investment when other financial instruments present risky prospect in the long run; 4) the stochastic trends are all above the unity. The two groups of countries have some different features, specifically: 1) the intensity of income elasticity is larger in the Anglo–Saxon economies than in the Euro group, except for Spain (this is the result of less financial sophistication within the Euro zone); 2) the equity market has a stronger role in the United Kingdom and United States than in the Euro Area country, except for the Netherlands.

The results of this analysis suggest that it remains crucial for regulators to carefully monitor the house price market, given its impact on the economic activities. To this purpose, it seems important, first of all, to develop better data collection systems across countries and to harmonize the systems, especially in the Euro zone. This will be important to have a better knowledge on the state of the house market. Then, given the swings in house prices, in the medium term, policies should aim at forestalling boom and bust cycles. This could be reached by proper (prudent) fiscal policies – which affect house prices largely through taxes and subsides – and structural policies, which can substantially impact on the supply side of the market. In particular, gradual changes in house taxation, especially when they are announced in advance, can help to avoid abrupt price movements. Maintaining a prudent fiscal stance could help prevent domestic demand pressures that would otherwise contribute to driving the house market away from its equilibrium. This is especially important for the Anglo–Saxon economies and Spain, given their high price response to income changes. Structural policies that affect the constructing industry and building zoning regulations should aim at mitigating excessive supply rigidities in order to lessen sharp price increases. This should be accomplished in the respect of environmental criteria. In addition, monetary policy interventions should be foreseen in the house market. In this respect, it seems important for the Central Banks to add to their specific goals the objective of smoothing excessive asset price fluctuations. This is because the primary objective of the ECB's monetary policy is to achieve and maintain general price stability in the Euro Area, that is, to keep inflation rates below – but close to – 2% over the medium term. The Federal Reserve has a twofold target: economic growth (including maximum employment) and stable prices, but the top priority is growth. The objective of the monetary policy adopted by the Bank of England is 'to deliver price stability – low inflation – and, subject to that, to support the Government's economic objectives including those for growth and employment'. Therefore, the inclusions of the price of houses and shares as explicit targets would be auspicious. This would also imply an effective supervision of the mortgage banking systems in order to restrain the vulnerabilities in the house market.

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APPENDIX

Table A1: Data

Series going from 1970:1 to 2010:2	Source and construction
Real house price indices CPI deflated (2005=100)	Data were collected from the Bank of International Settlements (BIS) and Thompson DataStream. For the United States, quarterly data were obtained from the BIS (code Q:US:0:2:1:3:0:0) and refer to the existing single-family houses index, not seasonally adjusted, for the whole country. For the United Kingdom, data were taken from the Thomson DataStream (code UKNSAQHPF). The house price index is calculated as a weighted average of prices for a standard mix of dwellings. For France, data were obtained from the BIS (code Q:FR:2:8:1:1:0:0). House prices refer to existing flats (Capital City) Index. For the Netherlands, data were collected from Nederlandse Vereniging voor Makelaars http://nieuws.nvm.nl/~/media/NVMWebsite/Downloads/OverNVM/English/Sale%20prices%20in%20the%20Netherlands%201985-present.ashx. House price index refers to all types of dwellings. For Spain, quarterly data were obtained from the BIS (code Q:ES:0:1:0:1:1:0). House prices refer to all types of dwellings, throughout the country. For Italy, the real house price index denotes all type of dwellings. Data were taken from Scenari immobiliari and transformed into quarterly series using the moving average procedure. For Germany, the real house price index refers to the BD real estate price index NSA. Data were taken from Thomson DataStream and transformed into quarterly series using the moving average procedure. To counter-check the last part of the series, quarterly data from Statistische Bundesamt Deutschland were considered. http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/EN/Content/Statistics/TimeSeries/EconomicIndicators/Prices/Content100/bpr110a,templateId=renderPrint.psml Where necessary, data were seasonally adjusted.

Table A1: (continued)

Real interest rates	Nominal long-term interest rates were collected from Thompson Datastream. Codes FROCFILTR, ITOCFILTR BDOCFILTR ESOCFILTR NLOCFILTR UKOCFILTR USOCFILTR. Nominal interest rates were adjusted to remove the effects of inflation and reflect the real cost of funds to the borrower.
Consumer price indices	Consumer price indices, based on 2005=100, were taken from the IMF's International Financial Statistics http://www.imf.org/external/data.htm
Real per capita GDP index 2005	GDP, at constant purchasing power parity in US$ millions, was divided by population and indexed (2005=100). Source: DataStream. Codes FROCFGVOD ITOCFGVOD BDOCFGVOD ESOCFGVOD NLOCFGVOD UKOCFGVOD USOCFGVOD
Share price indices (average) 2005=100	Data were collected from Eurostat and the IMF's International Financial Statistics via DataStream. For France, the SBF250 index of the Société des Bourses Françaises was considered. The index covers the common shares of the 40 enterprises with the largest capitalization. For Germany, data refer to the Deutscher Aktienindex. For Italy, data refer to the MIB index calculated by the Milan Stock Exchange and are based on the quoted prices of all stocks traded on that exchange. For the Netherlands, the AEX All Shares Index was considered. It covers all listed companies in the Amsterdam Stock Exchange, excluding investment funds and foreign-registered companies. For Spain, the General Index of the Bolsa de Madrid was considered. It covers the shares of more than 100 companies representing some 85% of total market capitalization. For the United Kingdom, data refer to the average of daily quotations of 500 ordinary Industrial shares on the London Stock Exchange. For the United States, the price-weighted monthly averages of 30 blue chip stocks quoted in the Dow Jones Industrial Average were considered.
Gross fixed capital formation – Private Residential (real term)	DataStream codes FROCFIHSD, ITOCFIHSD, NLOCFIHSD, UKOCFIHSD, USOCFIHSD, ESOCFIHSD BDOCFIHSD.
Population growth index 2005=100	DataStream codes FROCFPOPO, ITOCFPOPO, ESOCFPOPO, NLOCFPOPO, UKOCFPOPO, USOCFPOPO, BDOCFPOPO

Table A2: Selected literature survey on determinants of real house prices in industrialized countries

Investigator	Country, data and period	Methodology	Long-run real income elasticity	Explanatory variables Long-run real interest rate elasticity	Other independent variables
Annett (2005)	Euro Area (8 countries) yearly 1970–2003	ECM	0.7	−0.02	Real credit 0.2
Ayuso *et al.* (2006)	Spain yearly 1978–2002	ECM	2.8	Value not significant in nominal term	Stock market return −0.3
Bessone *et al.* (2005)	France yearly 1986–2004	Johansen ML	8.3	—	House stock supply −3.6
Fitzpatrick and McQuinn (2004)	Ireland yearly 1981–1999	Stock and Watson DOLS, FM-OLS, OLS	—	—	House stock -1.2; population 24–36 2.0; mortgage 1.3
Gattini and Hiebert (2010)	9 countries quarterly 1970Q1–2009Q4	VECM	3.07	−6.87 mixed interest rate short and long	Real house investment −2.2
Hofman (2005)	The Netherlands quarterly 1974Q1–2003Q3	ECM	1.5	−0.9	—
Hilbers *et al.* (2008)	16 countries	Panel MGE analysis (dependent variable price-rental ratio)	1.02 fast lane; 0.51 average performers; −0.76 slow movers; Panel: 0.38	—	Demographic pressure −11.3 (fast lane), −6.1 (average performers), −5.05 (slow movers); user costs −0.49 (fast lane), −0.72 (average performers), −1.12 (slow movers); Panel: demographic pressure −7.74, user costs −0.73
Hunt and Badia (2005)	UK quarterly 1972Q4–2004Q4	VAR	1.9 in 1999Q4 and 1.5 in 2004Q4	−6.0	—
Iossifov *et al.* (2008)	Two samples: (a) 17 advanced economies quarterly 1990Q4–2006Q4; (b) 89 countries annual 2005–2006	(a) 3SLS variables in 1st differences (b) cross section OLS in levels	(a) — (b) 0.28	(a) −0.24 (nominal short-term value) (b) −0.36 (real short-term value)	(a) Inflation proxy for mortgage debt −0.31; M2 proxy for financial deepening 0.14; government budget balance 0.7 (b) availability of credit 0.44

Table A2: (continued)

Investigator	Country, data and period	Methodology	Long-run real income elasticity	Explanatory variables Long-run real interest rate elasticity	Other independent variables
Klyuev, (2008)	US two frequency samples (a) annual data 1976–2002 (b) quarterly (i) 1972Q1–2008Q1 and (ii) 1972Q1–2002Q4	(a) Supply-demand OLS approach (b) asset price approach using Stock and Watson dynamic OLS	(a) 0.5 (b) —	(a) Real mortgage rate −0.009– (b) (i) −0.04 and (ii) −0.02	(a) Real construction cost 0.77; unemployment not significant; average house size not significant; (b) real rent (i) 1.27 and (ii) 0.74
McCarthy and Peach (2004)	US quarterly 1981Q1–2003Q3	Johansen ML	3.2	—	House stock supply −3.2
Meen (2002)	UK quarterly 1969Q3–1996Q1; USA 1981Q3–1998Q2	ECM	United Kingdom 2.5 United States 2.7	United Kingdom −0.035 United States −0.013	UK house stock supply −1.9; UK real wealth 0.33; US house stock supply −7.9; US real wealth 0.7
OECD (2005)	Ireland 1977Q1–2004Q4; the Netherlands 1970–2002; Spain 1989–2003	ECM	Ireland 1.8; the Netherlands 1.9; ES 3.3 to 4.1	Ireland −1.9; the Netherlands −7.1; ES −0.6 to −4.5	Ireland house stock/population −0.007; NL house stock/ population −0.52; ES house stock/population −6.9 to −8.1; ES population 12 to 16.9
Schnure (2005)	USA yearly 1978–2004	Panel analysis	0.2–0.3 short run rate	−0.21 to −0.28 short run rate	Unemployment −0.9 to −1.2; labor force 0.4 to 1.8 (short run)
Sutton (2002)	6 industrialized countries	VAR	GNI from 1.0–4.0	From −0.5 to–1.5	Stock prices from 1.0–5.0
Terrones and Otrok (2004)	18 countries yearly 1971–2003	Dynamic panel analysis	1.1	−1.0	Population growth 0.25; house affordability −0.14
Verbruggen *et al.* (2005)	The Netherlands yearly 1980–2003	ECM	1.33	−5.9	House stock supply −1.4
Wagner (2005)	Denmark 1993–2004	ECM	—	−7.7	House stock supply −2.9; demography 2.9

Source: Own elaborations

Table A3: Unit root tests

	hp		y		r		gfcf		pop		share		cpi	
	level	1st differ	level	1st differ	level	1st differ	level	1st differ	level	1st differ	level	1st differ	level	1st differ
	Prob[a].													
(a) Adjusted Dickey Fuller														
France	0.4308	0.0380	0.6320	0.0000	0.5349	0.0000	0.4953	0.0003	0.2065	0.0271	0.5927	0.0000	0.3877	0.0012
Germany	0.3083	0.0214	0.9988	0.0018	0.5268	0.0091	0.3156	0.0000	0.7071	0.0000	0.5523	0.0000	0.9515	0.0000
Italy	0.0964	0.0081	0.4312	0.0000	0.5532	0.0017	0.6435	0.0000	0.1821	0.0014	0.5346	0.0000	0.3988	0.0000
The Netherlands	0.9397	0.0302	0.9797	0.0000	0.4648	0.0000	0.4052	0.0000	0.8088	0.0026	0.6142	0.0000	0.4460	0.0803
Spain	0.8835	0.0113	0.7914	0.0007	0.7674	0.0055	0.4477	0.0029	0.3539	0.0000	0.8213	0.0000	0.5298	0.0000
United Kingdom	0.9024	0.0224	0.9153	0.0000	0.9477	0.0000	0.4180	0.0000	0.4899	0.0141	0.8625	0.0000	0.8277	0.0177
United States	0.1897	0.0319	0.9386	0.0000	0.6206	0.0000	0.1672	0.0000	0.1903	0.0000	0.8626	0.0000	0.7856	0.0029

Null Hypothesis: the variable has a unit root $I(1)$. Lag Length: Automatic - based on HQ, maxlag=13. The test is carried out with a constant.

	hp		y		r		gfcf		pop		share		cpi	
(b) Phillip–Perron														
France	0.9999	0.0000	0.5214	0.0000	0.0693	0.0000	0.3993	0.0000	0.3987	0.0001	0.6460	0.0000	0.3858	0.0000
Germany	0.8421	0.0214	0.9999	0.0170	0.4556	0.0001	0.3156	0.0000	0.7541	0.0000	0.6125	0.0000	0.0879	0.0000
Italy	0.2192	0.0035	0.3527	0.0000	0.2930	0.0000	0.5431	0.0000	0.0508	0.0000	0.5700	0.0000	0.9458	0.0000
The Netherlands	0.9831	0.0000	0.9751	0.0000	0.1544	0.0000	0.1518	0.0000	0.7274	0.0000	0.6092	0.0000	0.5084	0.0000
Spain	0.9865	0.0001	0.8376	0.0000	0.8117	0.0000	0.6581	0.0000	0.5468	0.0000	0.8500	0.0000	0.9943	0.0000
United Kingdom	0.9353	0.0000	0.8907	0.0000	0.3181	0.0000	0.3572	0.0000	0.8079	0.0000	0.9065	0.0000	0.9857	0.0000
United States	0.7379	0.0000	0.9548	0.0000	0.2887	0.0000	0.3215	0.0000	0.2271	0.0001	0.9065	0.0000	0.9744	0.0000

Null hypothesis: The variable has a unit root $I(1)$. Bandwidth: Newey-West automatic using Bartlett kernel. The test is carried out with a constant.
[a] MacKinnon (1996) one-sided p-values.