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HOUSE PRICE RESPONSIVENESS OF HOUSING INVESTMENTS ACROSS MAJOR EUROPEAN ECONOMIES

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Abstract

In comparison with the large literature on house prices, housing investments have been studied far less. This paper investigates the behaviour of private residential investments for the six largest European economies, namely: Germany, France, Italy, Spain, the Netherlands and the United Kingdom. It employs a common modelling structure based on an error correction approach and country specific models. First, co-integration among the parsimoniously specified set of fundamental variables is detected in all countries. Second, cross-country differences are found in the responsiveness of private residential investments to real prices and to other relevant factors. Germany has the strongest response of private residential investments to house price changes whereas Italy shows the lowest responses. In Spain investments seem to be primarily related to their lagged component and short-term changes in house prices, and show a poor relationship with deviations from long-term fundamentals. In some countries, the lagged component of residential investments seems to point to a high persistency effect.

Keywords: housing investments, elasticity, co-integration, error-correction mechanism

JEL Codes: C2, R30, E22

Non-technical summary

Private residential investment represents on average between 3% and 8% of GDP in the largest EU countries over the last 40 years. Despite its relatively small share of total expenditure, it is thought to be an important factor for business cycles because construction activity remains labour intensive (André, 2010). Additionally, housing investment responsiveness to prices is thought to play a key role in determining house price dynamics for both new and existing houses, which in turn are the most important assets in households' portfolio and hence a source of wealth effects. Moreover, possible differences of adjusting the housing investments to keep pace with demand forces may provide one explanation for the divergent amplified responses of house prices to market conditions. Following this last point, differences across EU countries in house price dynamics, and possibly also in private consumption patterns, are sometimes attributed to structural differences in housing investments. Thus, for example, the relatively subdued dynamics of house prices in Germany over the last couple of decades (which are also thought to have affected private consumption) were believed to be partly linked to a more elastic housing supply compared to other EU countries (see also Swank et al., 2002). Similar arguments have been put forward in the US. For example Glaeser *et al.* (2008) propose a model in which US cities with more elastic housing supply have fewer and shorter house price cycles, than cities with smaller price increases.

Despite the potentially important role of housing investments for the rest of the economy, there is a relative lack of empirical work in this field for European countries. With this paper we aim at contributing to the cross-country empirical literature of residential investment in the six largest economies of the EU, Germany, France, Italy, Spain, the Netherlands and the United Kingdom. The focus is on the short-to-medium term dynamics of residential investment that are often obscured in the existing empirical literature in Europe and that may be important to the build up of house price bubbles and business cycles. An empirical study of shorter-term dynamics presupposes a reasonable characterisation of the long-term residential investment. We propose an error correction approach based on a parsimonious set of long-term fundamental variables without imposing a common error structure across markets. The small set of variables included in the long-run equation comprise real private residential investments (*RHI*), real gross domestic product[1] (*GDP*), real long term interest rate (*INT*) and a proxy for land prices (*LAND*).

Cointegration among the parsimoniously specified set of fundamental variables is detected for all countries. Cross-country differences are found in the responses of private residential investments to real house prices and to the other relevant drivers. Residential investment is highly inertial in some countries: *ceteris paribus*, a 1 per cent increase in investment is followed by an additional increase between 0.6 and 0.7 per cent in a four

[1] Cleaned of the private residential investment component

quarters window for France and Spain whereas additional increases of 0.4 per cent (or below) are recorded in the other countries. Sizable differences are found in the short term responses to changes in house prices: following a 1 per cent increase in such prices, residential investment increases in the same quarter by 0.85 per cent in Germany, and by approximately 0.2 per cent in France and in Spain. Notably, an approximate tobin-Q is estimated in the short-run for Germany where a (negative) responsiveness of investments to cost changes of roughly 0.86 is detected. The response to house price and cost changes is insignificant in the other countries. Finally, differences are observed in the speed of adjustment to the long-run equilibrium (ECM): the adjustment takes roughly two years and a half in France and Italy, one year in the Netherlands and UK and more than three years in Germany. A non-statistically significant coefficient of adjustment is recorded for Spain where private residential investment developments seem to be mainly related to lagged investment dynamics and responses to house price changes.

To summarise, this paper contributes first, to shed further light on potential cross-country differences in investment responses to changes in prices and other factors. Second, the detected country differences in the responsiveness of investments stress the importance of considering country specific models in the analysis of the housing market. Third, the results in the paper confirm some of the available evidence from previous country specific studies - e.g. strong response of residential investments in Germany, and an insignificant response of investment to house prices in the short-term for the Netherlands.

1. Introduction

Private residential investment represents on average between 3% and 8% of GDP in the largest EU countries over the last 40 years. Despite its relatively small share of total expenditure, it is thought to be an important factor for business cycles *inter alia* because construction activity remains labour intensive (André, 2010). Additionally, housing investments are thought to play a key role in determining house price dynamics for both new and existing houses, which in turn are the most important assets in households' portfolio and hence a source of wealth effects. Moreover, possible differences of adjusting housing investments to keep pace with demand forces may provide one explanation for the divergent amplified responses of house prices to market conditions. The relevance of housing investments elasticity for monetary policy has also been recognised. A high responsiveness of investments may reduce the relevance of the discussion on the identification in real time of bubbles (Jaccard, 2010). For example, after a demand shock and in the extreme case of perfectly responsive investments all the adjustment in the market can be observed through quantity expansions as shown in Iacoviello (2005).

Following this last point, differences across EU countries in house price dynamics and possibly also in private consumption patterns can be sometimes attributed to structural differences in the housing market. Thus, for example, the relatively subdued dynamics of house prices in Germany over the last couple of decades (which are also thought to have affected private consumption) were believed to be partly linked to supply factors, where more responsive residential investments may facilitate the smooth functioning of a price-quantity mechanism compared to other EU countries (see also Swank *et al.*, 2002). The findings of the World Bank Doing Business 2011[2] report, comparing business regulation across world economies, support this intuition. In an EU ranking, Germany represents one of the countries with a lower average number of days (100 days) required to get a building permit whereas these statistics are more than double in Southern European economies reaching an average of 257 days required to get the same type of permits. Similar arguments on the potential relevance of the housing investment responsiveness to price signals have been put forward in the US. For example Glaeser *et al.* (2008) propose a model in which US cities with more elastic housing supply have fewer and shorter house price cycles, than cities with smaller price increases.

Despite the potentially important role of housing investments for the rest of the economy, there is a relative lack of empirical work in this field for European countries. This was already noted in the past and DiPasquale (1999) has made the observation that in comparison with the large literature on housing demand, investment behaviour has been studied far less, and often with inconclusive results. Baker (2003), Meen (2003) and Pryce (1999) have analysed the UK market and, in particular, the quantity side of the market.

[2] The International Bank for Reconstruction and Development / The World Bank, Doing Business 2011 – making a difference for entrepreneurs, Washington, DC 20433

Moreover, Muth (1960) found evidence of perfectly elastic supply in US. Poterba (1984) and Topel and Rosen (1988) both take q-theory-related approaches to model housing supply. The price of housing is the main determinant of new construction with estimated elasticities of new construction with respect to real house prices ranging between 0.5 to 2.3. No strong evidence has been found on the reaction of investments to costs in the short- and in the long-run (same result as in DiPasquale et al., 1994). In general, evidence on housing investment elasticities to cost shifters (see also Knudsen, 1994; Hakfoort and Matysiak, 1997) and to price changes in the short-run is mixed. One problem faced by the empirical literature in Europe has been the relative paucity of reliable and comparable data. Papers focusing on single country analysis (see Barot, 2001; Barot et Yang, 2004; Malpezzi et al, 2001; Grimes et al. 2010; Kenny, 2003) have found the long-run elasticity to costs ranging between -0.16 and -0.6 for Ireland, Sweden and UK whereas to prices between 0.8 and 1.

With this paper we aim at contributing to the cross-country empirical literature of residential investment in the six largest economies of the EU, namely: Germany, France, Italy, Spain, the Netherlands and the United Kingdom. The six economies account for more than 80 per cent of EU GDP and they are thought to have rather different housing investment reactions, in particular, for what regards the responsiveness to house and land prices. The focus is on the short-to-medium term dynamics of residential investment that are often obscured in the existing empirical literature in Europe. These dynamics may be important for the build up of house price bubbles and may affect business cycle fluctuations. An empirical study of shorter-term dynamics presupposes a reasonable characterisation of the long-term residential investment. We propose an error correction approach based on a parsimonious set of long-term fundamental variables without imposing a common error structure across markets. The small set of variables included in the long-run equation comprise real private residential investments (*RHI*), real gross domestic product[3] (*GDP*), real long term interest rate (*INT*) and a proxy for land prices (*LAND*). Cointegration among the parsimoniously specified set of fundamental variables is detected for all countries. Cross-country differences are found in the responses of private residential investments to real house prices and to the other relevant drivers. Residential investment is highly inertial in some countries: *ceteris paribus*, a 1 per cent increase in investment is followed by an additional increase between 0.6 and 0.7 per cent in a four quarters window for France and Spain whereas additional increases of 0.4 per cent (or below) are recorded in the other countries. Sizable differences are found in the short term responses to changes in house prices: following a 1 per cent increase in such prices, residential investment increases in the same quarter by 0.85 per cent in Germany, and by approximately 0.2 per cent in France and in Spain. Notably, an approximate tobin-Q is estimated in the short-run for Germany where a (negative) responsiveness of investments to cost changes of roughly 0.86 is detected. The response to house price and cost changes is insignificant in the other countries. Finally, differences are observed in the speed of

[3] Cleaned of the private residential investment component

adjustment to the long-run equilibrium (*ECM*): the adjustment takes roughly two years and a half in France and Italy, one year in the Netherlands and UK and more than three years in Germany. A non-statistically significant coefficient of adjustment is recorded for Spain where private residential investment developments seem to be mainly related to lagged investment dynamics and responses to house price changes.

The remainder of the paper is structured as follows. Section 2 describes our modelling approach and the variables employed (for a detailed description of the data see the Annex). Section 3 presents the estimation strategy. Section 4 presents the main results and robustness checks. Section 5 concludes.

2. Modelling housing investments

Private residential investments (HI) are a relevant component of total investments, as measured by means of the gross fixed capital formation[4] statistics, and they are a relatively small component of gross domestic product (GDP) in many advanced economies. Chart 1 reports the HI to GDP ratio computed over 1970-2009. The panel includes the five major euro area economies (i.e. Germany, France, Italy, Spain, the Netherlands) and the United Kingdom[5]. First, on average the residential investments to GDP ratio differs substantially across countries. For example, in UK private residential investments account for an average of 3.5 per cent of GDP over the sample whilst in the Netherlands and Germany the ratio is almost double. Second, the ratio had a decreasing trend for all countries, with the possible exception of Spain, and it has started to increase again (or stabilise) in the last decade, before dropping sharply in 2008-2009. Third, the ratio fluctuates relatively little from year to year, meaning that the year on year growth rates of investments and GDP show a high degree of correlation[6] between 1970 and 2009.

A reduced form approach to a long-run specification may start from the following reflections. In all of the countries and during most of the periods under consideration, the construction market as well as the respective markets for construction material can be described as competitive. A *priori*, therefore, one can expect that the long run supply of dwellings was not far from perfectly elastic. If so, this gives rise to a recursive price-quantity long run system, where the long run price of dwellings, q (excluding the cost of land), is determined by the long run construction costs, normal profits and taxes, irrespectively of the number of dwellings supplied (see Malpezzi and Maclennan, 2001). In

[4] Gross fixed capital formation is measured by the total value of a producer's acquisitions, less disposals, of fixed assets during the accounting period plus certain additions to the value of non- produced assets (such as subsoil assets or major improvements in the quantity, quality or productivity of land) realised by the productive activity of institutional units – definition taken from OECD glossary of statistical terms, the Glossary of the System of National Accounts 1993 and the UN classifications registry.

[5] The five euro area countries and the UK account for almost the 83 per cent of EU-15 in 2007 GDP weights.

[6] The correlation coefficients are: Germany, 0.62; France, 0.69, Spain, 0.63, Italy 0.82, the Netherlands 0.43, United Kingdom 0.54

such a recursive model we may estimate directly the reduced form equation, in which the equilibrium price of housing supplied is a function of factors affecting the demand for dwellings, such as income and long term interest rates (Gahvari, 1986). It should be noted that even with a perfectly elastic long term supply of dwellings, house prices are not expected to remain constant over time if demand for housing is growing. This is because house prices include also the price of land, the supply of which is unlikely to have been elastic, even in the long run[7]. Land available for construction is in general limited, giving rise to an inelastic supply. In a rather stylised way, we may write the unit price of housing (say per sqm), p, as the weighted sum of the price of dwelling (per sqm), q, and the price of land, l (also per sqm), that is, $p = q + s * l$. The weight s represents how much land is used per sqm of accommodation and depends both on the households' choices and on regulations (e.g. the maximum height of residential buildings). While the long run supply of dwellings and of land for construction is expected to be rather different, the demand for the two is very closely linked. This has some interesting implications for the long term model. In particular, dwellings and construction land are highly complementary goods in the households' portfolio. Typically, when buying a house, the household also buys a claim to the underlying land. More importantly for our purposes, most (but not necessarily all) factors that affect the household demand for dwellings also have a similar impact on the demand for land for construction purposes.

Taking all these considerations into account, we model the long-run residential investments[8] (*RHI*) as a function of income (real GDP cleaned of the housing investment component - *GDP*), real long term interest rate (*INT*) and a proxy for land prices (*LAND*) – see Annex for a detailed description of the data. *GDP* is supposed to exert a positive impact on all the variables entering in the system whilst *INT* a negative impact. The latter variable is a proxy for financing costs. The former is the economy wide income. Both variables may influence symmetrically the demand for housing and the demand for land. *LAND* is a derived variable. It is the price per sqm of land, l, computed using the price of dwellings and the deflator of private residential investments which in principle should reflect the q component of price p, namely construction costs (e.g. labour, transport and material costs) and company margins (see Annex for details on the employed variables). Note that the price of land, l, can be interpreted as an option[9] (Grenadier, 1996) irrespectively of the buyer type (e.g. either a construction company or a household). Consequently, the land

[7] If supply is unrestricted, then prices cannot be much higher than maintenance and production costs, no matter what the demand. The supply of land can be constrained by a diverse range of factors which can play different and muted roles across countries depending on societal preferences, regulations, economic policy and planning decisions. Among these factors, we can list: (1) land ownership and the incentives to bring land forward for development jointly with the distribution of land ownership; (2) the planning system and the influence on the amount of land that is made available; (3) the political contentious of land usage; (4) the presence of infrastructures and connectivity across sites.

[8] For details on the construction of the variables see the Appendix on Data.

[9] Depending on the current state of the economy and other factors, the landowner has always the option to leave the land idle for the current period and develop it later (Leung, 2004) and once the real estate development project starts, it is costly to terminate or to reverse.

variable may capture effects which are explicitly accounted for in the general specification of the demand for housing. The ability of land prices of capturing GDP, INT and other factors may vary across countries[10]. Last but not least, land is also a cost for construction companies. Indeed this model describes a long-run reduced form relationship.

When it comes to the short-run, one of the main questions we would like to explore is the reaction of residential investments to house price changes, cost shifts and the relevance of a persistency effect in investments behaviour. In principle housing investments are assumed to follow the long-run relation previously described. However, temporary shifts may exist. They can be directly related to observable short term dynamics of housing market and economy wide factors. For example, investments may react differently to shocks in the cost of production (*COST*) – e.g. raw material and labour costs. As already found in the pass-through literature, elasticities are different across products, across markets and countries (see Jiménez-Rodríguez and Sánchez, 2005; Ferrucci *et al.*, 2010). Henceforth, companies across markets may react differently to changes in costs because those are differently capitalized into house building costs depending *inter alia* on the nature of local supply (Gyourko and Saiz, 2006). Financing cost changes (*INT*) can exert an impact in the short run mostly depending on the degree of exposure of companies to refinancing operations and the maturity of the debt borrowed. Moreover, a certain degree of persistency in housing investments can be an additional driving factor which affects sustained deviations from the equilibrium. Indeed, adjustment costs prevent capital stock to adjust immediately to a new equilibrium level after a demand shock (Lucas, 1967; Kydland and Prescott, 1982). The change in the value of the produced asset, namely the selling price of a dwelling (*RPP*), may exert a significant impact on construction activities since it may generate short-run incentives to be maximised via an expansion in investments.

3. Estimation Strategy

Co-integration techniques are applied in this study. These techniques establish long-run equilibrium relationships between variables[11]. We use a two-step procedure already employed in McQuinn K. and O'Reilly (2007), Addison-Smyth et al. (2008) and Abou-Talb et al. (2008). A cointegrating regression based on dynamic OLS (DOLS), as suggested in

[10] Indeed, the relative importance of the fundamental drivers for land demand can be country specific and common across countries (e.g. the *X* variables mentioned previously). The former factors may be related to the distribution of landownership, household formation, cost of financing, age structure and immigration patterns differ across countries.

[11] In general, two conditions must hold for co-integration to exist. First, the individual variables should be integrated of the same order. Second, the (linear) combination of these variables should be integrated of an order less than the original variables. In this analysis we test for integration of order one, I(1), and of order zero, I(0), for the cointegrating relationships. It implies that any drift between variables in the short-run is temporary and it does not change the equilibrium, which holds in the long-run.

Stock and Watson (1993), is estimated in the first stage[12]. It should tackle problems related to the efficiency of the estimates[13]. A general model for a cointegrating relation for country *i* can be formulated as follow:

$$Y_{i,t} = \alpha_{i,0} + \sum_{j=1}^{F} X_{ij,t}\alpha_{ij} + \sum_{h=-q}^{q} D_{i,t-h}\gamma_{ih} + \varepsilon_t \qquad (1)$$

where $\alpha_{i,0}$ is the constant term, $X_{i,t}$ for $i = 1,\ldots,n$ is a set of *N* variables cointegrated in the long-run with $Y_{i,t}$, $D_{i,t}$ is the set of $\pm q$ lags and leads for the differentiated variables in $X_{i,t}$, α_i and γ_i are two sets of coefficients, and $\varepsilon_{i,t}$ is an error term.

As part of the first step, the presence of a unit root in the residuals of the cointegrating regression among the levels of the time series should be tested. The basic tests usually employed are the Engle and Granger (1987) test and the Dickey-Fuller (1979) test. These tests frequently show a high R^2 statistics and poor Durbin-Watson/Lagrange multiplier statistics suggesting a high degree of serial correlation (Breusch and Godfrey, 1981; Davidson and MacKinnon, 2004). Subsequently the Augmented Dickey-Fuller test can be implemented to take it into account. When computing cointegration tests, the above-mentioned statistics do not follow standard tabulated distributions, either in finite samples or asymptotically. Mackinnon (1990, 2010) provides accurate and extensive distribution tables[14], which cover a broad set of cases[15] useful for this study. A different approach to obtain unit root tests for residuals has been suggested by Phillips (1987) and extended by Phillips and Ouliaris[16] (1990). This test is asymptotically valid in the presence of serial correlation and heteroskedasticity of unknown form. In general, the power of cointegration tests is not very strong. Hence, having a broad set of tests allows more accurate testing of the cointegration hypothesis. For this reason, we employ also the

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[12] The DOLS approach assumes a parametric adjustment to the errors of the static regression. To this end, the full correction is obtained assuming a relationship between the residuals of a static regression, say ε_t^*, and the first differences of leads and lags of the explanatory variables and contemporaneous regressors, *X*. So that the relation can be written as: $\varepsilon_t^* = \sum_{h=-q}^{q} D_{i,t-h} + \varepsilon_t$ where *q* is the number of leads and lags and *D* represents the delta component of the *X* variables.

[13] DOLS and OLS are both super-consistent (when cointegration holds). Additionally the DOLS is also efficient whereas the OLS is not necessarily efficient.

[14] Mackinnon (1994, 1996) has developed advanced methods for calculating approximate distribution functions for the previously discussed

[15] The test statistics should not be modified in the case of heteroskedasticity. However, they have to be modified to allow for serial correlation

[16] Mackinnon (2010) points out that the critical values for these statistics are based on a limited number of replications. Henceforth, they may suffer from a considerable experimental error. Moreover, they are for 500 rather than an infinite number of observations. On the other hand, Phillips and Ouliaris distribution tables are asymptotically valid in the presence of heteroskesticity and serial correlation

Pedroni (1999, 2004) and the Johansen[17] (1991) tests. The latter approach to cointegration analysis, using MacKinnon *et al.* (1999) critical values, is a system based test since it tests for the existence of more than one co-integrating relationship. The former approach – Pedroni (1999; 2004) – extends the Engle-Granger framework to tests involving panel data proposing a set of seven cointegration tests. They allow for heterogeneous intercepts and trend coefficients across cross-sections and the standardized statistics are normally distributed. Two groups of tests are performed under two alternative hypothesis: (1) an homogeneity hypothesis of ρ for all the cross sections in equation 7 termed the within-dimension test or panel statistics test, $\rho_i = \rho < 1$; (2) a heterogeneous alternative also referred to as the between-dimension or group statistics test, $\rho_i < 1$.

The second step involves the estimation of the short-run dynamics where the error correction component is embedded into a dynamic model:

$$\Delta Y_{i,t} = \mu_i + \sum_{h=1}^{M} \delta_{i,h} \Delta Z_{i,t-h} + \sum_{c=1}^{C} \delta_{i,M+c} \Delta Y_{i,t-c} + \beta' e_{i,t-1} + \vartheta_{i,t} \qquad (2)$$

where μ_i is a constant, Z_i is a set of additional *M* variables entering the short run dynamics, which may (or may not) include some of the X_i variables, β is standardized adjustment coefficient, $e_{i,t-1}$ is the error obtained in equation 6 and $\vartheta_{i,t}$ is a normally distributed error term. The model is formulated for country *i*. All variables in equations 1 and 2 are defined in logarithms and the coefficients can be interpreted as long-run and short-run elasticities of residential investments to X_{it} and ΔZ_{it} variables.

4. Estimation results

The log-level of the variables entering equation 1 are integrated of order one whilst they are integrated of order zero in first differences. The results based on the augmented Dickey-Fuller – ADF – test are reported in table 1. It is the first evidence needed in order to proceed to test for co-integration among the variables. Three tests for cointegration are employed based on the testing procedures outlined in section 2.3. The partial equilibrium single equation residual tests based on an Engel-Granger type procedure are reported in table 2. The tests provide similar and comparable results when applying Phillips and Oularis (1990) and MacKinnon (1990; 2010) critical values. Co-integration is detected in

[17] Kunden (1994) applies a similar procedure to scrutinize the data and then it applies single-equation methods.

all countries when the specification includes four variables, namely: real housing investments, land price proxy, real GDP adjusted and real interest rate. No co-integration is found for France, Germany and Spain when the land proxy variable is excluded. It suggests that the latter is an important factor in driving investment decisions and in characterising housing markets. For Germany robustness analysis is needed and a separate discussion will follow. A further validation of the co-integrating relation comes from the Pedroni (1999) set of tests reported in table 3. The tests do reject the null hypothesis of no co-integration in five out seven statistics based on between- and within-dimension tests. The third evidence is derived from Johansen (1991) based tests[18]. It broadly supports one co-integrating relationship among the variables. Overall the three different sets of tests indicate the existence of co-integrating relationships between housing investment and the variables assumed to be its fundamental driving forces. Moreover, the specification including four variables seems to better capture the long-term trend of residential investments.

For Germany a supplementary analysis has been conducted. Germany is the only country in our sample that has faced a reunification process when two separate states have been unified. The German Democratic Republic – East Germany – was characterised by a lack of investments in the pre-unification era. In particular, it has been widely recognised that East Germany lacked of infrastructures in housing and buildings[19] (Maier, 2010). Henceforth, the reunification process may have temporarily altered the long-run relation between residential investments and its fundamental components since a large amount of public and private investments had been flowing into the ex-GDR as suggested also in Knetsch (2010). This trend may have altered the dynamics of the residential investments deflator and, consequently, it may have impacted on the land price proxy. In order to capture this effect, we propose an alternative version of the long run relation for Germany, which includes a dummy and interactions, terms for the employed variable between 1991 and 1995[20]. Accounting for this effect, co-integration is detected in the specification that includes a proxy for land (see “Germany reunification controls” in table 2).

[18] Additionally to the mentioned cointegration tests also a dynamic test is computed based on a VAR framework developed in Johansen (1991, 1995). The test is performed using a one lag specification which resembles the most the above mentioned tests in terms of lag automatic selection based on Akaike and Schwarz info criterion

[19] Investment in the physical plant of GDR cities was sacrificed. What is more, during the 1980s the regime devoted much of its scarce resources for urban development to projects in the capital. Moreover, housing was dilapidated and run down (Maier, 2010).

[20] We have checked the robustness of the estimates for alternative periods, namely: 1991-1992, 1991-1993 and 1991-1994. The results are broadly unchanged. We have also employed a specific dummy for the 1991Q1; however it does not appear to be significant. This signals that a more protracted shift may have occurred.

4.1 Long-run component

We estimate separate equations for each country. The main results for the long-run equilibrium equation are reported in table 5. They are based on DOLS estimations[21]. Heteroskedasticy and residual serial correlation are accounted for using Newy-West (1987) estimator of the regression error variance. As an additional cross check device, we have computed OLS estimations of the same models. Overall, no major differences are detected between the two methods. Table 5 reports two models estimated for each country, one without and one with the land price proxy. All the estimated coefficients have the expected sign. The model for Germany is specified including the reunification dummy and the interaction terms. For completeness table 6 reports a comparison of the model for Germany in table 5 with the model specified without interactions and dummies. No major differences in the size of coefficients are detected except for the elasticity to interest rate. In the following, we present results for the impact of each variable focusing on cross country differences.

The *GDP* variable exerts a positive impact on residential investments in all countries as expected. Looking at specification (1) the elasticity of investment to *GDP* ranges between 40 and 50 per cent for Germany, France, the Netherlands and UK. It equals 20 per cent in Italy and it is more than 100 per cent in Spain. In model (2) these differences persist. However, for UK and France the elasticity of investments to *GDP* becomes insignificant whilst in the other countries is reduced in size. Interestingly, the *LAND* variable seem to capture partially or entirely the effect of *GDP*. It is an expected result from the theoretical model sketched in section 2.1. In Germany, when the land price proxy is introduced, the elasticity of GDP rises close to one, instead.

The land price (*LAND*) is included in specification 2 only. To recall, dwellings and construction land are highly complementary goods in the households' portfolio and typically when buying a house, the household also buys a claim to the underlying land. More importantly for our purposes, most (but not necessarily all) factors that affect the household demand for dwellings also have a similar impact on the demand for land for construction purposes. The coefficient on land prices is positive in all countries. In the reduced form specification the land variable captures costs and demand effects. Apparently, the demand effect is stronger and dominates cost effects. In other words, the positive coefficient allows interpreting *LAND* as a proxy for an option to build. In this light the elasticity of investments to *LAND* should in principle reflect also the exogenous constraints imposed on building permissions and building capacity limitations while capturing long-run permanent demand drivers such as household formation, which has been growing steadily over time, and potentially also income effects. Indeed *LAND* reduces the elasticity of income, if not dominating it, in some countries (i.e. France, UK and Italy).

[21] We have cross checked the results using a SUR model that allows for a common structure across countries. As expected, the t-statistics turns out to be higher, but none of the following results are affected.

Investments elasticity to $LAND$ ranges between 0.4 and 0.5 in France, Italy and UK. It is around 0.1 in the Netherlands and Spain whilst it is close to unity in Germany. This result shows that the responsiveness of investments is different across major European economies even in the long-run. It suggests that there are possible structural factors capable of influencing the elasticity of investments, among them can be listed the availability of land and, possibly, the country regulatory framework.

The long-run estimation elasticities to the real long-term interest rate (INT) for France, Germany, Spain and the Netherlands are similar. They range between -1.9 and -2.2 for the specification that includes land prices whilst they are more disperse without the inclusion of land prices (between -1.8 and -3.5). In Italy and UK elasticities are around -0.8 in specification (1), and between -0.5 and -0.6 in specification (2). The cross country heterogeneity may reflect differences in the maturity of funding costs, with more short term maturity for those countries having a lower elasticity.

4.2 Short-run dynamics

Results are based on quarter-on-quarter differences. The error correction term included in the short-run dynamic equations is based on the DOLS approach as defined previously in table 5 and sections 3. The long-run equation entering the short-run model includes the land variable. We have chosen this specification since cointegration is detected for all countries (see table 2). The results in table 7 are based on OLS estimates[22] whilst table 8 reports the outcome of a two stage least square – TSLS – approach. We have instrumented house price changes, which are already included with one lag, using two lags of the same variable and lagged population dynamics (see section 4.3 for tests). The instruments approach is used as a cross check of the OLS approach since theoretically the inclusion of the lagged component of the dependent variable (residential investments) should already serve as an instrument and capture past dynamics of the explanatory variables. The number of lags is selected on the basis of the exclusion of autocorrelation in the residuals (see section 4.3 for tests) and on the assumption that residential investment dynamics may have a certain degree of persistence. An alternative specification is also proposed. It excludes the lags of the dependent variable and it is based on a TSLS approach. Having a benchmark model estimated in OLS and a comparable model based on TSLS[23] simplifies the comparison with any other alternative model. All in all, the tables of results report the responses of investments to lagged investment changes (ΔRHI), included with four lags, the response to lagged changes in the value of the asset (ΔRPP), to construction costs ($\Delta COST$) and to interest rate (ΔINT). As a benchmark model we refer to the results based on the OLS estimation reported in table 7.

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[22] We have cross checked the results using a SUR model allowing for every component to be country specific. The results remain unchanged.

[23] This approach is employed in the specification with four lags as a cross check device since the lagged dependent variable captures already the lagged effect of the other explanatory variables.

Operating costs changes (*ΔCOST*), such as raw material and salaries, do not affect investment in the short-run. This finding is in line with the literature, which has strived to find a statistically significant impact of costs (see also Knudsen, 1994; Hakfoort and Matysiak, 1997). Germany is an exception since the cost variable results to be statistically significant. Financing cost changes (*ΔINT*) seem to be of minor relevance in the short-run except for Italy. This feature may be related to the overall financing conditions, the level of demand and supply, and the term structure of credit lines.

The short-run reactions of investments to real house price changes (*ΔRPP*) are different across countries. Germany has the highest elasticity[24] of around 0.85. It matches with a (negative) elasticity to cost of roughly -0.86. These two pieces of information together suggest that an approximated Tobin-Q has been estimated in the short-run dynamics of German investments. The responsiveness of investments to asset value changes is positive and statistically significant for France and Spain whereas Italy, the Netherlands and UK show no evidence of short-run price responsiveness to prices. The result for the Netherlands confirms evidence already reported in Vermeulen and Rouwendal (2007). On the one hand, a higher elasticity of investments to asset values may generate more volatility in output in the short-run since it generates a larger reaction. On the other hand, a higher elasticity reduces margins and it prevents to generate extra profits in the short-run. To the contrary excessive short-term profits may trigger excessive dynamics in housing investments over the medium term and they can be implicitly a source of boom and bust dynamics. Under this interpretation, the high responsiveness of investments to house price changes in Germany may have prevented the generation of large imbalances in the form of high short term returns.

The speed of adjustment to the long-run disequilibrium (*ECM*) is similar across Germany, France and Italy. The size of the coefficient suggests an adjustment cycle of around three years. The adjustment coefficient is similar and higher in the Netherlands and UK. This should be combined to a very low persistency in housing investments. Interestingly, residential investments in Spain do not seem to be sensitive to a long-run disequilibrium whereas the Spanish model of housing investments seems to be mainly driven by short-run developments in real residential property prices and entails a certain degree of persistency. Consequently, building activity in Spain seems to be mainly related to past activity and potential short-term gains in asset values. Such behaviour is consistent with the evidence of boom and bust dynamics in the recent investment cycle for Spain.

For all countries, but Italy, a significant persistence of investments (*ΔRHI*) is detected. The estimated coefficients on investments reported in table 7, and in any other specification including lagged investments, reflect the summed effect of four lags. The joint significance has been tested. Two set of Wald tests have been conducted, namely: (i) under the null hypothesis the sum of the lagged coefficients is equal to zero; (ii) under the null

[24] A 0.1 elasticity means that a 10% increase in real house prices triggers a reaction in residential investments of 1%.

hypothesis the single lags are one equal to the other and they are equal to r=0. The results of both tests reject the null hypothesis for all countries, but Italy. Usually construction activities take time to be completed. Accordingly the results of the tests together with the estimated cumulative impact suggest that once started construction investments may take long to be terminated. Indeed, four lags equal to one year time span. The lower persistency in investments for the Netherlands is coupled with a high coefficient on the speed of adjustment, β, implying that investments are less persistent since they tend to revert quickly. All in all, the higher is the persistence of investments, the more pronounced can be a housing investment cycle.

The combination of information stemming from the elasticity of investment to costs and to asset values with the information coming from the persistency of investments may be of help in interpreting the underlying market structure. For example, a low response of residential investments to prices combined to a high level of persistency in investments may contribute to high and persistent profits for firms – given the potentially high margins obtained. These factors may contribute to amplified effects over the business cycle for the economy as a whole.

The results from the OLS and the TSLS (see table 8) embedding the long-run equation based on model (2) in table 5 are very similar and comparable in terms of size and sign of the coefficients. Small differences between the two methodologies are detected primarily in the persistency coefficient of the lagged investment component for some countries. This difference can be explained with marginally muted sizes of coefficients on the other explanatory variables. Given this result, we have estimated the TSLS model without the inclusion of lags of the dependent variable[25] (see table 9). For all countries, as expected, the explanatory power of the model decreases when the results are compared to the models estimated including the lagged investment component. Interestingly, the overall results are confirmed. It confirms the relevance of short-run real house price changes for residential investments dynamics after controlling for costs and other factors.

4.3 Cross-checks, specification tests and robustness

In the literature a cross-country analysis has been frequently associated to panel estimation approaches. Coherently with this, panel results are reported as a crosscheck device of the country specific models. Table 10 reports results for a panel based on DOLS estimation including fixed country effects and using the model specifications reported in table 5. All the variables considered are significant and with the expected sign. This confirms in a panel framework the previous results for single countries. Moreover, the inclusion of land reduces the size of the other coefficients similarly to the single country models. Last but not least, the estimated coefficients in the DOLS estimation are close to the average of the coefficients stemming from the single country regressions. In detail,

[25] In general the OLS is not biased. However, the t-statistics for the coefficient are overestimated.

depending on the model specification and estimation approach, the average coefficient on GDP ranges between 0.6 and 0.4, the coefficient for the land price proxy is roughly 0.3 and the coefficient on the real long term interest rate falls in between -1.7 and -1.2. As found in the single equation models, the inclusion of land reduces the size of the GDP coefficient (see section 4.1). However, comparing these estimated coefficients with the country specific coefficients reported in tables 5 and 6, a Hausmann (1978) test for common cross-country coefficients fails in this case. This last point stresses again the importance of cross-country differences.

Panel results for the short-run dynamics are reported in table 11. Estimations include fixed country effects. Specification (1) involves a long-run component based on the panel estimations in table 10, whereas specification (2) is based on long-run equations estimated country by country as reported in table 5. An assessment of the panel results against the country by country estimates shows that separate short-run estimations are required since a Hausmann (1978) type test rejects common coefficients across countries for all the variables entering the short-run specification. A comparison across panel estimations suggests that results are similar. Additionally, the inclusion of a long-run component based on single country regressions (model specification 2) increases the fit of the model and the speed of the adjustment coefficient is higher than in specification (1).

We have conducted a number of tests to evaluate the instruments employed and to select the number of lags of the dependent variables to be included in the right-hand-side of the model. The selected number of lags – four – reflects the minimum number required to eliminate autocorrelation in the residuals as tested in the top panel of table 12. To test for this, we have employed an F-statistics based test (see also Breusch and Godfrey, 1981). The null hypothesis corresponds to all coefficients equal to zero except the intercept. The null hypothesis tests the joint non-statistical significance of an *n* number of lagged residuals in explaining the actual residual against any other alternative. Under the null, the selected minimum number of lags of the dependent variable is four[26]. Table 12 reports also two tests for the validity of the employed instruments in the TSLS approach. The first test is based on the F-test statistics in an inverted regression method where the null hypothesis assesses the joint significance of instruments and independent variables on the residual. The second test assesses the validity of the over identifying restrictions and it reports *p*-values. Under the null hypothesis that the overidentifying restrictions are satisfied, the J-statistic times the number of regression observations is asymptotically χ^2 distributed with degrees of freedom equal to the number of overidentifying restrictions – see Newey and West (1987). The selected set of instruments cannot be rejected.

Additionally, we have conducted a robustness check looking at the sensibility to a sample size change. To cross check the robustness of the results reported in table 7, we have

[26] In some countries (e.g. the Netherlands) the number of lags can be lower. However, we have opted for a common lag structure across countries.

estimated the same models from 1970 to 1998. By doing so, we exclude two important factors, namely: the entry into the monetary union and the start of the last cycle in the housing market. The results are reported in table 13. They confirm the findings previously outlined and therefore the robustness of our estimates.

4.4 Combining the short- and the long-run estimates

We have conducted a simulation exercise, which is effectively comparable to an impulse response exercise, following the approach in Bachmeier and Griffin (2003)[27]. We are interested in the effect of a *ceteris paribus* permanent asset value increase on investment activities. There are permanent factors that can influence a shift in the value of residential assets. For example, permanent shifts can be associated with demand shifts such as a change in the permanent income, population growth and household dynamics[28] but also with changes in regulation and consequently supply. These are fundamental domestic factors, which can permanently alter the quantity of housing via increased needs and/or modified requirements for residential land. The model used for this exercise is calibrated on the results reported in table 7. It is the preferred model for its long-run and short-run statistical properties as explained in section 4. The model is able to derive only a partial reaction[29] of investments to assets value changes based on a long-run reduced form equation and partial short-run dynamics[30]. Under these assumptions, we generate a permanent increase[31] of 1 per cent in the real value of land.

Charts 3 and 4 show the results of the exercise. Chart 3 reports the cumulated response of real residential investments after a permanent shift in land price. The values on the *y*-axis represent the percentage deviation from the initial level. A (new) level of investments and a full convergence is generally reached after 10 to 15 periods (quarters) – 3 years roughly. However, a general convergence is reached after 4 to 8 periods roughly – i.e. 1 to 2 years. More specifically, a 75 per cent response in level is reached after 4 periods. France stands out since the same level of response is reached in 8 periods. It suggests a long lagged response of housing investments to asset value shocks. Moreover, the level shift equals roughly 0.4 per cent in Spain and France. It is slightly lower in the United Kingdom and a fifth in Italy whilst it is 1.5 per cent in Germany. The latter is more than the level shift in the land price value. It should be stressed that by historical comparisons a shock of 1 per

[27] See this article for a more detailed description of this methodology and for the reasons we prefer the impulse responses which are derived from the two-step procedure of Engle and Granger (1987).
[28] The average growth of households between 1998 and 2005 differs across countries. In Germany household formation growth (0.6 per cent per year) is less than a fourth of Spanish figures (2.7 per cent per year). This strong cross country divergence may have contributed to generate different shocks to the housing market.
[29] There are no feed back effects from quantities to prices
[30] Henceforth, the simulation results should be interpreted with caution because the systemic relation of prices and quantities is only partial.
[31] The model is symmetric so that positive and negative shocks exert the same impact in absolute value.

cent in real terms in Germany is quite substantial when compared to the volatility of real house prices[32].

Chart 4.a shows the quarter on quarter percentage response of private residential investments to a permanent shock of 1 per cent change in the proxy for land value. The results report the point estimates[33] of impulse responses as in Bachmeier and Griffin (2003). Germany has the strongest response which is more than a 1 per cent increase in investments after 2 quarters. The other countries have annual responses ranging between 0.1 and 0.8 per cent. In chart 4.b we report the same figures excluding Germany. It becomes clearer that a high degree of heterogeneity exists also across this group of countries. Low responses are recorded in Italy and Spain while France and United Kingdom reaction is similar. The Netherlands fall somewhat in between these two groups of countries. However, the persistence of the reaction differs between the latter countries with France showing a higher degree of persistency.

5. Concluding remarks

We have detected differences in the responsiveness of housing investments across major European economies, employing a common modelling structure based on an error correction approach and country specific estimations. The long-run investment coefficient on *LAND* ranges between 0.4 and 0.5 in France, Italy and UK. It is around 0.1 in the Netherlands and Spain whilst it is in the contour set of unity for Germany. The short-run reaction of housing investments to house price changes is different across countries. Germany has the highest elasticity[34] of around 0.85 which jointly with a (negative) elasticity to cost of roughly -0.86 approximates a tobin-Q. The short-run responsiveness of investments to house prices is positive for Spain and at a lower extent for France whilst there is not a strong evidence of responsiveness in Italy, in the Netherlands and UK. Furthermore, the speed of adjustment to the long-run co-movement (*ECM*) is similar across Germany, France and Italy. It suggests an average adjustment cycle of roughly three years. A higher adjustment coefficient is estimated for the Netherlands and UK, which is combined with a low persistency in housing investments. A not significant adjustment coefficient is recorded for Spain where investment dynamics seem to be primarily driven by short-term developments, namely the lagged investment component and residential property price changes.

Additionally, we have simulated a reaction of investments to a common asset value increase. As a result, Germany has the strongest response whereas Italy is the less responsive. The difference in the responses and estimated coefficients in the models may

[32] For example, the volatility of real house prices in Germany has been 0.028 between 1970 and 2009 whereas it has been around 0.1 in Spain and in Italy.

[33] Confidence intervals are available upon request. We have employed posterior simulation to calculate confidence intervals of a nonlinear function of the coefficients (see Rossi et al., 2005; Koop, 2003)

[34] A 0.1 elasticity means that a 10% increase in real house prices triggers a reaction in residential investments of 1%.

be affected by several demand and supply factors. Among the supply factors the evidence reported in the introduction to this paper on the time required to get a building permit fits well with our findings on cross country differences in the responsiveness of housing investments to changes in prices.

To summarise, this paper contributes to shed further light on potential cross country differences in investment responses to changes in prices and other factors. Second, the detected country differences in the responsiveness of investments stress the importance of considering country specific models in the analysis of the housing market. Third, the results in the paper confirm some of the available evidence from previous country specific studies - e.g. strong response of residential investments in Germany, and an insignificant response of investment to house prices in the short-term for the Netherlands.

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Annex: Data

Data were collected from various international and national sources. The series employed covers a long period spamming from roughly 1970 to 2009. Henceforth, series for some variables and specific countries entail more than one source. This procedure was applied only when it has not been possible to find the required missing data from a common national source. In order to guarantee a high degree of cross country harmonisation, a common source principle has been applied as preferred selection criteria.

The following country abbreviations are used: DE for Germany, FR for France, ES for Spain, IT for Italy, NL for the Netherlands and UK for the United Kingdom.

The following abbreviations of sources are used: *OECD*: Organisation for Economic Co-operation and Development; *OEO*: OECD Economic Outlook; *MEI*: Main Economic Indicators – OECD; *QNA*: Quarterly National Accounts – OECD; *ESA95*: European System of National Accounts 95; *NSI*: National Statistical Institute; *ECB/ESCB*: European Central Bank and European System of Central Banks (including individual National Central Bank); *STAT*: Eurostat and National Office of Statistics; *MEI*: Main Economic Indicators – OECD; *BIS*: Bank of International Settlements.

Nominal Private Residential Investments (NHI)

Country: DE; ES; FR; IT; UK
Source: *ESA95*. Definition: Gross fixed capital formation: housing **-** Current prices **-** National currency. Frequency: Quarterly. Unit: Millions. Adjustment details: Working days and seasonally adjusted. Starting date: DE – 1991; ES – 1980; FR – 1978; IT – 1980; UK – 1970.

Country: NL
Source: *QNA*. Definition: GFCF residential construction – current prices. Frequency: Quarterly. Unit: Millions. Adjustment details: Seasonally adjusted. Starting date: NL – 1987.

The series for DE and IT are backdated with: Source: *QNA*. Definition: Gross Fixed Capital Formation **-** Current prices – National Currency. Frequency: quarterly levels. Unit: Millions. Adjustment details: seasonally adjusted. DE: series for West Germany. The series for the FR is backdated with: Source: *OEO*. Definition: the series is obtained combining the real private residential investment and the residential investment deflator - $NHI = DNHI * RHI$. The series for NL and ES are backdated with: Source: *ECB/ESCB*.

Real Private Residential Investments (RHI)

Country: DE; ES; FR; IT; UK
Source: *ESA95*. Definition: Gross fixed capital formation: housing **-** Chain linked volumes – reference year 2000. Frequency: Quarterly. Unit: Millions. Adjustment details: Working days and seasonally adjusted. Starting date: DE – 1991; ES – 1995; FR – 1978; IT – 1981; UK – 1970.

Country: NL
Source: *QNA*. Definition: GFCF residential construction – current prices. Frequency: Quarterly. Unit: Millions. Adjustment details: Seasonally adjusted. Starting date: NL – 1987.

The series for DE and IT are backdated with: Source: *QNA*. Definition**:** Gross fixed capital formation: housing **-** Constant prices – National Currency. Frequency: quarterly levels. Unit: Millions. DE: series for West Germany. The series for the FR is backdated with: Source: *OEO*.

Definition: Gross fixed capital formation: housing. Frequency: quarterly levels. Unit: Millions. The series for ES is backdated with: Source: *ECB/ESCB*. The series for NL is backdated from 1977 with: Source: *QNA*. Definition**:** Gross fixed capital formation: housing **-** Constant prices – National Currency. Frequency: quarterly levels. Unit: Millions; for 1970-1976 with: Source: *ECB/ESCB*.

Private Residential Investments Deflator (DNHI)

Country: DE; ES; FR; IT; NL; UK
Definition: it is obtained from the decomposition of real and nominal private residential investments via the formula: $DNHI = (NHI/RHI)*100$. Index base: 2005

Nominal Gross Domestic Product (GDP)

Country: DE; ES; FR; IT; NL; UK
Source: *ESA95*. Definition: Gross domestic product at market price **-** Current prices **-** National currency. Frequency: Quarterly. Unit: Millions. Adjustment details: Working days and seasonally adjusted. Starting date: DE – 1991; ES – 1980; FR – 1978; IT – 1980; NL – 1987; UK – 1970.

The series for DE, ES, FR and IT are backdated with: Source: *QNA*. Definition**:** Gross domestic product **-** Current prices – National Currency. Frequency: quarterly levels. Unit: Millions. Adjustment details: seasonally adjusted. DE: series for West Germany. The series for the NL is backdated with: Source: *OEO*. Definition: Gross domestic product, value, market prices. Frequency: quarterly levels. Unit: Millions.

In order to isolate the impact of the private residential investment component, the series have been adjusted (*ADJGDP*) applying a standard accounting equation: $ADJGDP = GDP - NHI$.

The real adjusted GDP series (*ADJGDP*) have been deflated with CPI.

Consumer Price Deflator (CPI)

Country: DE; ES; FR; IT; NL
Source: STAT. Definition: Harmonized index of consumer prices **-** Overall index. Frequency: monthly index transformed quarterly taking the inter-quarter average level. Starting date: DE – 1985; ES – 1992; FR – 1990; IT – 1987; NL – 1988.

Country: UK
Source: *STAT*. Definition: retail prices, all items. The owner-occupied component has been excluded. Frequency: monthly index transformed quarterly taking the inter-quarter average level. Starting date: 1970.

The series have been backdated with the national CPIs: Source: *STAT*, *ECB/ESCB*. An alternative deflator based on the GDP deflator was also tried and led to practically the same results.

Long Term Interest rates (INT)

Country: DE; ES; FR; IT; NL; UK

Source: *OEO*. The basic definition refers to the long-term interest rate on government bonds. In 1991 for DE the series is backdated with the Former Federal Republic of Germany long-term interest rate on government bonds. The series in real terms is constructed as the difference between the nominal series and the *ex-post* inflation rate based on the consumer price deflator.

Construction Costs (COST)

Country: DE; ES; FR; IT
Source: *MEI*. Definition: Cost of construction – residential. Frequency: quarterly. Index base: 2005. Starting date: DE – 1970, ES – 1971, FR – 1970 and IT – 1970.

Country: NL
Source: *BIS*. Definition: Cost of construction – residential. Frequency: quarterly. Index base: 2005. Starting date: NL – 1970.

Country: UK
Source: *STAT*. Definition: Construction output prices, all residential buildings. Frequency: quarterly. Index base: 2005. Starting date: 1980. Backdated with the private residential investment deflator.

The real construction cost series have been deflated with CPI.

Nominal Residential Property Prices (HP)

Country: DE; ES; FR; IT; NL; UK
Source: *OECD*. Definition: Residential property prices – the index coverage varies across countries. Frequency: quarterly – data for some countries (e.g. DE and IT) have been interpolated (OECD). Index base: 2005. For details on original sources, definitions and frequency see Girouard N., Kennedy M., van den Noord P. and André C. (2006). The real residential property price series have been deflated with CPI.

Tables

Table 1. Augmented Dickey-Fuller Test Statistics for the variables entering the cointegrating equation

	Germany		France		Italy	
	level	*first diff.*	*level*	*first diff.*	*level*	*first diff.*
Real Priv. Resid. Inv.	-1.707	-12.983	-1.713	-4.157	-1.361	-11.608
Real GDP adj.	-0.968	-10.300	-0.743	-8.277	-2.012	-7.002
Real Land Proxy	0.362	-7.616	-1.365	-3.724	-1.225	-8.460
Real Int. Rate	-2.053	-8.318	-1.452	-8.718	-1.481	-8.932
	The Netherlands		**Spain**		**UK**	
Real Priv. Resid. Inv.	-1.739	-20.822	-1.520	-3.768	-2.755	-6.948
Real GDP adj.	0.540	-11.225	0.655	-5.350	0.212	-6.037
Real Land Proxy	-1.157	-4.056	-0.233	-4.727	0.845	-5.867
Real Int. Rate	-1.959	-13.028	-1.526	-7.900	-2.785	-7.086

Notes: Augmented Dickey-Fuller Test including constant; Lag length criteria: automatic selection based on Schwarz info criterion; t-statistics are reported; Test critical values: 1% level -3.472; 5% level -2.880; 10% level -2.577

Table 2. Cointegration tests based on Phillips-Ouliaris (1990) and MacKinnon (1990, 2010)

	Real housing investments Land price proxy Real GDP adjusted Real interest rate			Real housing investments Real GDP adjusted Real interest rate		
	Phillips-Ouliaris	Mackinnon	t-statistics	Phillips-Ouliaris	Mackinnon	t-statistics
Germany	I(1)	I(1)	-2.454	I(1)	I(1)	-1.632
Germany - reunification controls	I(0)**	I(0)**	-3.966	I(1)	I(1)	-2.685
France	I(0)**	I(0)**	-3.962	I(1)	I(1)	-2.644
Italy	I(0)**	I(0)**	-3.968	I(0)**	I(0)*	-3.271
The Netherlands	I(0)***	I(0)***	-5.276	I(0)***	I(0)***	-5.145
Spain	I(0)**	I(0)**	-3.949	I(1)	I(1)	-2.921
UK	I(0)***	I(0)***	-5.506	I(0)***	I(0)***	-4.602

Critical values are based on Phillips-Ouliaris (1990) and MacKinnon (1990, 2010)

Null hypothesis: Presence of unit root. Rejection at *** 1 per cent; ** 5 per cent; * 10 per cent.

Note: I(1) refers to a process integrated of order 1 and I(0) to a process integrated of order 0; the "Germany reunification controls" model includes a dummy for the unification period (1990-1995) and also interation terms over the same period for GDP, land proxy and interest rate – see for details table 6

Table 3. Pedroni cointegration tests

		1		2	
		Real housing investments Land price proxy Real GDP adjusted Real interest rate		Real housing investments Real GDP adjusted Real interest rate	
		No Trends	*with Trends*	*No Trends*	*with Trends*
within-dimension test	Panel *v*	3.812*	2.236**	3.671*	1.999**
	Panel *ρ*	-6.549*	-6.297*	-6.808*	-7.002*
	Panel *pp-t*	-5.546*	-6.254*	-5.213*	-6.282*
	Panel *t*	-0.954	-0.747	-1.482***	-1.511***
between-dimension test	Panel *ρ*	-6.722*	-5.374*	-7.145*	-6.074*
	Panel *pp-t*	-4.470*	-3.854*	-4.068*	-4.001*
	Panel *t*	-1.567***	-0.951	-1.831**	-1.253

Critical values are based on Pedroni (1999). * 1 per cent; ** 5 per cent; *** 10 per cent

Notes: The null hypothesis is no cointegration relationship for all countries. The alternative for the within-dimension tests is a cointegration relationship and the degree of autocorrelation in the residuals is the same across countries. The alternative for the between-dimension tests is a cointegration relationship and the degree of autocorrelation in the residuals may differ across countries.

Table 4. Johansen based cointegration tests

	Real housing investments Land price proxy Real GDP adjusted Real interest rate			Real housing investments Real GDP adjusted Real interest rate		
	No Intercept and No Trend	Intercept and No Trend	Intercept and Trend	No Intercept and No Trend	Intercept and No Trend	Intercept and Trend
Germany	1	1	0	1	1	0
France	1	1	1	1	1	1
Italy	1	1	1	1	1	1
The Netherlands	2	2	1	2	2	1
Spain	1	1	1	1	1	1
UK	1	1	1	1	1	1

Note: Reported cointegrating relations at 0.05 level and critiacl values based on MacKinnon-Haug-Michelis (1999) with no lags interval

The results are based on maximum eigenvalues statistics and they do not differ from the trace statistics

Table 5. Long-run equations estimated country by country – DOLS

		DOLS			
		GDP	***INT***	***LAND***	***CONST***
Germany	(1)	0.509***	-1.843**	..	-0.110**
	(2)	0.994***	-1.878***	1.148***	-0.048*
France	(1)	0.380***	-3.469***	..	0.156***
	(2)	-0.004	-2.220***	0.500***	0.038***
Italy	(1)	0.242***	-0.853***	..	0.076***
	(2)	0.061*	-0.513***	0.378***	0.004
The Netherlands	(1)	0.541***	-2.699***	..	0.017
	(2)	0.419***	-1.873***	0.141***	0.005
Spain	(1)	1.324***	-2.197***	..	-0.037**
	(2)	1.211***	-2.160***	0.108**	-0.045**
United Kingdom	(1)	0.431***	-0.861***	..	0.111***
	(2)	-0.076	-0.680***	0.516***	0.066***

**** 1 per cent; ** 5 per cent; * 10 per cent significance level*

Note: the DOLS estimated for superconsistency including 1 leads and lags of the variables in delta; the "Germany" model includes a dummy for the unification period (1990-1995) and also interation terms over the same for GDP, land proxy and interest rate

Table 6. Long-run equations estimated for Germany – OLS/DOLS – (comparison of specifications with and without interactions)

		Real GDP	***Real Long Term Int. Rate***	***Real Land Proxy***	***Constant***
		DOLS			
Germany	(1)	0.543***	-0.956	..	-0.124***
	(2)	1.088***	-1.229**	1.292***	-0.040
Germany - unfication controls	(1)	0.509***	-1.843**	..	-0.110**
	(2)	0.994***	-1.878***	1.148***	-0.048*

**** 1 per cent; ** 5 per cent; * 10 per cent significance level*

Note: the DOLS estimated for superconsistency including 1 leads and lags of the variables in delta; the "Germany - unfication controls" model includes a dummy for the unification period (1990-1995) and also interation terms over the same period for GDP, land proxy and interest rate

Table 7. Short-run equation based on OLS and ECM based on model (2) from table 5

OLS						
	Germany	France	Italy	The Netherlands	Spain	United Kingdom
ΔRHI(-1 to -4)	0.315 b/(c)	0.706 +/(+)	0.217 ./(.)	0.012 b/(+)	0.591+/(+)	0.178 ./(+)
ΔRPP(-1)	0.845**	0.160**	0.024	0.39	0.219**	0.09
ΔCOSTS(-1)	-0.863**	-0.086	0.031	0.054	-0.148	-0.063
ΔINT(-1)	0.073	0.247	-0.334**	-1.690	-0.022	-0.023
ECM	-0.063**	-0.109***	-0.102***	-0.286**	-0.027	-0.243***
R²	0.12	0.48	0.15	0.38	0.34	0.24

**** 1 per cent; ** 5 per cent; * 10 per cent significance level; "+ ", "b" and "c" are 1%, 5% and 10% significance levels if the joint significance of lagged investment component. Two levels are reported since two different Wald tests are conducted - see note. HAC standard errors are employed.*
Note: the ECM variables are based on DOLS reported in table 5. ΔRHI(-1 to -4) is the sum of four lagged coefficients on residential investments dynamics. Two sets of Wald tests are conducted: (i) under H0 the sum of the lagged coefficients is equal to zero; (ii) under H0 the single lags are one equal to each other and equal to r=0 - the results of this second test are reported into brackets (). The number of lags included in the models is based on the Akaike info criterion. Four corresponds to the maximum number of lags included.

Table 8. Short-run equation based on TSLS and ECM based on model (2) from table 5

TSLS						
	Germany	France	Italy	The Netherlands	Spain	United Kingdom
ΔRHI(-1 to -4)	0.333 ./(c)	0.776+/(+)	0.211 ./(.)	0.014 c/(+)	0.687+/(+)	0.457 b/(+)
ΔRPP(-1)	0.816**	0.047**	0.029	0.806**	0.151**	-0.333
ΔCOSTS(-1)	-0.799**	-0.065	0.019	0.002	-0.068	-0.063
ΔINT(-1)	-0.124	0.235	-0.300**	-1.829	0.079	0.149
ECM	-0.071**	-0.113***	-0.103***	-0.186**	-0.032	-0.285***
R²	0.12	0.47	0.15	0.34	0.33	0.22

**** 1 per cent; ** 5 per cent; * 10 per cent significance level; "+ ", "b" and "c" are 1%, 5% and 10% significance levels if the joint significance of lagged investment component. Two levels are reported since two different Wald tests are conducted - see note. HAC standard errors are employed.*
Instruments: The lagged change in price has been instrumented with previous lags in prices and lags in population
Note: the ECM variables are based on DOLS reported in table 5. ΔRHI(-1 to -4) is the sum of four lagged coefficients on residential investments dynamics. Two sets of Wald tests are conducted: (i) under H0 the sum of the lagged coefficients is equal to zero; (ii) under H0 the single lags are one equal to each other and equal to r=0 - the results of this second test are reported into brackets (). The number of lags included in the models is based on the Akaike info criterion. Four corresponds to the maximum number of lags included.

Table 9. Short-run equation based on TSLS excluding lagged investments and ECM based on model (2) from table 5

	TSLS					
	Germany	France	Italy	The Netherlands	Spain	United Kingdom
ΔRPP(-1)	0.980***	0.494***	0.035	0.052	0.386***	0.326*
ΔCOSTS(-1)	-0.658**	-0.104	0.036	0.727	-0.160	-0.140
ΔINT(-1)	-0.115	-0.056	-0.357***	-1.226	-0.217	-0.157
ECM	-0.047*	-0.022**	-0.053**	-0.627***	0.003	-0.233***
R^2	0.08	0.24	0.09	0.30	0.15	0.18

**** 1 per cent; ** 5 per cent; * 10 per cent significance level. HAC standard errors are employed.*

Instruments: The lagged change in price has been instrumented with previous lags in prices and lags in popualtion

Note: the ECM variables are based on DOLS reported in table 5, model (2).

Table 10. Long-run equation estimated in a pooled regression framework – panel approach

	DOLS	
	(1)	(2)
GDP	0.649***	0.441***
INT	-1.694***	-1.470***
LAND		0.290***
CONST	0.035***	0.012

**** 1 per cent; ** 5 per cent; * 10 per cent significance level*

Note: the DOLS estimated for superconsistency including 1 leads and lags of the variables in delta; country fixed effects are included in all the specifications; Cross-section SUR (PCSE) standard errors & covariance (d.f. corrected)

Table 11. Short-run equation in a pooled regression framework – panel approach based on OLS

	(1)	(2)
ΔRHI(-1 to -4)	0.012 c/(c)	0.013 c/(c)
ΔRPP(-1)	0.133*	0.118*
ΔCOSTS(-1)	0.215	0.219
ΔINT(-1)	-0.239	-0.208
ECM	-0.099**	-0.192**
R^2	0.21	0.23

**** 1 per cent; ** 5 per cent; * 10 per cent significance level*

Note: (1) is based on the panel estimations in table 10 whereas (2) is based on single countries long-run equations from table 5. Both ECM include the land proxy in the long-run. ΔRHI(-1 to -4) is the sum of four lagged coefficients on residential investments dynamics. Two sets of Wald tests are conducted: (i) under H0 the sum of the lagged coefficients is equal to zero; (ii) under H0 the single lags are one equal to each other and equal to r=0 - the results of this second test are reported into brackets ().

Table 12. Autocorrelation and instruments tests for models in tables 8, 9, 10 and 11

	Germany	France	Italy	The Netherlands	Spain	United Kingdom
Autocorr test for the models in tables 7 and 8 - F-test based						
OLS	0.68	1.51	0.42	0.22	1.39	0.92
TSLS	0.74	1.55	1.43	2.00	1.31	1.92
(1) Instruments test - F-test on inverted regression - F-statistics reported						
TSLS	0.16	0.04	0.10	0.69	0.15	0.67
(2) Instruments test - test the validity of overidentifying restrictions - p-values reported						
TSLS	0.52	0.92	0.91	0.59	0.65	0.90

Note: The autocorrelation test and the instruments test (1) are based on the F-test where H_0 is all coefficients (except the intercept) equal to zero. The autocorrelation (instrument) test assesses the joint significance of seven lagged residual coefficients (instruments and depend variable on the residual). The F-test stastics are reported in the table and the *** 1 per cent; ** 5 per cent; * 10 per cent significance levels indicate the relative statistical probabilities of not accepting H_0. The instruments test (2) assesses the validity of overidentifying restrictions. Under the null hypothesis that the overidentifying restrictions are satisfied, the J-statistic times the number of regression observations is asymptotically with degrees of freedom equal to the number of overidentifying restrictions, see Newey and West (1987a).

Table 13. Short-run equation estimated between 1970 and 1998 based on OLS and ECM based on model (2) in table 5 – with long-run estimated over a restricted sample (between 1970 and 1998)

	Germany	France	Italy	The Netherlands	Spain	United Kingdom
OLS						
ΔRHI(-1 to -4)	0.292 b/(b)	0.728 +/(+)	0.177 c/(b)	0.013 c/(+)	0.595 +/(+)	0.299 +/(+)
ΔRPP(-1)	0.704**	0.284**	0.007	0.349	0.144**	0.057
ΔCOSTS(-1)	-0.681*	-0.225*	0.148	-0.285	-0.158	0.397
ΔINT(-1)	0.239	0.260	-0.349***	-1.248	0.045	0.031
ECM	-0.074**	-0.138***	-0.126***	-0.200***	-0.035	-0.352***
R^2	0.11	0.47	0.19	0.39	0.27	0.28

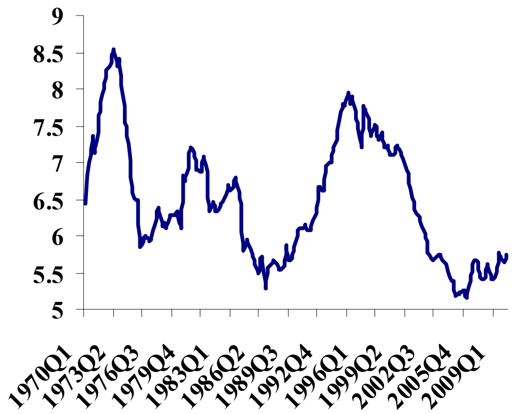
**** 1 per cent; ** 5 per cent; * 10 per cent significance level; "+ ", "b" and "c" are 1%, 5% and 10% significance levels if the joint significance of lagged investment component. Two levels are reported since two different Wald tests are conducted - see note*

Note: the ECM variables are based on DOLS reported in table 5. ΔRHI(-1 to -4) is the sum of four lagged coefficients on residential investments dynamics. Two sets of Wald tests are conducted: (i) under H0 the sum of the lagged coefficients is equal to zero; (ii) under H0 the single lags are one equal to each other and equal to r=0 - the results of this second test are reported into brackets (). The number of lags included in the models is based on the Akaike info criterion. Four corresponds to the maximum number of lags included.

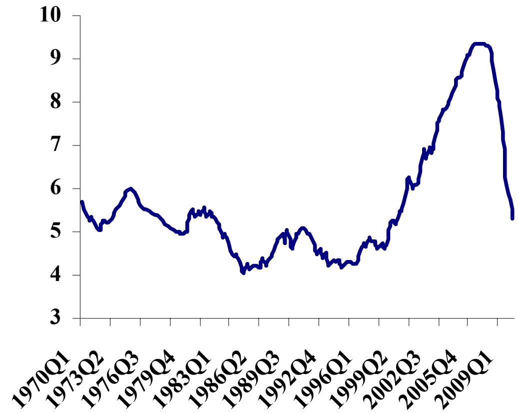
Figures

Chart 1. Dynamics of private residential investments to GDP ratio – *percentage points*

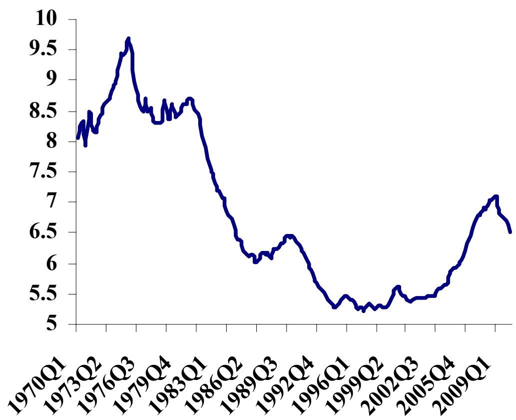
Germany



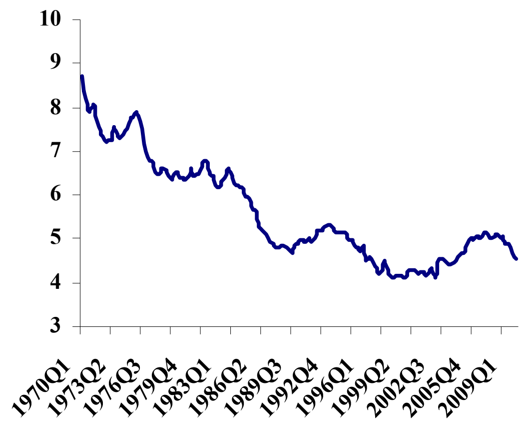
Spain



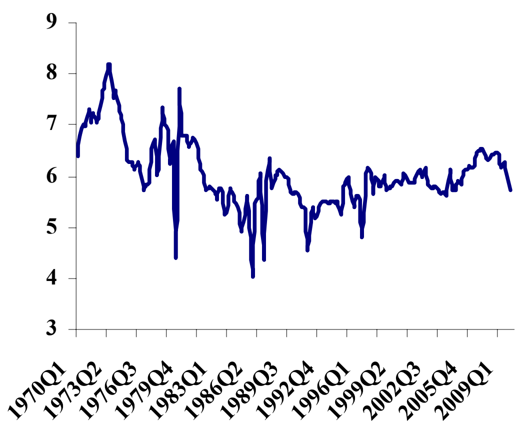
France



Italy



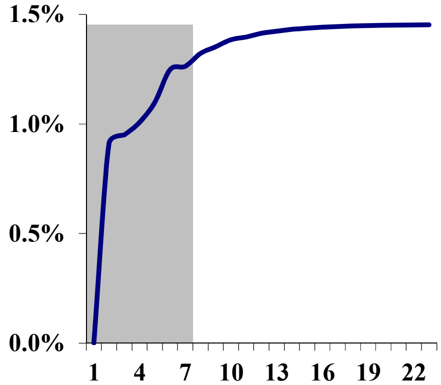
The Netherlands



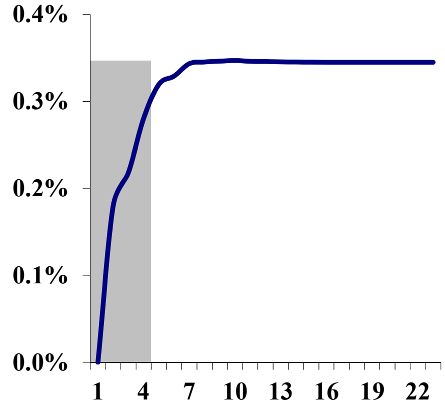
United Kingdom

Chart 2. Cumulated response of private residential investments to a permanent price increase *(75% percent level response in grey shaded area)*

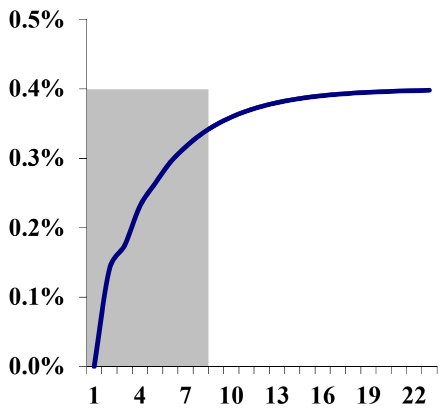
Germany



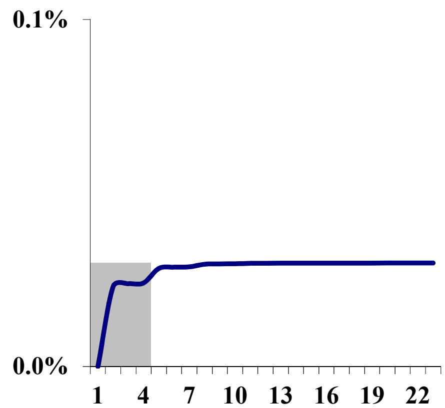
Spain



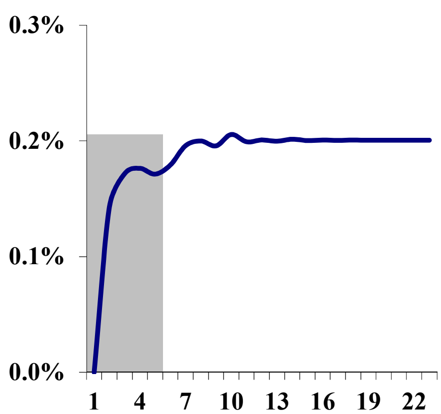
France



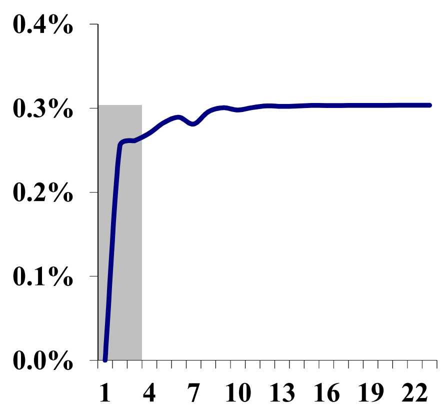
Italy



The Netherlands



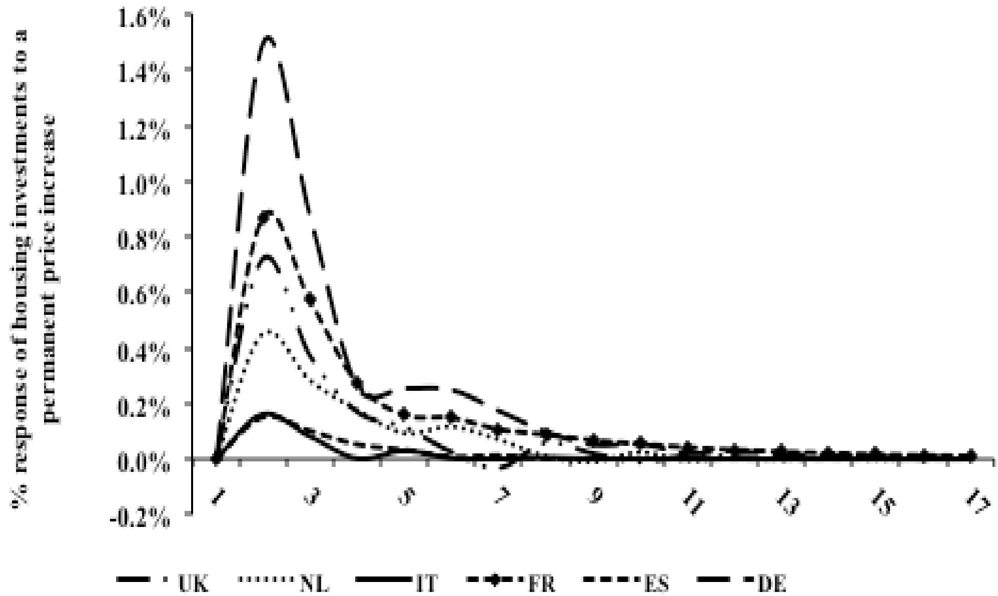
United Kingdom



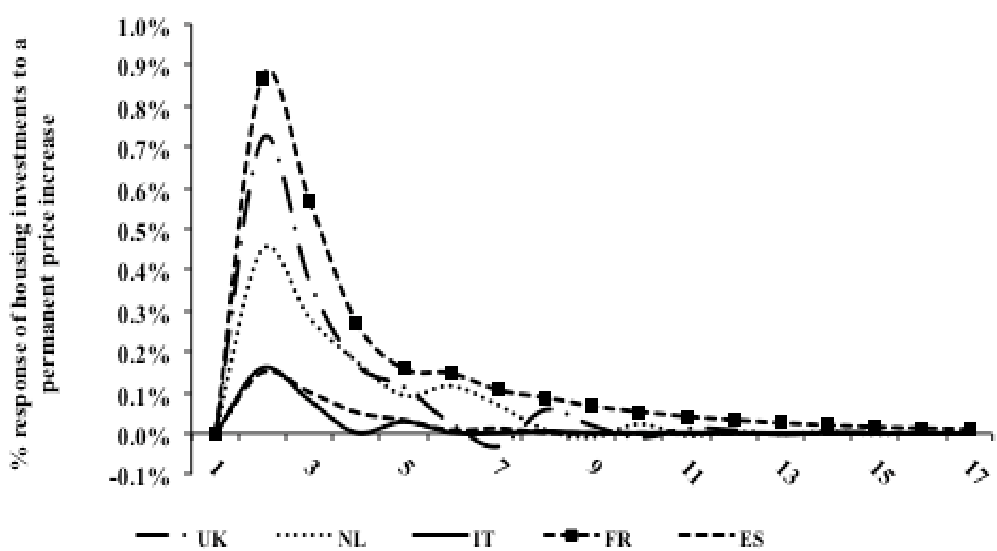
Note: the shock reflects 1% increase in the value of land keeping all the other variables unchanged. Model calibrated on coefficients in table 7.

Chart 3. Country responses of private residential investments to 1 per cent permanent price increase

a. All countries



b. Excluding Germany



Note: the shock reflects 1% increase in the value of land keeping all the other variables unchanged. Model calibrated on coefficients in table 7.