Three empirical essays on house prices in the euro area

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WÌDMUNG

Àn e Sundgäuer Frìnd
un Frìnd vom Sundgäu,
Aimé Fuchs.

Àls Màthemàtiker ìsch er g' sìì e Held
Hìtta no wìrd von Ìhm verzählt
D'r Paatrimoine un Elsasser Sproch,
Dia het er g'hàba so hoch.
Er het sìch ìmmer ìnteressiert àn àlta Sàcha,
Do drìber het er so griaslig chena Làcha
B'sunders d'r Sungäue ìsch Ìhm so glaga àm Harz,
Ìn Freid un sogàr ìn Schmarz
D'r Sundgäu ìsch fìr Ìhn chüm g' sìì beschrieba
Denn Ewig düat er fìr Ìhn sini Heimet blieba.

Gedìcht vom e n àndara Fuchs wo ìn Nìeder-Räuschpa Gedìchtle fuchst, äisera lieba un luschtiga Doni.

Graphie : Edgar Zeidler

OVERVIEW

Motivation

The real euro area house price has increased steadily since 1997 reaching more than 6.5% in 2004 and 2005. The rise on its own is not as striking as the long lasting effect of the phenomenon. Indeed, it is the longest lasting house price increase ever experience in the euro area since data are available. Dramatic asset price volatility can harm real economic activity, as witnessed by manifold historical episodes like in Japan in the beginning of the 90s. Boom-bust cycles in asset prices impinge on household's wealth and so aggregated demand. Due to asymmetric information, a dramatic collapse can eventually cause a credit-crunch or even a disruption of the credit supply (systemic failure).

ECB's primary objective is to maintain price stability, which means broader spoken macroeconomic stability. As house price movements have significant effects on real economic activity, the ECB has to pay special attention on house market development. In ECB policy, the second pillar pertains to the money aggregate M3, while mortgage loan development is a counterpart of M3. In 2005, the ECB suspected mortgage loan development to fuel soaring house prices. Thus, this thesis aims at shedding more light on the factors driving house prices. Is there any fear of sharp decline? More precisely, the thesis addresses following questions:

- In which framework can we explain house price movements? Can we explain house price movements in an asset pricing model underpinned by arbitrage mechanism or rather in a more general demand supply interaction framework?
- Which factors drive house price movements?
- What is the knock-on house prices, mortgage borrowing and stock of dwelling following a monetary policy shock qualitatively and quantitatively?
- What belongs to short-term / and long-term? One task of the thesis is also to disentangle long-term from short-term dynamics.
- Is current house price above its fundamental value?
- If yes how would it converge back to its equilibrium level if the tide eventually started to turn?

The literature partially investigates these questions. On the one hand, Tsatsaronis & Zhu (2004), IMF (2004) and Lecat & Mesonnier (2005) use a panel of OECD countries. However, they do not investigate either the interaction with the mortgage market, or the estimation of long-term house price, or the convergence to steady state. At least they come to general conclusions on house market and price determinants. On the other hand, McArthy & Peach (2004) and Martinez & Angel (2003) focus on the USA and Spain respectively by using time series econometrics. Thus, their conclusions are country specific. No author investigates the situation in the euro area as a whole. To the best of my knowledge, no survey comes to euro area policy conclusions which could enlighten the ECB.

Methodological development

The major problem with respect to the euro area is the lack of data. Indeed, the frequency of residential property price is as a rule yearly and for most countries only from the mid 70s to 2005. The time dimension for time series econometrics is too low for reliable and stable estimates. This raises the problem of stability and power of the estimates. As a result, in all my three working papers I implement the following strategy. I estimate the parameters in a panel econometric framework and thereafter use the estimated coefficients to simulate euro area fitted values. I do not derive country-specific conclusions but instead euro area conclusions. This assuages the criticism as regards the heterogeneity problem among cross-sections (countries).

In my first working paper, I investigate the question whether one can explain past house price movements by the arbitrage theory. Since arbitrage is a static phenomenon, I use within FE and RE estimators. I tried many alternatives from the less to the most specified model. The residuals of all five models show a very strong autocorrelation. The pattern of the residuals proves that the theoretical framework is not suited to explain the history of house prices. Arbitrage is not the core mechanism in house price determination. As a result, conclusions based on house price over rents ratio are inconsistent. Why house price movements are not mainly driven by arbitrage in our empirical investigation? This may be due to large transaction costs, but also housing is un-tradable by nature, and finally government regulations. There are friendly tax schemes to promote home ownership against alternative assets, there are other government regulations like tenants rights and even massive public investment to build social houses for low-income households.

Instead, in my second working paper, I suggest to analyze directly the interaction of supply and demand together with the mortgage market. I estimate together the reduced house market and the reduced mortgage market. I have three endogeneous variables*: house prices*, *stock of dwelling* and *mortgage loan*. To proxy ECT (error correction term), inspired by IMF (2004) and Lecat & Mesonnier (2005), I try three different affordability ratios. The two last ratios are interest rate adjusted. To the best of my knowledge, nobody has estimated a SEM (Simultaneous Equation Model): house market, mortgage market in a panel framework and that for the euro area. First, a FE term is the minimum heterogeneity to allow due to the strong heterogeneity among countries. As a result, RE and pooled OLS are biased. Second, the house price process exhibits strong persistence due to the household expectations on the demand side and the inertia of the supply. As house price is a persistent process, the autocorrelation term renders the within FE (LSDV) also biased. To estimate consistent estimates with endogeneous variables, IV methodology must be implemented, like Anderson & Hsiao (1981) or the well-known GMM Arellano-Bond (1991) dynamic panel estimator (AB). However, in macro panel data, the time dimension is much larger than the cross-sectional dimension. As proved by Haque, Pesaran & Sharma (1999) but also Judson & Owen (1997) a trade off arises between efficiency and consistency. As a result, I check the results with other estimators which are biased but may be more efficient, e.g. the LSDV (within FE estimator). The LSDV estimates are close to the AB estimates, thus validating the choice of the AB estimator.

In the third working paper, a general equilibrium model underpins the choice of macro-variables. Again, the small time dimension on a country level hinders robust estimates with classical time series via VECM methodology. Heterogeneous estimators are normally unstable (individual country estimates vary within wide ranges) and unreliable, although they have the desirable property of allowing for differences among countries. Panel econometrics allow a substantial gain in power. Thus, to disentangle long-term from short-term dynamics, the PMG (Pooled Mean Group) estimator developed by Pesaran, Shin & Smith (1997) is used. The PMG assumes homogeneity of long-run coefficients (or a sub-set) but without making implausible assumption of common short-term coefficients. In the short-term coefficients are allowed to vary across countries. Indeed, mortgage and house market in the euro area are characterized to be strongly heterogeneous (ECB, 2003 and section 2, third working paper). Once again, to the best of my knowledge as regards the housing market in the euro area or in a country, nobody has never used the PMG methodology to estimate a long-run house price equilibrium.

Common conclusions

The conclusions derived from the second and third working papers are alike. First, the short-term dynamics is essentially driven by disposable income per capita and the autoregressive term. Moreover, the demographic variables and rents do not account in the short-term house price dynamics. Second, the long-term house price phenomenon is better investigated in the third working paper than in the second. The empirical results of the PECM (third working paper) suggest a strong long-term empirical relationship between house price, disposable income, interest rate, stock of dwelling, population, and mortgage loan. Moreover, long-term house price equilibrium is mainly driven by disposable incomes and interest rates. In the second working paper, real house prices show mean reversion to affordability ratios, crude and interest rate adjusted. The model with the crude affordability ratio explains actual house price accurately except from 2002 to 2005. This is because it does not capture the interest rate moves in level and in variation.

Two economic implications can be derived. First, in the wake of the EMU process, households in the euro area have experienced a positive shift in their borrowing capacity which have a positive impact on house price dynamics. Second, the business cycle since 1999 has been stabilized by means of an optimal "leaning against the wind policy" which has no pedigree in the euro area. Since 2001, the economic slowdown should have dampened house price growth. However, the weak economic activity has been offset by an accommodative policy. Indeed, monetary policy stance indicators like interest rate and mortgage loan development prove a loose policy which sustained strong housing demand. Low short-term interest rates and expectations of future price increase allowed households to capture housing credits with apparent strong collateral. The staggered housing supply has provoked an excess of demand which has fueled soaring house prices. At the time this thesis is written, this demand is still overshooting supply and the disequilibrium has not started to revert yet.

Current house price cycle is largely above 2% since 1998, i.e. already 8 years, the longest lasting cycle ever experienced. Two effects mentioned above explain this, i.e. low interest rate in level due to the ECB credibility (in addition, international low inflation environment) and variation in interest rate (optimal monetary policy). In contrast, the duration of the previous cycle was much shorter. As inflation was already rising in the end of the 80s, the Bundesbank raised its discount rate in 1988, and kept tightening it until 1992 due to the German monetary reunification. The one to one exchange with the OST mark obliged the Bundesbank to lead an even harsher policy. This provoked a German specific shock. The other member countries of the ERM (European Exchange Rate Mechanism) had to follow at odds with an optimal monetary policy. Consequently, the “euro area” interest rates increased dramatically. Beyond the cyclical component, the overall interest rate level was excessively high, well above the optimal interest rate which would have been necessary to stabilize the "euro area" business cycle and to maintain price stability. The financial liberalization in the mid-80s caused sharp real estate increases. Thereafter, high interest rates coupled with a weak business cycle and a credit crunch due to bank distress dampened relatively quickly soaring house prices.

In the third working paper, the PMGE (Pooled Mean Group Estimator) which estimates the euro area house price equilibrium depicts three positive misalignments with respect to actual house prices. The first started during the second oil price shock until the mid 80's. The second began in the late 80's and ended in the mid 90's. Finally, current house prices have overshot equilibrium price since 2001 and have not shown mean reversion yet. This history is in line with the literature on housing. However, the gap between house price equilibrium and current price cannot be assimilated to a bubble as defined by Stiglitz (1990). Instead, the misalignment of current prices to long-term equilibrium price characterizes a natural feature of the functioning of the house market.

As regards the mortgage market, collateral (house price) is the only core factor. Consequently, house market and mortgage market strongly interact via the collateral. Banks relax their lending standards by favorable house price prospects due to asymmetric information. Households can capture more mortgage loans which fuels demand. Higher house price impinges positively on household's wealth. This self-perpetuating process is then reversed by a trigger event like monetary policy tightening. An interest rate increase of 1% causes a 1% house price inflation drop and a 0.4% decline in mortgage loan growth rate in the long-term. The interest rate shock has only a temporary effect on the mortgage market on its own but the collateral (house price) drop leads to a long lasting fall in mortgage loan volume. To conclude, interest rate increase impinges negatively on real house price growth, proving that demand outweighs supply. As a result, monetary can influence house price growth.

Supposing the tide starts to turn in 2006, current house prices would smoothly catch-up equilibrium price in 5 to 6 years according to the PECM. In the simulation of current house prices adjustment to equilibrium level, I suppose that all explanatory variables equal simultaneously their steady value in 2006 and onwards. The adjustment depicts a 4% growth rate in 2006 decaying steadily and slowly over time. This is a smooth and soft landing in opposite to the "biggest bubble in history" documented by the Economist for instance. This empirical study might prove that no recession will occur and even less a deflation. First, most of the huge house price increase in the euro area is explained by the fundamentals and second, the bank risk exposure is relatively moderate, they have mostly already implemented Basel II. Bank risk management includes real estate stress test scenarios where expected stress losses are thoroughly estimated. The conclusion of the thesis concerns the euro area. Thus, sub-level or local crises are not excluded.

Reading

All three working papers are self-contained and can be read independently. Nevertheless, there is clearly a progression over the three working papers. The first paper tries to explain house price movements by means of the arbitrage theory. The pattern of the residuals proves that the theoretical framework is not suited to explain the history of house prices. Arbitrage is not the core mechanism in house price determination. As a result, the second paper analyzes directly the interaction of supply and demand together with the mortgage market. A SEM is estimated by means of the well-known GMM Arellano-Bond (1991) dynamic panel estimator. The empirical estimates render satisfactory results of the short-term dynamics. However, the long-term specification is less well specified. Consequently, the third paper disentangles long-term from short-term dynamics by means of a PMG estimator developed by Pesaran, Shin & Smith (1997). The long-term equation estimates allow simulating a long-term euro area house price. Furthermore, the PMG assumes homogeneity of long-run coefficients (or a sub-set) but without making implausible assumption of common short-term coefficients. This assuages the criticism regarding the inherent homogeneity assumption in the panel framework. In conclusion, the three papers highlight the main determinants driving the house price dynamics and the possible misalignment with respect to the long-run house price equilibrium.

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Are euro area house prices overvalued ? an asset pricing approach

House price dynamics, mortgage market and monetary policy in the euro area

Long-run house price equilibrium and short-term dynamics in the euro area

Are euro area house prices overvalued? an asset pricing approach

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February 21, 2007

Abstract

Real house prices have risen to historical levels in the last eight years in numerous euro area countries like Ireland, Spain and the Netherlands and to a lesser extent in France and Belgium. Since 1997, euro area house prices have grown positively and have increased steadily reaching almost 7% in 2004 and 2005 despite the falling real house price in Germany which accounts for roughly one third of the euro area house prices. As a result, the European central bank (ECB) has shown concern about this dramatic appreciation. Indeed, large real house price movements might cause adverse shocks on the economy via the wealth effect and the bank lending channel, which in turn impinge on the HICP (Harmonized Index Consumer Price). Consequently, this paper aims at answering the question whether the current residential property price is in line with the fundamental price. Arbitrage equations underpinned by the asset pricing theory are estimated to find out what is explained by fundamentals and what may be due to speculative behavior. The robustness of the estimation is highly improved by the use of panel econometrics. The empirical results show an overvaluing of approximately 12% in the euro area. However, the pattern of the residuals casts some doubts on the validity of the arbitrage theory and thus on the empirical results. Indeed, housing assets are non-tradable by nature and house prices might not be essentially driven by arbitrage behavior.

JEL Classification: C13, C23, G12
Key words: panel econometrics, asset pricing, house price

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1 Introduction

The unprecedented dramatic real house price increase for the last 8 years in numerous European countries and elsewhere in the world raised a question: can the booming house price be explained by fundamentals, or is it rather due to speculative behavior with the threat to burst? Dramatic asset price volatility can have significant effect on real economic activity, as witnessed by numerous historical episodes ranging from the 1929 Wall Street crash to the more recent Tokyo housing and equity bubble. Boom-bust cycles in asset prices can eventually cause either a period of credit crunch (due to asymmetric information) as highlighted by Bernanke (1983), Bernanke et al. (1995), or even a collapse of the entire financial system - systematic failure - via bank bankruptcy. Besides, strong asset price volatility can harm the real economy essentially through housing wealth effect, which in turn impinges on private consumption and aggregate demand (OECD, 2002 ; IMF, 2001). As the primary objective of the ECB is to maintain price stability, the ECB pays attention to asset price movements without targeting it directly.

This paper aims at tackling the question whether current euro area house price increase is sustainable, i.e. in line with the fundamentals. To investigate this question, this study uses the theory of asset pricing valuation. Asset pricing theory in turn is based on the concept of present value and arbitrage opportunity. The fundamental value of a house can be considered as the present value of the real (expected) housing services over time. House ownership (like any other asset) gives a flow of house services proxied by rent payments during time of possession. In other words, the fundamental house price results from households arbitrage opportunity between housing assets and alternative assets like bonds for instance. Thus, the purchase of a house gives a flow of its future rents during time of possession, and finally a gain/loss when selling the house (Ayuso & Restoy, 2003; Bessone, Heitz, & Boissinot, 2005).

The choice of the econometric methodology is based on two considerations. The first involves the time dimension of the available data. Indeed, on a country level the time dimension is too short for robust estimates. The annual data available ranges from 1975 to 2005 (31 observations) for house prices. Panel econometrics allows a substantial gain in power. Moreover, panel estimators are proven to deal better with the problem of measurement bias (see Baltagi, 1995). Second, one major criticism against panel econometrics due to the parameter homogeneity hypothesis, does not really hold in this paper. Indeed, the coefficients estimated are used on a euro area level. As arbitrage equations are considered static, panel estimator like fixed effects and random effects are considered.

An outline of the paper is as follows: Section 2 highlights euro area house market stylized facts. Section 3 reviews the basic theory which underpins the equation estimated under the hypothesis of either time-varying risk premium or constant risk premium. Section 4 investigates the stationary and cointegration pattern of the panel series and reviews the main testing strategy used. Section 5 shows the empirical results concerning not only the elasticities but also the statistical tests. Finally, Section 6 concludes by comparing fundamental price and current house price in the euro area as a whole.

2 Some stylized facts in the euro area house market

The euro area real house price growth rate has risen steadily from year to year since 1997, reaching almost 7% in 2005 (see Figure 1). From 1975 to 2005, such a large growth rate was only attained once, the peak year of the well-known 90's bubble which occurred in the majority of euro area countries (see Annex 3).[1] The average real euro area annual growth rate for the period 1997 to 2005 is more than twice as large as the growth rate of the whole sample (see Table 1, last line EA8). All euro area countries have experienced the same pattern, except Germany (see Table 1). Indeed, the German real house price has exhibited negative growth rates for the last 8 years while Germany accounts for more than one third of the euro area house price (see Annex 2 where aggregation methodology is discussed). Despite this fact, euro area house prices have experienced a strong increase. As can be remarkably seen in Figure 1, house price motion exhibits a strong cycle, one of its key feature. Consequently, house price movements in the last eight years correspond to a booming phase, which is nothing exceptional. However, never before 1975 had such a house price increase lasted so long, i.e. more than 8 years and that in so many countries. Countries which have experienced outstanding real house price increase in the last eight years are: Ireland, Spain, France and the Netherlands with respectively: 11.27, 8.76, 6.43 and 6.22 on average (see Table 1 and Annex 3). The other euro area countries have also experienced a strong house price increase[2] but to a lesser extent.

Table 1: univariate analysis housing prices and rents growth rate (Real)

Country	Residential Property Price				Housing rents			
	1976-2005		1997-2005		1976-2005		1997-2005	
	Aver.	St. Dev	Aver.	St. Dev	Aver.	St. Dev	Aver.	St. De.
DE	-0.44	2.64	-2.20	1.18	0.69	1.28	-0.10	0.70
FR	2.57	4.97	6.43	4.40	0.74	1.37	0.35	1.18
IT	2.26	7.53	3.94	4.23	0.84	3.69	1.05	1.76
ES	4.27	9.62	8.76	4.68	-0.56	3.81	1.56	1.36
NL	2.90	9.26	6.22	5.20	1.40	1.69	0.60	1.44
BE	2.44	6.02	3.91	1.69	0.71	1.53	0.04	0.67
FI	1.39	9.97	5.79	4.78	0.41	2.54	1.28	0.69
IE	4.58	7.72	11.27	6.17	-0.77	5.81	1.55	4.54
EA8	1.83	3.63	4.39	2.17	0.74	1.02	0.58	0.85

This study aims at understanding the underlying factors explaining the booming house price. In an asset pricing approach, the most straightforward idea is to investigate whether price movements are commensurate with yields for a given asset, the so-called price-earning ratio. Figure 1 shows that it is not the first time that the euro area price rent ratio (house prices over rents) deviates from its historical mean. However, the sharp increase of the house price rent ratio is exceptional, reaching unprecedented levels in countries like Ireland, Spain, France, Belgium and the Netherlands (see Annex 3). The average growth

[1] The house price bubble at the beginning of the 90's has been particularly significant in Spain, Finland and Italy, and to a lesser extent in Ireland, France and Germany.

[2] As regards the outlier Germany, I suggest the following explanation. The reunification provoked massive investment in the housing sector, which in turn increased housing supply. Thereafter, housing demand did not follow the supply as German households purchasing power flattened. The staggered housing supply could not adjust quickly enough to match demand. Excess housing supply may explain the subdued house price.

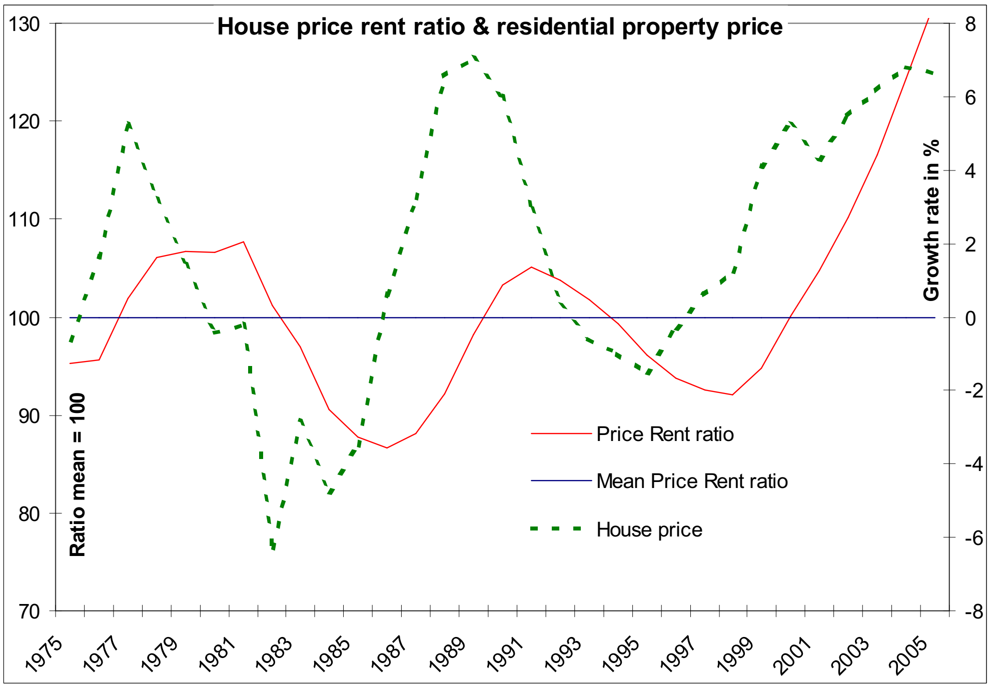

Figure 1:

rate of house price is systematically larger than housing rents for both periods and for every country (except Germany). In four euro area countries (accounting for more than fifty percent of euro area house price) housing rents growth slowed down in the last eight years (Table 1). A huge house price growth increase coupled with a moderate rent growth explain the strong house price rent ratio increase in the euro area.

The volatility of both house prices and rents have fallen in the last nine years for all countries. As a sheer matter of period division, the last nine years pertain to a booming phase exclusively, whereas the entire time sample encompasses more than two cycles. As can be seen in Table 1, the standard deviation of the last 9 years is smaller than the one over the entire sample. On the other hand, the volatility of the real house prices are systematically larger for all countries than the housing rents volatility for any period. As a result, the house price cycle drives the house price rent ratio with a forward of a couple of years. This is the consequence of a well known pattern observed on house market. House prices exhibit stronger volatility than housing rents which is much more stable over time. Legislative schemes protecting tenants rights dampen housing rents increase and volatility. As a rule, housing rents track the consumer price index. Indeed, government measures try to keep the lid on housing rents, at least state regulations try to maintain housing rents in line with the cost of living for low income households.[3] As a result, price ratio peaks may not be due to a bubble caused by speculative behavior (Stiglitz, 1990)[4] but rather to

[3]In France for instance, half of the dwelling rental park is owned by a public body which rents below market price, the so-called "HLM". This public body is directly subsided by the Ministry of Social Affairs.

[4]In Stiglitz's definition, the non fundamental part of a price increase is a bubble. The level of price which has been raised beyond what is consistent with the underlying fundamentals of the asset pricing evaluation is considered a bubble. This phenomenon is based on expectations: buyers of the asset do so

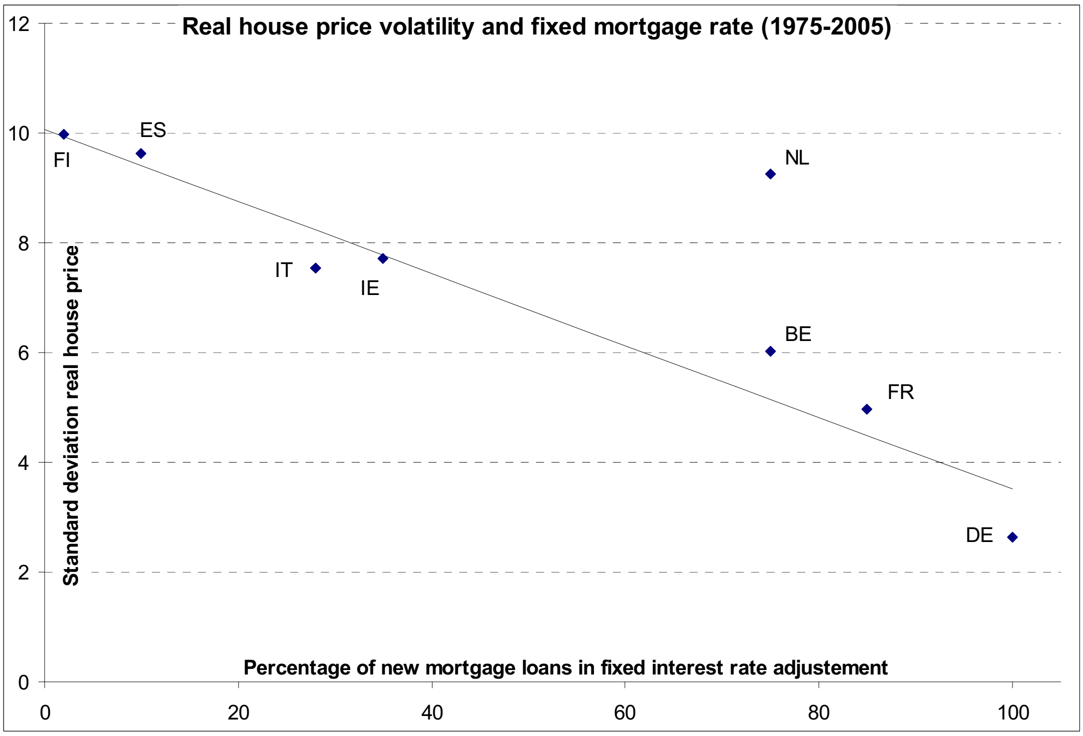

Figure 2:

the consequence of government regulations. I will come back to this fact in the conclusion of the paper.

Table 1 highlights the strong heterogeneity existing in residential property price volatility across euro area countries. Despite the convergence of macro-aggregates in the EMU, the functioning of the housing market depends essentially on country and local structural factors. The mortgage market system, local planing and urbanization schemes, taxes and land availability for instance remain country and even local specific. Mortgage market features affect strongly house price volatility as stressed in ECB (2003) and by Tsatsaronis & Zhu (2004). In countries where longer-term, fixed rate mortgages with no prepayments have been more important, house prices tend to be less sensitive to interest rates and other macro-aggregates. This leads to less volatile house prices. The scatter diagram above (Figure 2) corroborates this statement. Indeed, a robust negative correlation between house price volatility and the percentage of outstanding mortgage loans with fixed interest rate contracts is established. The Netherlands is the only outlier as house price volatility is strong, despite a mortgage finance system predominantly based on fixed mortgage rate payments. There are other features on the house market like Loan To Value (LTV) and Mortgage Equity Withdrawal (MEW). Among countries with predominantly fixed mortgage interest rates, the Dutch mortgage market is the only one characterized by a high LTV and where MEW is current practice (see Table 2). This might explain the Dutch idiosyncrasy.

with the expectation of future price increase.

Table 2. Heterogeneity among EMU countries in the mortgage market				
Main Mortgage loan features	Countries	Sample	Variables	
Fixed rate contracts	DE, FR, IT, NL, BE	Group 1	Int. rate 1	i1, r1
Variable rate contract	ES, FI, IE	Group 2	Int. rate 2	i2, r2
Low LTV, restrictive MEW	DE, FR, IT, ES, BE	Sub-s1	dummy	du1
High LTV, developed MEW	NL, FI, IE	Sub-s2		

A thorough review of national features within the euro area mortgage market is given in ECB (2003) and by Tsatsaronis & Zhu (2004). Based on these two surveys, Table 2 depicts the salient features among the eight countries of the euro area (EA8) between floating and fixed mortgage rate tradition, but also between more or less conservative bank practices in providing mortgage credit loans. MEW and high LTV characterize less conservative bank lending behavior. As a result, slope heterogeneity between fixed and variables mortgage interest rate country groups might be necessary to find consistent results. For country group 2, the sensitivity of house prices with respect to short term interest rates should be much larger, according to Meen's (2002) empirical findings, for instance. Moreover, the arbitrage mechanism between housing and an alternative asset might also work differently in a country where MEW is current practice relative to a more conservative mortgage market country. To conclude, the mortgage market features among euro area countries schematized very crudely in Table 2, must be investigated during the estimation in section 5.

3 Asset pricing valuation

3.1 Basic model

In this section, I briefly discuss basic theoretical aspects which underpin the empirical estimation. The user cost of housing is commonly defined as:

$$uc_t = P_t \left(r_t + \delta_t - \frac{P_t^e}{P_t} \right), \tag{1}$$

see for instance Muellbauer & Murphy (1997) and McCarthy & Peach (2002); and r is the real interest rate, δ is the depreciation rate, or the rate of maintenance costs including property taxation, finally, the ratio expected house price (P^e) over house price is the expected appreciation of house price. The representative household purchasing a house in period t will bear the cost related to home ownership, i.e. the user cost uc_t described in equation (1) and the price (value) of house purchased: P_t. The whole financial expenses in period t are then: $uc_t + P_t$. On the other hand, housing might yield rents from tenant or housing services (equivalent to rents) if the owner keeps the house for its own needs. Like stocks or currency, house property does not guarantee payment of certain income. The uncertainty concerning the rent payment (R_t) as well as the capital gain in terms of future price is based on expectations. Under the hypothesis of risk-averse households, a risk premium is introduced: ξ_t. As a result, housing revenue is characterized by housing rents diminished by the risk premium : $R_t - P_t\xi_t$. As household maximizes its utility in a free market, the costs of house ownership equals housing yields, which gives equation:

$$uc_t + P_t = R_t - P_t\xi_t, \tag{2}$$

and substituting equation (1) into (2) yields:

$$P_t(1 + r_t) = R_t + P_t^e - P_t\delta_t - P_t\xi_t. \tag{3}$$

Bessone & Boissinot (2005) derive the same arbitrage equation (3). The household investing the amount P_t in an alternative asset (risk free bond) yields a return given in the L.H.S. of equation (3). On the other hand, if the household invests in housing, it yields a return given in R.H.S. of equation (3). After some minor arrangements, the risk premium is derived:

$$\xi_t = \frac{R_t}{P_t} + \frac{P_{t+1}^e - P_t}{P_t} - \delta_t - r_t. \tag{4}$$

The risk premium equals the real housing rent, the expected house price inflation subtracted from depreciation rate and the interest rate of a risk free asset.

3.2 Time-varying risk premium

The risk premium indicates the degree of risk households take. A higher risk premium means more risk-averse households, i.e. they value a given risk higher. Figure 3 depicts the euro area[5] time-varying risk premium generated from equation (4) according to two different house price expectations. Under the hypothesis of naïve expectations,[6] it is assumed that the expected house price growth is the average of last two years (moving average). Since 2000, the risk premium has exceeded the 90's house price bubble. Unfortunately, the cycle of the risk premium is shaped by the house price cycle itself as can be observed in Figure 3. The conclusion should thus be taken with caution. Consequently, a second risk premium was calculated by assuming zero expectation (expected house price equals current house price). This impedes the house price cycle to shape the time-varying risk premium. The zero expectation risk premium is substantially less volatile than the former premium. However, this latter risk premium has been increasing since 1997. Housing depreciation does not account for much and rents slightly increased in the euro area. Altogether, the increase of the zero house price growth expectation risk premium is due to a falling interest rate. The U-shaped zero house price growth expectation risk premium recounts the history of the real interest rate and monetary policy the last 30 years. Overall, the level of time-varying risk premium might be misleading in evaluating possible house price bubbles and speculative behavior.

However, the first difference of the naïve expectation risk premium shows interesting properties as leading indicator of euro area house price growth rate, see Figure 4 (and Annex 5). The first difference of the euro area risk premium has exhibited downward trends since 2001 but is still positive. If we believe in this empirical regularity, it may indicate that real house price growth rates will slow down as the indicator is downward-trended.

[5] Annex 4 shows country-specific risk premiums.

[6] The view of naïve forecast expectation can be challenged, so can rational expectations. Semi-rational expectations seem a realistic assumption with regard to earlier empirical finding (Muellbauer & Murphy, 1997). A model must be estimated, however, to extract semi-rational expectations from the data. Consequently, I keep on the naïve expectation hypothesis.

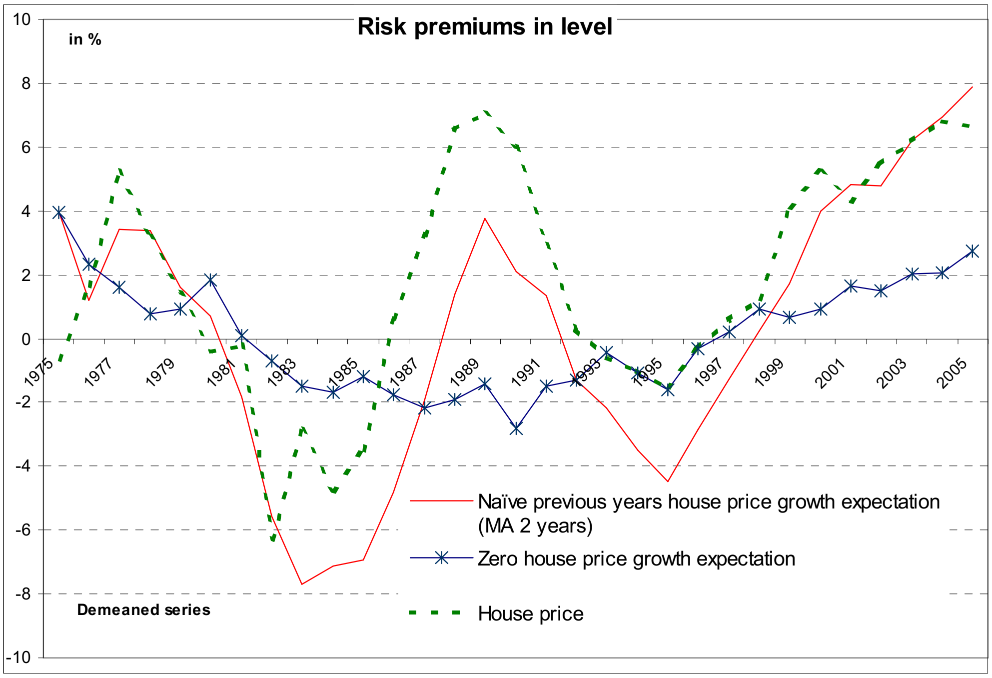

Figure 3:

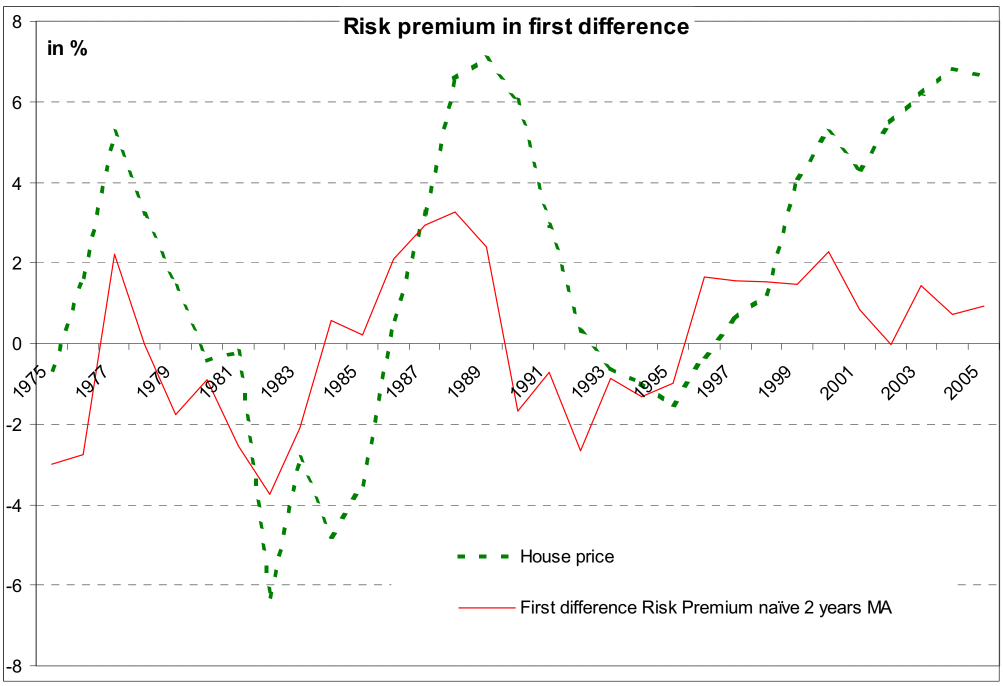

Figure 4:

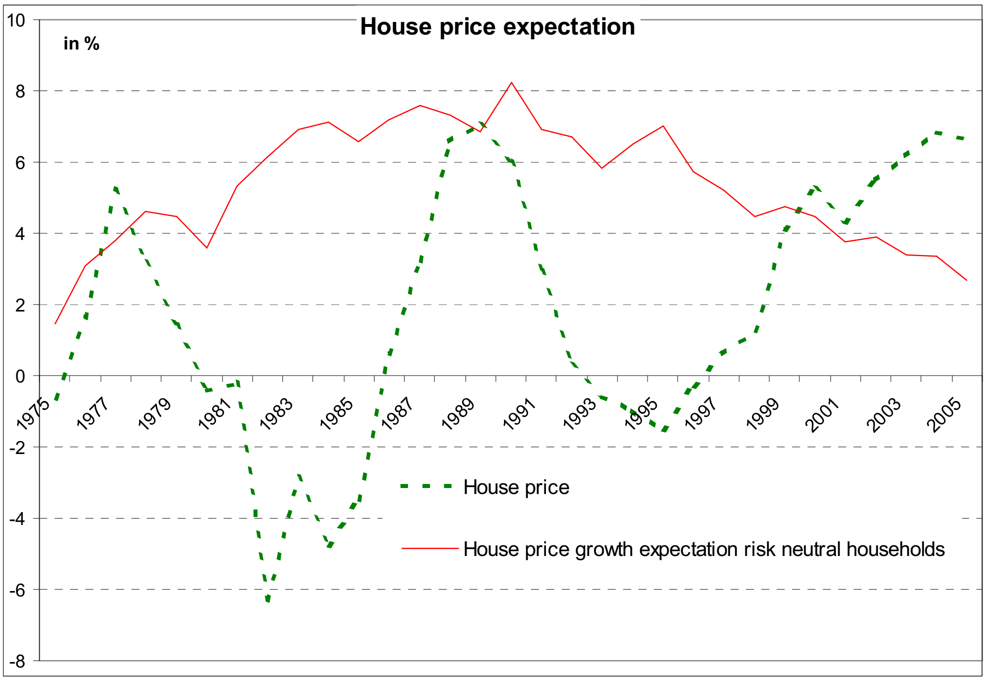

Figure 5:

3.3 Constant risk premium

The hypothesis of time-varying risk premium is relaxed in this subsection. I suppose instead risk-neutral households, i.e. with zero risk premium. An inflation house price (π^h) expectation (operator E_t) can be derived from equation (3). This house price expectation does not contain speculative elements as defined by Stiglitz (1990) or self-fulfilling expectations aspects. Instead the expectation in equation (5) is based on fundamental elements like housing rents and interest rates.

$$E_t(\pi_{t+1}^h) = r_t - \frac{R_t}{P_t} + \delta_t. \tag{5}$$

Figure 5[7] depicts the euro area expected inflation with the actual real house price growth. The huge real house price increase since 1997 cannot be explained by the "fundamentals". This "fundamental" expected house price does not help us any further as it is the opposite of the "zero house price expectation risk premium" shown in Figure 3.

More promising is to suppose a non-zero time constant risk premium different from zero. As a rule, a myriad of theoretical and empirical studies use this hypothesis (Baker, 2002; Ayuso & Restoy 2003; McCarthy & Peach, 2004). Thus, solving equation (3) with respect to the ratio $\frac{P_t}{R_t}$ yields:

$$\frac{P_t}{R_t} = \frac{1}{r_t - \frac{P_t^e - P_t}{P_t} + \delta_t + \xi}. \tag{6}$$

[7] Annex 6 depicts the "fundamental" house price expectations in euro area countries.

Another alternative to derive almost the same equation (albeit less specified) is to consider the fundamental house price as the present value of all future housing services which is proxied by market housing rents. For instance Weeken (2004) derives such fundamental house price. The theoretical underpinning is given in Aoki, Proudman & Vlieghe (2002) and Piazzesi, Schneider & Tuzel (2003). These models consider the house price as the present value of its expected future payoffs R_t (Rents) discounted at rate DR:[8]

$$\frac{P_t}{R_t} = \frac{(1+g)}{DR-g} = \frac{(1+g)}{r+\xi-g}. \tag{7}$$

However equation (7) includes fewer variables than equation (6). Indeed, the depreciation and expected capital gain are missing due to more restrictive hypotheses.

4 Data properties and panel econometrics

4.1 Unit root tests

Time series unit root tests (e.g. ADF or KPSS tests) applied individually to each section (country) lack power. There are too few observations (T=31) for robust time series tests, nevertheless the time span is long enough to be concerned by the stationary proprieties of the series. As a consequence, to gain power, panel unit root tests are performed. *Levin, Lin & Chu* (1993) and *Im, Pesaran & Shin* (1997) tests for instance do not take into account possible cross-sectional correlations. Instead, a new generation of panel unit root tests[9] have been developed dealing with cross-sectional correlations: *Bai & Ng* (2001), *Moon & Perron* (2003), *Choi* (2002). Monetary union and the convergence process imply a very strong cross-sectional correlation among the series of the data set. This is particularly true for the interest rates. All four tests perform a unit root test only on the idiosyncratic component. The *Bai & Ng* test supposes to know the number of common factors (total factor model) ; consequently this test is not performed. *Moon & Perron*, but also *Choi*, on the other hand, eliminate the common components of the series, and so perform a unit root test on the transformed series. *Moon & Perron* and *Choi* panel unit root test are the most relevant in this study in view of their asymptotic properties.

Thus, *Moon & Perron* and *Choi* tests have been performed. The null hypothesis for both tests is unit root. The number of lags were chosen automatically section by section based on the SIC (Schwartz Information Criteria) with maximum lag order of 4. Annex 8 gives the main results. Consumer price inflation rate (π), depreciation rate (δ), the log of the real house price ($\ln P$) , the log of the real housing rents ($\ln R$) but also nominal interest rates (short-term: $i1$) and (long-term: $i2$) are I(1). The denomination 1 and 2 refers to country groups defined in Table 2. House prices and housing rents are in log level. On the other hand, the null hypothesis of unit root is rejected for the series: house price rent ratio ($\frac{P}{R}$) and real interest rates (long: $r1$ and short: $r2$), they are considered stationary. The house price ratio is the ratio of an I(1) over and I(1), which is, as a rule, expected to be I(0). As regards the interest rates, the results are in line with the Fisher equation. The nominal interest rates (long and short) and inflation are cointegrated with a

[8] A more detailed computation is given in Appendix 7. It is important to emphasize that in order to solve equation 6, I am obliged to assume a constant (time-invariant) housing rent growth rate: g.

[9] The new generation of unit root tests have been performed thanks to the matlab codes developed by Christophe Hurlin.

cointegration coefficient which equals one. Consequently, the residuals of nominal interest rates (long and short) minus inflation rates are stationary and so are the real interest rates.

4.2 Cointegration tests

The use of cointegration techniques to test the presence of long-run relationships among integrated variables has enjoyed growing popularity in the empirical literature. Once again, the inherently low power of these tests when applied to time series leads me to use panel cointegration tests.[10] Pedroni (1999) proposes 7 statistics to test the null hypothesis of no-cointegration with multiple regressors (heterogenous slopes among cross sections). As highlighted by Pedroni (2004), the *panel-t* and the *group-t* statistics offer good asymptotic properties in view of the panel dimension (time dimension and number of cross-sections). As a result, the investigation on long-run cointegration among series will be based on these two statistics only. It is also more relevant to use the *parametric* statistics, since the sample accounts to only 248 observations. Under the Ho hypothesis of no-cointegration, the statistics have to be compared with the critical values of the standard normal distribution $N(0,1)$.

Annex 9 reports the results of Pedroni's cointegration tests. The null hypothesis is clearly rejected at 5% for the two series house prices and rents. When nominal interest rate is added (long or short), the null hypothesis of no-cointegration cannot be rejected at any common level. However, according to Pedroni's test, the four series house price, rents, nominal short and long interest rate cointegrate. Inflation rate too cointegrate with the former last series. However, the addition of depreciation rate weakens the result. Indeed, the null hypothesis cannot be rejected at 5% but almost at 10% for the panel ADF statistic. To investigate the cointegration properties of the panel series, an alternative option will also be used. The residuals of the different specifications will be tested for unit roots.

4.3 Estimation strategy

Panel econometrics is chosen in this paper for manifold reasons. First, the time dimension of the available data on a country level is too short for robust estimates. Indeed, the annual data available ranges from 1975 to 2005 (31 observations). Panel econometrics allows a substantial gain of power. Second, panel estimators are proven to deal better with the problem of measurement bias (Baltagi, 1995). Third, one major critic against panel econometrics lies in the strong hypothesis of parameter homogeneity. Hereinafter, the panel coefficients estimates are used to simulate euro area fitted housing price. Conclusions are not driven on a national level, but on a euro area level instead. This assuages the scepticism as regards the homogeneity assumption pertaining to panel econometrics.

Estimating an arbitrage equation requires static estimators. Arbitrage is rather viewed as an instantaneous phenomenon, i.e. static by nature where dynamism is absent. I trust the arbitrage theory in this study.[11] Currently, there are two extremes to estimate static

[10] The cointegration tests have been performed thanks to the Rats program provided by Pedroni (1999).

[11] The static view based on the arbitrage theory is followed slavishly. Consequently, static estimators like FE and RE are used. However, the residuals shown in section 5 cast serious doubts on the relevance of this hypothesis. It appears on the contrary that house price is an autoregressive process (strong persistence), which finally questions the validity of the arbitrage theory in valuing house prices.

phenomenon in panel econometrics. The first supposes to estimate N separate regression (for each country) and to calculate the coefficient means. This estimator is consistent but mostly inefficient. At the other extreme are the traditional pooled estimators, such as Fixed Effects (FE), Random Effects (RE) and pooled OLS which assume that the slope coefficients and error variance are identical. The asymptotic properties in case of large T and small N with traditional panel econometric procedures have proven to produce inconsistent estimates in panel data unless the slope coefficients are in fact identical.

Thus, country specific conclusions based on panel econometrics are avoided. As already stressed, panel estimated coefficients are used to derive euro area conclusions. Although this assuages the problem of coefficient homogeneity, slope heterogeneity is tested to eschew possible inconsistent estimates. This choice is grounded on the fact that floating versus fixed mortgage rate practice is the salient feature characterizing the different European mortgage market as explained in section 2. Furthermore, a breakdown into two subgroups based on other mortgage market features as reported in Table 2, like LTV or MEW gives almost the same subdivision, except the Netherlands. First, I will try both alternatives, by including and then excluding the Netherlands from sub-group 2. Second, a Wald test will be performed to determine whether coefficients between group1 and group2 are significantly different.

In addition to slope heterogeneity, the classical heterogeneity tests to detect the presence of an unobserved time invariant effect are also performed. The testing strategy proposed by Greene (2003) is followed but adapted to the purpose of this study (see Annex 10). Accordingly, OLS estimates are compared to RE or FE estimates to determine whether heterogeneity across sections (countries) is present. If the most restrictive form was eventually chosen, i.e. pooled OLS, autocorrelation and heteroscedasticity tests would be performed.

Suppose a RE model estimate, i.e. heteroscedasticity is allowed among sections (countries): $Y_{i,t} = x_{i,t}\beta + u_i + e_{i,t}$ and u_i is the unobserved time-invariant effect. The error composite term is $\eta_{i,s}$, and $\eta_{i,s} = u_i + e_{i,s}$. The Breush & Pagan (1979) test is perfectly suited to test the presence of an unobserved effect. If the model does not contain an unobserved effect, pooled OLS is efficient and all associated pooled OLS statistics are asymptotically valid. The absence of an unobserved effect is statistically equivalent to test Ho: $\sigma_u = 0$ (null hypothesis) which is equivalent to test that the error composite term $\eta_{i,s}$ is not serial correlated $corr(\eta_{i,s}, \eta_{i,t}) = 0$ (Greene, 2003). Breush & Pagan (1979) derive a statistic using the Lagrange multiplier principle in a likelihood setting. If the null hypothesis is rejected, it proves that there is heteroscedasticity among sections, and so the RE is significant. However this does not mean yet that a RE is the most suited model, this only proves that there is heterogeneity across sections. Indeed, there is another competing specification that might induce the same results, the FE.

Zama (1995) shows the inconsistency of the Breush & Pagan (1979) test under certain circumstances. After estimation of a RE model, an alternative heteroscedasticity test has been developed by Baltagi & Li.[12] They consider a spatial panel regression model with

[12] Stata software performs a joint test for serial correlation and random effects and calls it the Baltagi-Li (1991-1995) test. However, to the best of my knowledge, the first piece of literature explaining this test is Baltagi, Song, Jung & Koh (2003) while Baltagi & Li (2000) deal with joint test of spatial correlation and functional form, see under References.

serial correlation over time for each spatial section and spatial dependence across these sections on a particular point in time. In addition, they allow for heterogeneity across the spatial sections through random effects. Testing for any one of these symptoms ignoring the other two leads to misleading results. They argue that ignoring serial correlations in the error term results in consistent, but inefficient estimates of the regression coefficients and biased standards errors. They derive a joint and conditional LM test. Under Ho, no spatial or serial error correlation and no random country effects is assumed. For the sake of clarity, suppose serial correlation wants to be tested, the error composite term can be rewritten: $\eta_{i,t} = u_i + \nu_{i,t}$ as in the Baltagi & Li test, under Ho not only $\sigma_u = 0$ but also $\nu_{i,t}$ is serially uncorrelated. More precisely, under Ho, the joint hypothesis is: $\sigma_u = 0$ and $\rho = 0$; and $\nu_{i,t} = \rho\nu_{i,t-1} + \zeta_{i,t}$ with $\zeta_{i,t}$ being white noise.

To decide between a RE estimator or a within FE estimator, the Hausman (1979) test is performed. Under the null of the Hausman test, both FE and RE are consistent and the coefficients are not significantly different. The RE model assumes $corr(u_i, e_{i,t}) = 0$ and if it does not hold, the RE is inconsistent, so the FE is the only alternative. The result of the test is a vector of dimension k , the number of parameter estimated, i.e. $\dim(\beta)$ which will be distributed as a $\chi^2(k)$. If the null hypothesis is rejected, FE estimator is consistent. For further explanations, see Greene (2003) and Annex 10.

In the same stance, heterogeneity tests can be performed following a FE estimation. Indeed, the same type of heteroscedasticity test has been developed following a FE estimate which, under the null hypothesis, assumes independence of the errors. A deviation from independent errors in the context of panel series is likely to be due to contemporaneous correlations across cross-sectional units. Thus, Breush & Pagan proposes to test cross-sectional independence of residuals. Under the null hypothesis, uncorrelated residuals among cross sections is assumed. The test is a χ^2 test. The rejection of the null hypothesis might indicate heteroscedasticity among cross sections and so justify the use of a FE or RE estimator. Furthermore, a modified Wald test was performed to test for groupwise heteroscedasticity. Under Ho, it is assumed that the variance of every single cross-section equals the variance of the whole (hypothesis assumed in a pooled OLS). Finally a Fisher test was performed on the significance of the fixed effect constant, as explained in Annex 10.

If the conclusion of no heterogeneity came out, then the more restrictive pooled OLS would be considered. The pooled OLS estimator is the most efficient estimator among all others, it is said to be BLUE.[13] The key condition for pooled OLS to consistently estimate the parameters is that the errors ($e_{i,t}$) have mean zero and are uncorrelated with each of the regressors (E(e)=0, Cov($x_{i,t}, e$)=0). The underlying theoretical model tested is: $Y_{i,t} = x_{i,t}\beta + u + e_{i,t}$ and $e_{i,t}$ is white noise. This pooled OLS does not allow any heterogeneity among sections (countries). Consequently, it is assumed that all explanatory variables are exogenous. An explanatory variable is said to be endogenous if it is correlated with e. The endogeneity leads to inconsistent and biased estimations in an OLS framework. Numerous reasons can cause endogeneity. The most current one is due to omitted variables. Indeed, in a panel data set, it is very usual to have heterogeneity across section (countries) without having a variable explaining it. Fixed effects and random effects take into account

[13] Best Linear Unbiased Estimator

the unobserved effects to a certain extent. Thus, FE and RE avert correlation between regressors and the error terms.

The residuals of the pooled OLS need to be checked for autocorrelation and heteroscedasticity. The former is tested by means of Wooldridge's (2003) autocorrelation test in first difference. The heteroscedasticity test is based on a likelihood ratio test, which compares the variance corrected for heteroscedasticity by a FGLS estimator with respect to the uncorrected variance. Strong autocorrelation and heteroscedasticity might indicate the presence of unobserved heterogeneity through individual effects. In that case, the estimated parameters are inconsistent. In conclusion, these results suggest that the OLS estimates suffer from a misspecification due, for example, to unobserved countries heterogeneity (omitted variable bias). This problem can be addressed by either adding more explanatory variables or by allowing for additional individual effects (FE or RE).

5 Empirical results

5.1 Model specifications

In section 3, two equations were derived, i.e. (6) and (7); and in section 4.1 and 4.2 unit root tests and cointegration tests concluded on series characteristics. Thus, theoretical consideration but also cointegration and stationary properties give five possible specifications which will be investigated:

$$\frac{P_t}{R_t} = \alpha_1 r_t + \alpha_0. \tag{S1}$$

$$\ln P_t = \alpha_2 \ln R_t + \alpha_3 i_t + \alpha_0. \tag{S2}$$

$$\ln P_t = \alpha_2 \ln R_t + \alpha_3 i_t + \alpha_4 \pi_t + \alpha_0. \tag{S3}$$

$$\ln P_t = \alpha_2 \ln R_t + \alpha_3 i_t + \alpha_4 \pi_t + \alpha_5 \delta_t + \alpha_0. \tag{S4}$$

$$\ln P_t = \alpha_2 \ln R_t + \alpha_3 i_t + \alpha_4 \pi_t + \alpha_5 \delta_t + \alpha_6 \frac{p_t^e - p_t}{p_t} + \alpha_0. \tag{S5}$$

The forms of the specifications have been chosen to eschew spurious estimation. In specification (S1), all variables are stationary. In specification (S2), the real house price (in log) is I(1) and thus introducing nominal interest is the only alternative. Arbitrage equations are generally expressed in real terms, consequently including inflation might be justified.[14] In specification (S2) and (S3), all variable series contain a unit root. According to Pedroni's cointegration test, the variable series in specification (S2) and (S3) cointegrate, under the condition that both, long and short nominal interest rates are included (see Annex 9). Specifications (S4) and (S5) only include variable series integrated of order one. However, the cointegration weakens when the depreciation rate is added. In specification (S5) the naïve house price expectation growth is I(0). Even though specification (S5)

[14]The coefficient in front of the inflation variable (α_4) should be 1 to match precisely arbitrage theory. Indeed, nominal interest rate minus inflation yields real interest rate, which is the determinant variable for arbitrage decisions with respect to real house prices.

comprises this I(0) variable, I refrain from excluding it on the grounds of economic theory. Furthermore, it is worth undertaking the empirical estimation of all five specifications and to compare them. The validity of each specification and the best among the specifications will be evaluated in the light of the empirical results.

5.2 Coefficient estimates

To be on the safe side, I will first estimate the most heterogeneous form discussed in section 4.3, i.e. the FE model with slope heterogeneity between country group 1 and 2.[15] Table 3 reports the empirical results. Variables $r1$ and $r2$ stand for real interest rate in country group 1, respectively country group 2. By the same token, $i1$ and $i2$ denote nominal interest rate in country group 1 respectively country group 2. All estimated semi-elasticities have the right sign. Moreover, the *t-test* (student test) indicates that all coefficients are significant except inflation in specification (S3) and (S4), and depreciation. The Fisher tests (Table 3) corroborate the overall significance of the coefficients. As expected, the explanatory power of the model increases as the specification includes more variables. The first specification only explains 11% which is very low whereas specification (S5) explains almost two third of the total variance. Consequently, imposing a price ratio seems too restrictive as R square rises to 32% in specification (S2). Furthermore, the coefficient in front of log of housing rents (α_2) equals 0.28, which is significantly different from 1 at 99%, according to the Wald test. According to the theory, the coefficient should have been close to 1. In addition, coefficients α_2 in specification (S3), (S4) and (S5) are significantly different from 1 at 99% according to the Wald test.

Not surprisingly, when the short-term and the long-term interest rate are included in the specification, the short-term rate is not significant in country group 1, and vice-versa, long-term interest rate is not significant in country group 2. Thus, arbitrage decision in countries with floating mortgage rate are more sensitive to short maturity bonds; whereas households in countries where fixed mortgage rate is predominant rather focus on bonds with longer maturity. Five year bond yield (respectively 3 month inter-bank offered rate) is the natural counterpart to fixed mortgage rate (respectively floating). Consequently, the short-term interest rate in country group 1 and the long-term in country group 2 are dropped.

The interest rate semi-elasticities between country group 1 and group 2 are significantly different from each other according to the Wald test at 99% in (S2), (S3), (S4) and (S5). Country group 1 semi-elasticities are larger in absolute value than country group 2 in specification (S1), and vice-versa for all other specifications. This result casts some more doubts on the validity of specification (S1). Meen (2002) shows that in the long-run, the elasticity in the UK is around 3 times as great as in the US.[16] In countries where longer-term fixed rate mortgage predominate, house prices tend to be less sensitive to movements in short and even long-term interest rates. The explanation lies in the transmission mechanism of the monetary policy. Monetary policy interest rate moves impinge more strongly on the mortgage rate where adjusted (flexible) mortgage interest rate is current practice. The wealth effect affects more strongly households (IMF, 2001) and

[15] Including the Netherlands in the second group improved the estimates. This splits the cross-section exactly into half: four countries in group 1 and four countries in group 2.

[16] In the USA, fixed mortgage rate practices predominate, while adjustable ones predominate in the UK mortgage market.

the credit channel (Bernanke, 1983; Bernanke & Gertler, 1995) impinge more heavily on household's net worth. Together, these effects may well explain the house price sensitivity differential with respect to interest rate between country group 1 and 2. However, I am aware that these explanations do not stem from the arbitrage theory.

Table 3: FE coefficient estimates						
Specification		(S1)	(S2)	(S3)	(S4)	(S5)
Dep. var.		$\frac{P_t}{R_t}$	$\ln P_t$	$\ln P_t$	$\ln P_t$	$\ln P_t$
	α_0	0.93 (35.16)	-0.05 (-1.16)	-0.05 (-1.18)	-0.02 (-0.09)	0.05 (-0.29)
$r1_t$	α_{11}	-3.49 (-4.43)				
$r2_t$	α_{12}	-1.08 (-1.88)				
$\ln R_t$	α_2		0.28 (1.80)	0.40 (2.27)	0.40 (2.27)	0.51 (3.21)
$i1_t$	α_3		-2.55 (-3.36)	-2.23 (-2.16)	-2.26 (-2.16)	-2.41 (-2.79)
$i2_t$	α_3		-4.01 (-7.29)	-3.93 (-5.28)	-3.94 (-5.27)	-4.04 (-6.50)
π_t	α_4			0.09 (0.88)	0.12 (0.19)	1.28 (2.24)
δ_t	α_5				-1.54 (-0.18)	-2.91 (-0.42)
$\frac{p_t^e - p_t}{p_t}$	α_6					1.92 (11.35)
R^2		0.11	0.32	0.34	0.34	0.63
F		F(2,238) =11.55	F(3.237) =36.09	F(4,228) =28.20	F(5,227) =22.47	F(6,210) =58.49
	p-lim	0.00	0.00	0.00	0.00	0.00

As depicted in Table 4, the wide range of FE coefficients indicates harsh heterogeneity among countries. The null hypothesis of all FE equal to zero ($u_i = 0$) is strongly rejected by the Fisher test at any common level of significance (Table 4, last rows). Finally, on average, half of the total variance is due to the FEs, as can be seen in Table 4 (rho). Altogether, this indicates strong heterogeneity among countries. Nevertheless, I follow the testing strategy framed in Annex 10 and section 4.3. Moreover, despite strong heterogeneity among countries, there is another candidate estimator which deals with heterogeneity among sections: the RE estimator.

Table 4: Fixed Effect estimates					
Specification	(S1)	(S2)	(S3)	(S4)	(S5)
Dep. var.	$\frac{P_t}{R_t}$	$\ln P_t$	$\ln P_t$	$\ln P_t$	$\ln P_t$
DE u_1	0.29	0.21	0.21	0.21	0.28
FR u_2	0.14	0.10	0.09	0.08	0.08
IT u_3	0.17	0.19	0.17	0.16	0.14
ES u_4	-0.16	0.01	0.02	0.02	-0.03
NL u_5	-0.13	-0.31	-0.31	-0.31	-0.31
BE u_6	0.04	-0.06	-0.05	-0.05	-0.03
FI u_7	-0.01	0.17	0.18	0.19	0.21
IE u_8	-0.33	-0.33	-0.32	-0.32	-0.35
σ_u	0.20	0.22	0.21	0.21	0.23
σ_e	0.17	0.22	0.22	0.22	0.17
$rho = \frac{\sigma_u^2}{\sigma_u^2+\sigma_e^2}$	0.59	0.49	0.47	0.47	0.65
F	F(7,238) =25.2	F(7,237) 25.87	F(7,228) =23.52	F(7,227) =21.06	F(7,210) =37.38
p-lim	0.00	0.00	0.00	0.00	0.00

5.3 Heterogeneity tests

The heterogeneity tests prove overwhelming heterogeneity. Table 5 summarizes tests' results. First, after the RE estimation, the Breush & Pagan test was performed, and the null hypothesis of no-serial correlation in the error composite term is overwhelmingly rejected. Second, as stressed by Baltagi et al. (2003), heteroscedasticity in the error composite term (or error component term) should be tested jointly with serial and spatial correlation in the residual. Consequently, Baltagi & Li' test was performed. As can be seen in Table 5, the joint null hypotheses are strongly rejected. Third, after the FE estimates shown in the previous sub-section, I once again performed a Breush & Pagan test. The null hypothesis of no-correlation among country error terms is rejected at any common level. Annex 11 reports the correlation matrix for each specification. Fourth, the Fisher test under the null hypothesis of equal R square between pooled OLS and FE, is strongly rejected as well. Fifth, the modified Wald test where under the null hypothesis all variance of the FE coefficients are equal is rejected. Altogether, these tests prove that pooled OLS for any specification would have lead to inconsistent estimates.

Table 5: Heterogeneity tests: RE, FE					
specif.	Test stat.	Random Effect (RE)		Fixed Effect (FE)	
(S1)	Br.&Pagan	$\chi^2(1) = 384.3$	p=0.00	$\chi^2(28) = 196.9$	p=0.00
	Bal.&Li/F	$LM = 443.1$	p=0.00	$F = 44.1$	p=0.00
	M. Wald.			$\chi^2(8) = 63.2$	p=0.00
(S2)	Br.&Pagan	$\chi^2(1) = 857.9$	p=0.00	$\chi^2(28) = 167.2$	p=0.00
	Bal.&Li/F	$LM = 650.1$	p=0.00	$F = 25.9$	p=0.00
	M. Wald.			$\chi^2(8) = 431.5$	p=0.00
(S3)	Br.&Pagan	$\chi^2(1) = 484.2$	p=0.00	$\chi^2(28) = 180.9$	p=0.00
	Bal.&Li/F	$LM = 552.4$	p=0.00	$F = 23.5$	p=0.00
	M. Wald			$\chi^2(8) = 359.0$	p=0.00
(S4)	Br.&Pagan	$\chi^2(1) = 350.8$	p=0.00	$\chi^2(28) = 180.5$	p=0.00
	Bal.&Li/F	$LM = 431.9$	p=0.00	$F = 21.1$	p=0.00
	M. Wald			$\chi^2(8) = 323.5$	p=0.00
(S5)	Br.&Pagan	$\chi^2(1) = 350.8$	p=0.00	$\chi^2(28) = 137.03$	p=0.00
	Bal.&Li/F	$LM = 431.9$	p=0.00	$F = 37.4$	p=0.00
	M. Wald		p=0.00	$\chi^2(8) = 270.9$	p=0.00

Finally, to decide whether the FE or RE is more appropriate, I performed the Hausman test. Statistically, the FE estimator always guarantees consistent estimates but they may not be as efficient as with the RE estimator. Under the null hypothesis, both estimators are consistent but the RE coefficients are the most efficient, while under H_1, only FE estimator coefficients are consistent. If FE and RE coefficient estimates are statistically alike (insignificant p-value, Prob>χ^2 larger than .05, at 95%) then it is safe to use the RE estimator. In the opposite, if p-value is significant the within FE estimator should be used. Table 6 summarizes the results for all 5 specifications. The null hypothesis for specification (S1), (S2) and (S3) cannot be rejected. This result is at odds with econometrics intuition. The probability to be able to use RE estimator should be much larger in a more specified model than less specified. The result casts some doubts on the validity of the Hausman test. The Hausman test does lack power due to the low time dimension. Nevertheless, specification (S1), (S2) and (S3) have been estimated by means of the RE estimator. Annex 12 shows the RE estimates. The coefficient estimates are very close to the FE estimates. Hausman test results may be reliable, after all.

Table 6: Hausman test		
specif.	Test stat.	p-value
(S1)	$\chi^2(2) = 3.82$	p=0.15
(S2)	$\chi^2(3) = 0.73$	p=0.87
(S3)	$\chi^2(4) = 0.55$	p=0.97
(S4)	$\chi^2(5) = 23.8$	p=0.00
(S5)	$\chi^2(6) = 27.5$	p=0.00

Since the R square of specification (S1) is very low, I will attempt to better specify the model. In opposite to FE estimator, a RE model allows a dummy variable.[17] Countries where MEW is developed have been identified in Table 2. The dummy variable equals 1 for the Netherlands, Ireland and Finland and 0 for the other countries. This MEW dummy variable (du1) is significant, unfortunately, the R squares remains at 11%. Table 7 reports

[17]Indeed, a dummy variable drops with a within estimator.

the results. The p-value value of the Hausman test of this new specification is even larger (p=0.3) and consequently RE coefficient estimates are still very close statistically to FE coefficient estimates.

Table 7: RE coefficient estimates		
Specif.		(S1)
Dep. var.		$\frac{P_t}{R_t}$
	α_0	1.02 (12.92)
$r1_t$	α_{11}	-3.25 (-4.25)
$r2_t$	α_{12}	-1.19 (-2.07)
$du1$		-0.24 (-2.01)
R^2		0.11
$Wald$		$\chi^2(3)$
		=24.4
p-val		0.00

5.4 Residuals

Annex 13 depicts the residuals of specification (S1),[18] (S3) and (S5) for each country.[19] The diagnostic tests for the normality of residuals were performed. Except specification (S1), the joint tests show that the residuals are normally distributed at 5% level (see Table 8). One cannot trust these results. As can be seen in Annex 13, the residuals exhibit very strong autocorrelation. Interestingly, the volatility of the specification (S5) is lower because it includes past year house prices. The variables in specification (S5) are in level while consumer price inflation and past years house prices stemming from expectation operator are expressed in growth rates. Thus, it is not an autoregressive term, but it may indicate that the house price is an autoregressive process, i.e. serially correlated. Furthermore, I performed the Moon & Perron and Choi unit root test, the null hypothesis of unit root cannot be rejected at any common level. Altogether, should one conclude to a misspecified model? Empirically yes. This means that the standard errors and the results of the inference tests are not reliable. Worse, the coefficient estimates might be biased.

[18] In specification (S1), the ratio housing price over rents is not in logarithm form. Consequently, the raw residuals have been transformed to express percentage points deviation and so comparable to the residuals of the other specifications.

[19] Residuals of specification (S2) and S(4) are so close to (S3) that they are omitted on the graph for the sake of clarity.

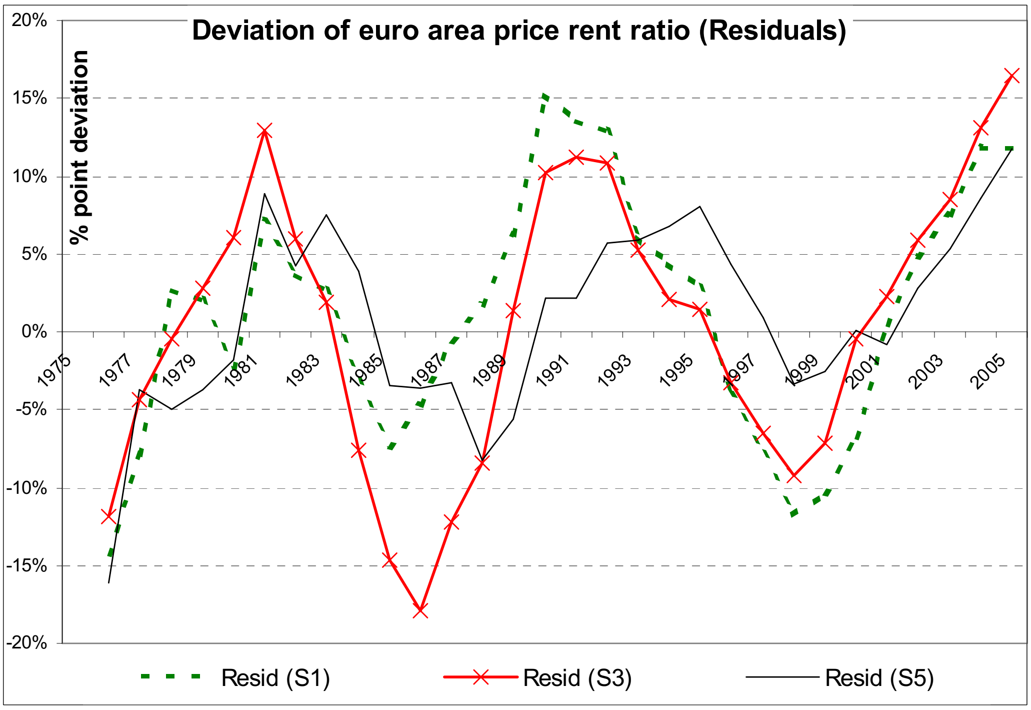

Figure 6:

Table 8: test for normality of residuals				
Spec.	Skewness p-lim	Kurtosis p-lim	Joint $\chi^2(2)$	p-lim
(S1)	0.00	0.02	12.48	0.00
(S2)	0.08	0.73	3.20	0.20
(S3)	0.13	0.70	2.48	0.28
(S4)	0.13	0.71	2.45	0.29
(S5)	0.06	0.26	4.83	0.09

Annex 2 gives a detailed explanation of the aggregation methodology. Euro area aggregates are constructed for the entire time span, including the period prior to the launch of the euro. The fitted values of the euro area house price were calculated by means of the panel FE coefficients presented in Table 3. Figure 6 depicts the euro area residuals which were derived. How can one interpret the residuals? Considering specification (S5) for instance, one might suppose that all the variables of the fundamental arbitrage equation are specified whereas the residuals cannot be considered white noise. Consequently, any systematic residual deviation from x-axis as seen in Figure 6, might be considered as a missing variable. This missing variable can be interpreted as a speculative behavior close to the bubble defined by Stiglitz (1990). Indeed, supposing specification (S5) as the "fundamental" equation, the residuals can thus be considered as the "speculative part" not explained by housing rents, interest rates, depreciation and the naïve expectation hypothesis.

Thus, according to the arbitrage theory, the overvaluing of the current euro area housing price ranges from 10 to 15% depending on the estimation. At the end of the period under consideration, the deviation is about 12% for both specifications (S1) and (S5). Moreover, the deviation of specification (S3) is larger than the one in specification (S1) while during the bubble in the beginning of the 90's, it was the opposite. This is explained by relatively important consumer price inflation in the 90's while then, inflation has remarkably fallen. Housing rents have also increased more since 1997 relative to the beginning of the 90's. Indeed, specification (S1) imposes a one to one relationship between housing price and rents, whereas specification (S3) not even one to half. Overall, the current deviation in percentage points is roughly identical to the peak reached during the bubble in the beginning of the 90's. Finally, the residuals of specification (S5) exhibit the lowest volatility and are lagged of two periods with regard to the two other specifications residuals. This is due to the house price expectation term. The naïve forecast assumption imply that past house price growth rates are picked up in estimation (S5) in level.

On a country level the following conclusions can be derived. The arbitrage theory suggests that in 2005 (last year of the sample) the Belgian (respectively the Dutch) house price level is overvalued of over 25% (respectively 40%). For the Spanish and the Irish current real house price level, the overvaluing is even larger, but differs between specifications. Specification (S5) may indicate an overvaluing of 25% in France, 40% in Spain and 50% in Ireland. Specification (S1) shows an even larger overvaluing of more than 60% in Spain and Ireland. Annex 13 shows these deviations by countries. It is however important to stress that a panel econometric model which imposes strong homogeneity is not the best tool to conclude on a sectional (country) level despite the heterogeneity in interest rates slopes between group 1 and 2 and the fixed effects. For this very reason panel parameter estimates have been used to simulate residuals on euro area series.

6 Conclusion

According to the arbitrage theory and to the most specified model, the misalignment with respect to the fundamental price in the euro area is about 12%. However, interpreting the residuals of the arbitrage equation as the deviation of price rent ratio from their fundamental valuation might be misleading. Omitted variable bias is of huge concern, it is very unlikely to have solely non fundamental elements in the residuals. Residuals might include other factors not captured by the very restrictive assumption of the arbitrage theory, and the missing factor may not only be the speculative part. Residuals exhibit strong autocorrelation because house prices seem to be a persistent process not captured by the arbitrage theory. This empirical model underpinned by the asset pricing theory is misspecified.

I will now try to review two core variables of the model, namely house prices and rents. These two variables are determined very differently, thus they actually diverge. House prices and rents level evolve around a time trend. ECB (2003) argues that the deterministic trend of the former is much steeper than the latter. On the one hand, the scarcity of available land drives land costs above the costs of living. On the other hand, public government regulations keep housing rents in line with the cost of living, as already explained in section 2. As a consequence, the gap between house prices and rents is building up over time. This structural misalignment might explain the lackluster performance of the asset pricing theory applied to house price. State regulations impede arbitrage mechanisms from working as efficiently as it should in a free market. The asset pricing theory is not only flawed by the discrepancy between rents and house prices. Only a minority of households invests in housing in accordance with the arbitrage theory. Importantly, housing is non-tradable by nature and the arbitrage theory cannot be applied.

These remarks cast serious doubts on the validity of the arbitrage theory as regards housing.[20] House prices are not essentially driven by arbitrage and speculative behavior. Baker (2002) and The economist (2005) assert that a bubble has developed on the ground of very high house price rent ratio. This empirical survey assails their analyses based on the underlying asset pricing theory. Another theoretical framework should be investigated instead, where house prices result from the matching of demand and supply of housing. According to the literature, housing supply might be driven by factors like the availability and cost of land, the cost of construction and investments. Factors that impinge on the demand for housing over longer terms include growth in household's disposable income, shifts in demographics, permanent institutional framework as for example the legal tax framework promoting home ownership against other type of wealth accumulation, financing conditions (level of mortgage interest rate) but also financing tradition. Addressing this question makes us suggest to investigate house price long-term and short-term dynamics by considering the house market directly.

[20] Nevertheless, it may be plausible that arbitrage theory explains better commercial real estate movements rather than residential. Indeed, the part of investors and speculators is traditionally larger in the commercial real estate segment. Furthermore, the yearly frequency might not be appropriate, a lower frequency would have been preferable. Finally, I have to acknowledge that I do not take into account transaction costs and taxes due to data scarcity. Would arbitrage models enhanced by tax and transaction costs better explain house price movements?

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ANNEX 1: Data

Annual data from 1975 to 2005 are used covering the longest available common period of 8 EMU countries: Germany (DE), France (FR), Italy (IT), Spain (ES), the Netherlands (NL), Belgium (BE), Finland (FI) and Ireland (IE). As the Residential Property Price is not available for the period under consideration, Luxembourg, Portugal, Greece and Austria were excluded. As a result, the sample consists of 31 observations in the time dimension and 8 cross-sections. The panel series are: *residential property price*, *housing rents*, *consumer price index*, *interest rate short-term*, *long-term, housing depreciation rate.* Real series were constructed by deflating the nominal series by the corresponding domestic CPI indices.

The residential property price is provided by the ECB, which in turn was calculated from the national Central Banks and private agencies like the BulwienGesa AG in Germany and the European Mortgage Federation, for instance. This ECB database was completed by the one of Claudio Borio from the Bank of International Settlement. The collection is a weighted average of series for new dwellings and existing dwellings. Data before 1995 include only West Germany. Concerning the year 2005, I completed the dataset on residential property price thanks to Livia Figà-Talamanca of the European Mortgage Federation (2006).

The CPI is the yearly average of the monthly HICP (Harmonized Index Consumer Price) from 1980 to 2005. ECB database uses Eurostat data and national CPI with a fixed euro conversion rate. The database was filled by the cost of living index for all households, all items, provided by the BIS. The source of the Irish CPI however is the National Central Bank of Ireland as the BIS cost of living index is not available.

For all countries including Germany, the ECB Desis database was used for the nominal short and long-term interest rate which is the 5 year government bond yield and the 3 month interbank offered rate, respectively. Once again, the data set was filled by the European commission DG-ECFIN AMECO database for data prior to 1990 except for Germany, where I used the International Financial Statistics of the IMF for the long term interest rate and the OECD Main Economic Indicator for the short term interest-rate.

The sectorial Housing CPI was chosen as proxy for rents, except for Finland prior to 1995, where a rent index provided by the Finish National Statistic Office (Veli Kettunen) was used. The ECB database on rents was also been filled for Spain, from 1976 to 1984, for Ireland from 1975 to 2004. These data were provided by respectively the Instituto Niacional de Estadística (Web site) and the Irish Central Bank (McQuinn Kieran). As 1975 was missing for Germany, Spain and the Netherlands, I projected the missing value by linear extrapolation over approximately the last 10 years (depending on the pattern of the series).

The housing depreciation rate (δ_t) was calculated according to the following formula: $\delta_t = \frac{GFCF_t - (NCS_t - NCS_{t-1})}{NCS_{t-1}}$
GFCF and NCS stand for Gross Fixed Capital Formation and Net Capital Stock in housing sector, respectively. National sources but also the European Mortgage Federation database were used.

ANNEX 2: Euro area aggregation

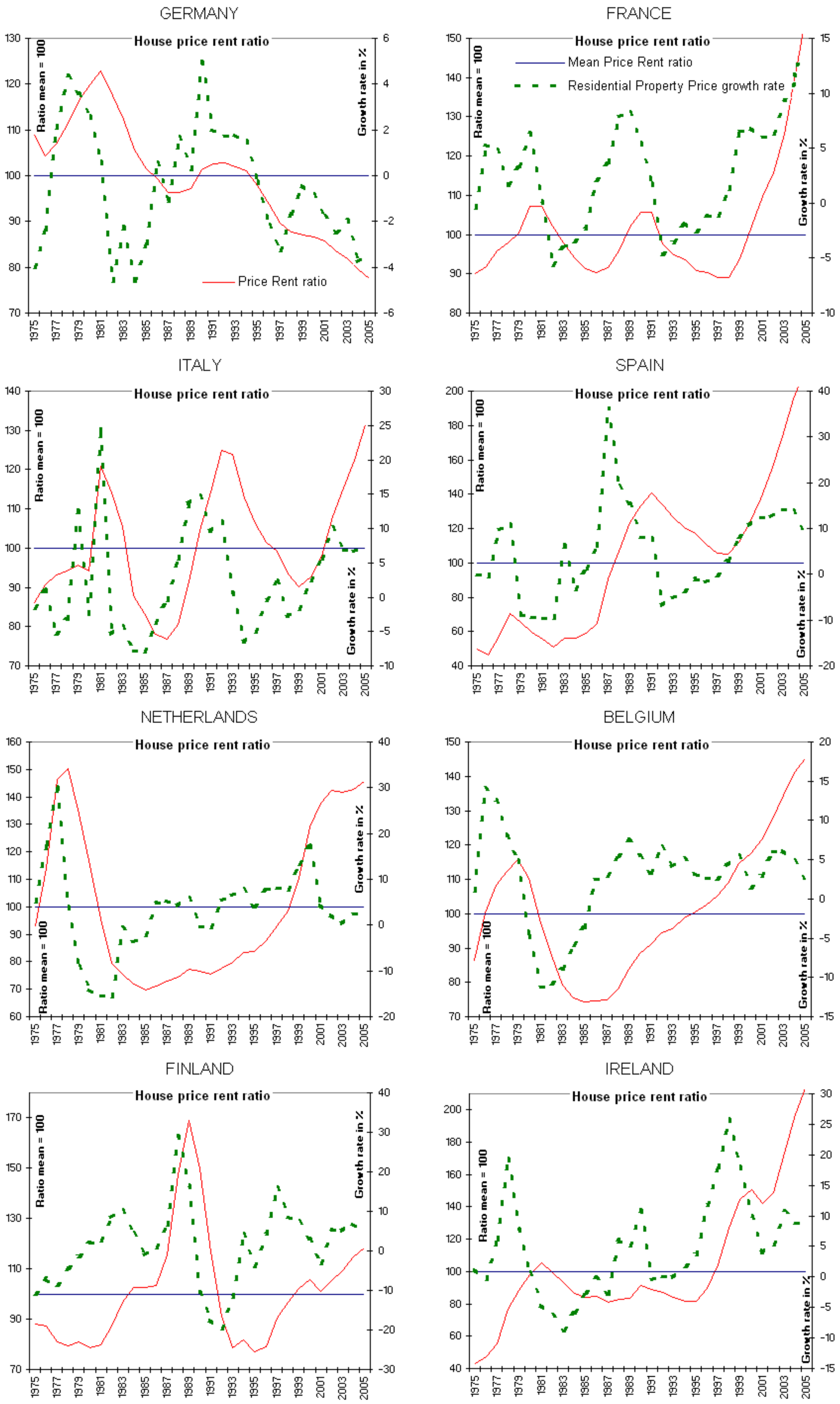
Currently 12 EU countries have joined the EMU, the member states are: Belgium (BE), Germany (DE), Greece, Spain (ES), France (FR), Ireland (IE), Italy (IT), Luxembourg, the Netherlands (NL), Austria, Portugal and Finland (FI). The euro area was restricted however to 8 countries due essentially to the lack of data for some countries. The weighting was recalculated for the eight countries (Table 1A2.1) by following ECB methodology (see ECB, 2005b) applied to the Residential Property Price (RPP) and the Harmonized Consumer Price Index (HICP).[21] National series of interest rates and CPI, respectively RPP index and housing rent indices were aggregated to euro area series by applying HICP weighting, respectively RPP weighting. First, The HICP for the euro area is published by Eurostat. However, as the study only uses the national data set of 8 countries, for congruence reasons an artificial euro area CPI was constructed according to the European consumer basket (see Table A2.1) for the entire sample. Second, in opposite to the CPI, the national RPPs are not harmonized. Despite the possible error margins, price trends and movements are correctly reflected (see BIS, 2005). The GDP weighted index used to aggregate the national RPPs (Table A2.1) is an acceptable solution given the available data. Overall, the reliability of the euro area RPP is strong. Finally, the euro area depreciation rate was calculated with respect to the formula given in Annex 1. For this purpose the national Gross Fixed Capital Formation and the Net Capital Stock in the housing sector were added up to euro area series.

Table A2.1

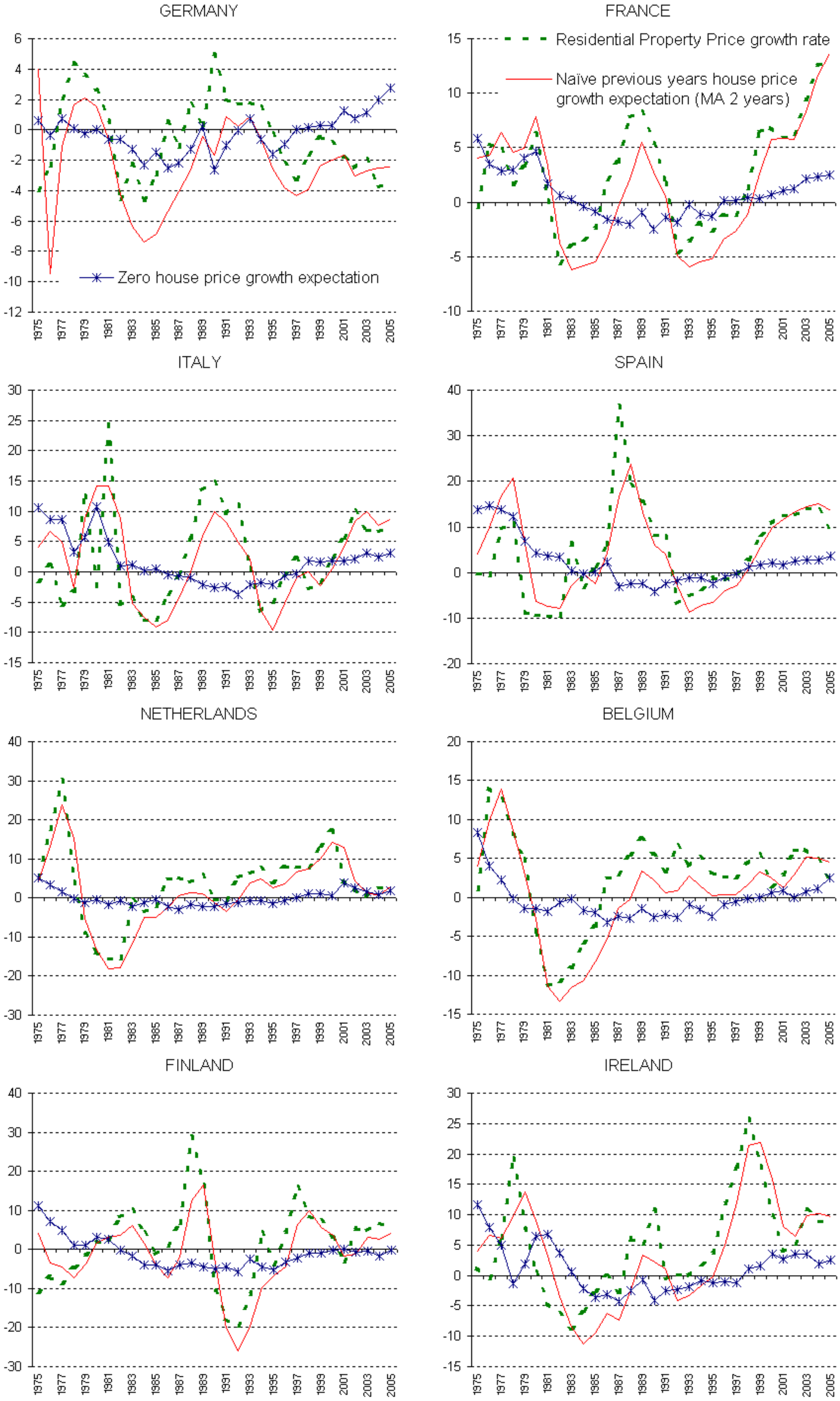
Weightings		
Country	% in HICP	% in RPP
DE	32.46	31.61
FR	22.26	23.13
IT	20.85	19.32
ES	11.84	11.06
NL	5.86	6.75
BE	3.58	4.00
FI	1.74	2.13
IE	1.41	2.00

[21] see "Compendium of HICP reference documents (2/2001/B/5)" under http://forum.europa.eu.int

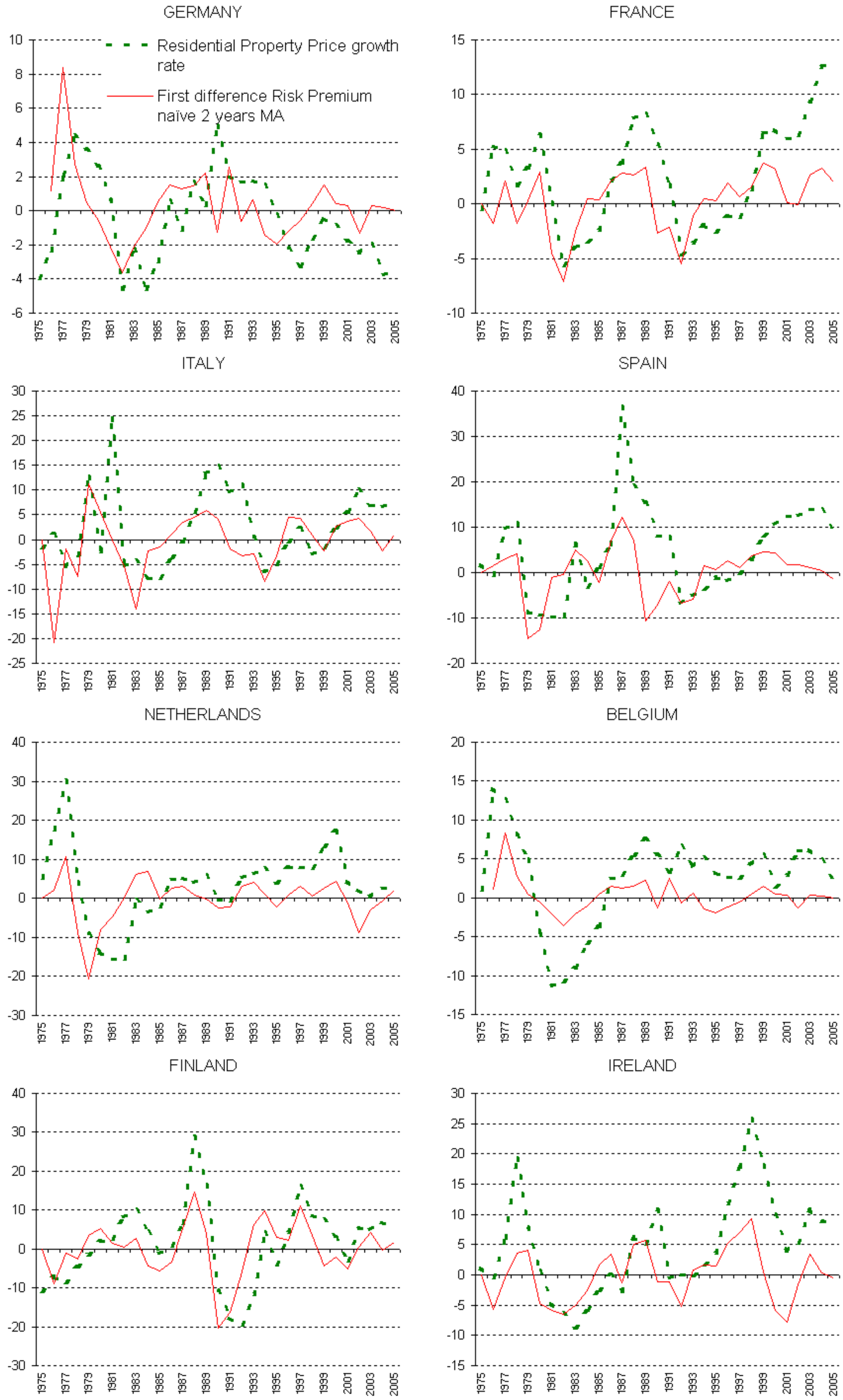
ANNEX 3: Price rent ratios and residential property price growth rates



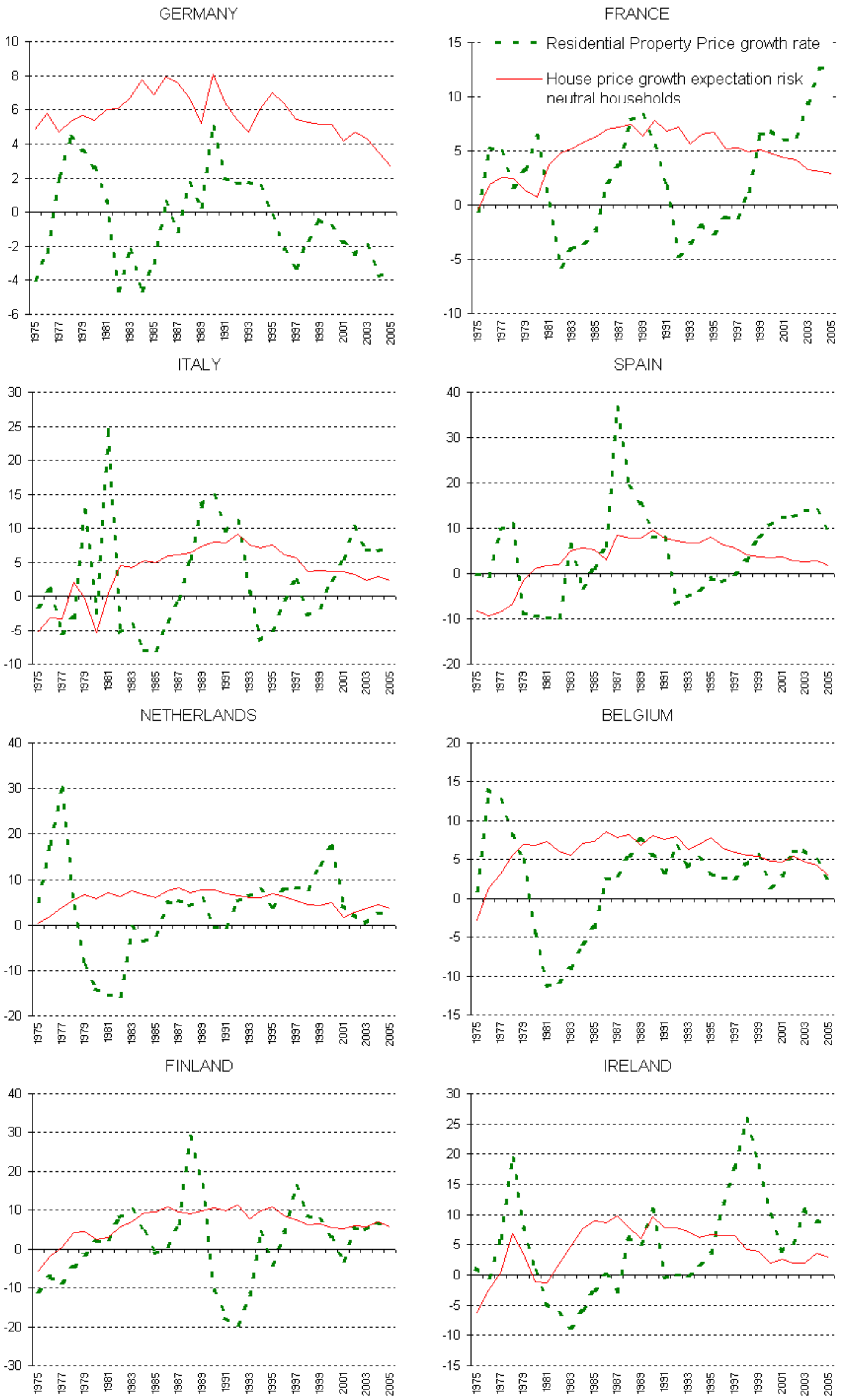
ANNEX 4: Risk premiums and house price growth rates (in %)



ANNEX 5: First difference risk premiums naïve expectation and house price growth rates (in %)



ANNEX 6: Fundamental real residential property price expectations (in %)



ANNEX 7: House price present value

The empirical literature (see Weeken, 2004) suggests a housing pricing equation derived by Aoki, Proudman & Vlieghe (2002) and Piazzesi, Schneider & Tuzel (2003) models. These models consider the house price as the present value of its expected future payoffs R_t (Rents) with a constant growth rate g and discounted at rate DR:

$$P_t = \sum_{j=1}^{\infty} \frac{R_{t+j}}{(1+DR)^j} = R\frac{(1+g)}{(1+DR)} \left[1 + \frac{1+g}{1+DR} + ... + \left(\frac{1+g}{1+DR} \right)^{n-1} \right] \quad \text{(A7.1)}$$

$$= R\frac{(1+g)}{(1+DR)} \left(\frac{1 - \left(\frac{1+g}{1+DR} \right)^n}{1 - \frac{1+g}{1+DR}} \right).$$

Suppose now that: $\frac{1+g}{1+DR} < 1$, then the price ratio can be derived from equation (A7.1):

$$\frac{P_t}{R} = \frac{(1+g)}{DR - g} = \frac{(1+g)}{r + \xi - g}. \quad \text{(A7.2)}$$

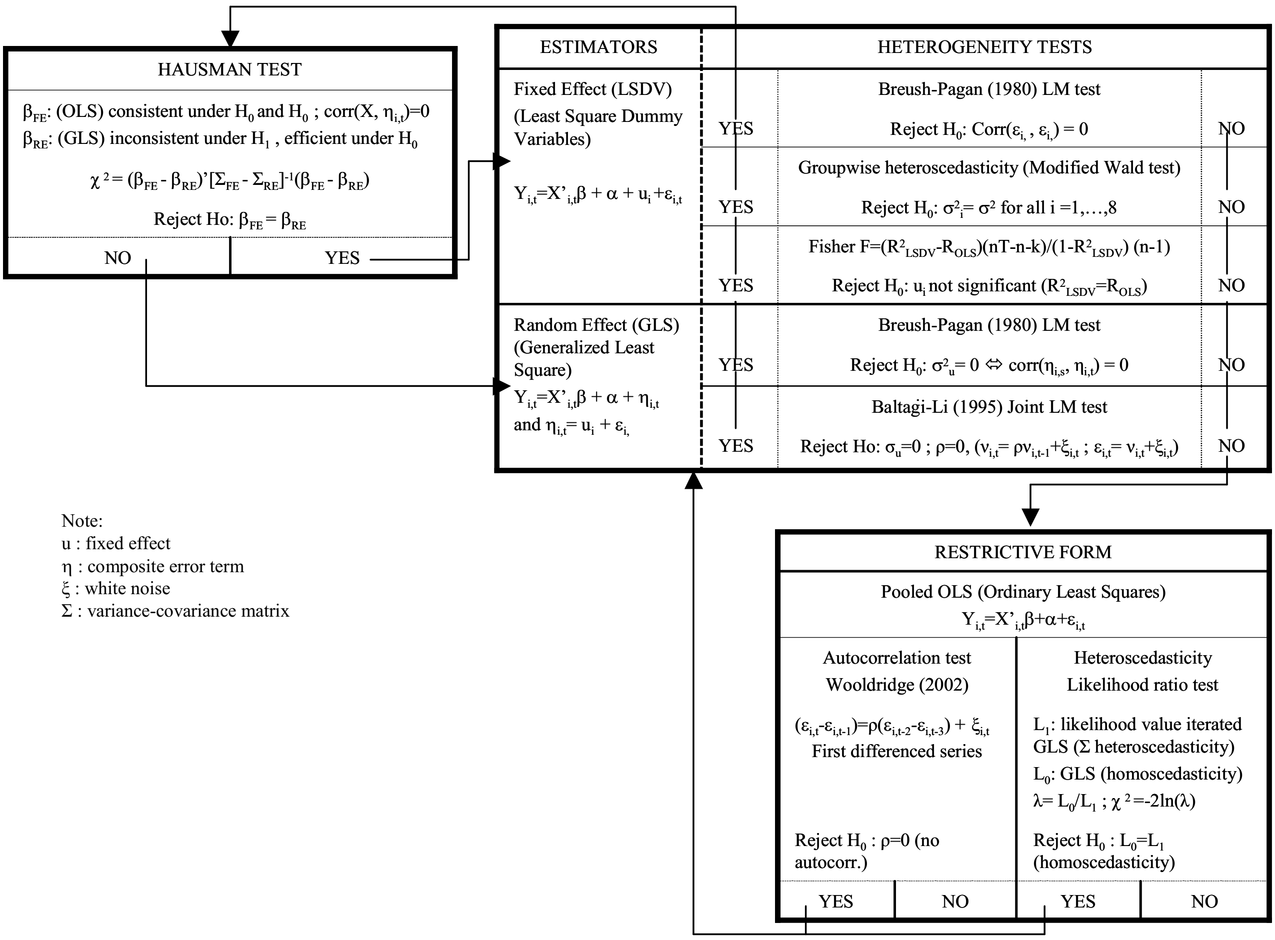
ANNEX 8: Moon & Perron (2003), Choi (2002) panel unit root tests

Var	Test	Deterministic terms	Statistics Z(Choi), tb (M&P)	p-value
$\frac{P}{R}$	Choi	c	-3.53	0.00
	M&P	c	-1.89	0.03
$r1$	Choi	c	-7.18	0.00
		c	-13.98	0.00
$r2$	M&P	c	-6.37	0.00
		c	-8.11	0.00
$\ln P$	Choi	c,t	1.90	0.97
		c	-0.12	0.45
	M&P	c,t	-0.46	0.32
		c	-2.26	0.01
$\ln R$	Choi	c,t	1.02	1.00
		c	0.70	0.76
	M&P	c,t	-0.09	0.46
		c	-3.09	0.00
$i1$	M&P	c,t	0.81	0.79
		c	-3.65	0.13
$i2$	Choi	c	0.62	0.73
	M&P	c	-3.67	0.12
π	Choi	c	1.74	0.96
	M&P	c	-4.10	0.20
δ	Choi	c	0.51	0.85
	M&P	c	-3.58	0.17
$\Delta \ln P$	Choi	c	-5.49	0.02
	M&P	c	-5.18	0.11

ANNEX 9: Pedroni's cointegration tests parametric panel ADF statistic and parametric group ADF statistic

Specification	$\ln P$	$\ln R$	$i1$	$i2$	π	δ	panel ADF	group ADF
(S1)	x	x					-2.0	-1.5
	x	x	x				-0.76	-0.32
	x	x		x			0.13	1.23
(S2)	x	x	x	x			-2.1	1.85
(S3)	x	x	x	x	x		1.49	2.88
(S4)	x	x	x	x	x	x	1.85	1.52

ANNEX 10: Testing strategy static estimator: pooled OLS, random effect (RE), fixed effect (FE) estimator



Note:
u : fixed effect
η : composite error term
ξ : white noise
Σ : variance-covariance matrix

ANNEX 11: Correlation matrix of residuals FE estimates by specifications

Specification (S1): correlation matrix of residuals FE

	ε_1	ε_2	ε_3	ε_4	ε_5	ε_6	ε_7	ε_8
ε_1	1.00							
ε_2	-0.58	1.00						
ε_3	0.19	0.33	1.00					
ε_4	-0.74	0.87	0.28	1.00				
ε_5	-0.63	0.53	-0.19	0.47	1.00			
ε_6	-0.69	0.55	0.03	0.63	0.86	1.00		
ε_7	-0.08	0.38	-0.15	0.30	-0.13	-0.28	1.00	
ε_8	-0.84	0.67	-0.11	0.61	0.81	0.76	0.04	1.00

Specification (S2): correlation matrix of residuals FE

	ε_1	ε_2	ε_3	ε_4	ε_5	ε_6	ε_7	ε_8
ε_1	1.00							
ε_2	-0.14	1.00						
ε_3	0.57	0.52	1.00					
ε_4	-0.31	0.68	0.17	1.00				
ε_5	-0.45	0.39	0.12	0.28	1.00			
ε_6	-0.23	0.58	0.41	0.38	0.90	1.00		
ε_7	-0.01	0.15	-0.19	0.16	-0.49	-0.55	1.00	
ε_8	-0.35	0.69	0.25	0.32	0.65	0.75	-0.15	1.00

Specification (S3): correlation matrix of residuals FE

	ε_1	ε_2	ε_3	ε_4	ε_5	ε_6	ε_7	ε_8
ε_1	1.00							
ε_2	-0.19	1.00						
ε_3	0.56	0.48	1.00					
ε_4	-0.34	0.65	0.13	1.00				
ε_5	-0.44	0.40	0.13	0.22	1.00			
ε_6	-0.27	0.55	0.39	0.31	0.91	1.00		
ε_7	0.01	0.14	-0.21	0.18	-0.50	-0.57	1.00	
ε_8	-0.34	0.68	0.21	0.25	0.58	0.69	-0.13	1.00

Specification (S4): correlation matrix of residuals FE

	ε_1	ε_2	ε_3	ε_4	ε_5	ε_6	ε_7	ε_8
ε_1	1.00							
ε_2	-0.19	1.00						
ε_3	0.56	0.49	1.00					
ε_4	-0.36	0.65	0.14	1.00				
ε_5	-0.43	0.39	0.13	0.22	1.00			
ε_6	-0.26	0.55	0.39	0.32	0.91	1.00		
ε_7	0.00	0.15	-0.22	0.19	-0.49	-0.56	1.00	
ε_8	-0.33	0.68	0.22	0.24	0.58	0.69	-0.13	1.00

Specification (S5): correlation matrix of residuals FE

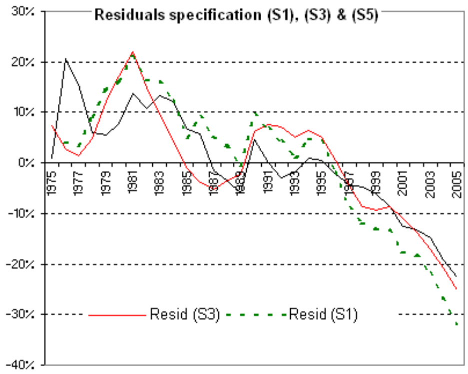
	ε_1	ε_2	ε_3	ε_4	ε_5	ε_6	ε_7	ε_8
ε_1	1.00							
ε_2	-0.47	1.00						
ε_3	0.38	0.20	1.00					
ε_4	-0.52	0.60	-0.01	1.00				
ε_5	-0.33	0.43	0.18	0.08	1.00			
ε_6	-0.39	0.55	0.29	0.13	0.90	1.00		
ε_7	0.10	-0.06	-0.33	0.12	-0.50	-0.63	1.00	
ε_8	-0.32	0.58	0.13	-0.00	0.74	0.73	-0.14	1.00

ANNEX 12: Random Effect (RE) coefficient estimates

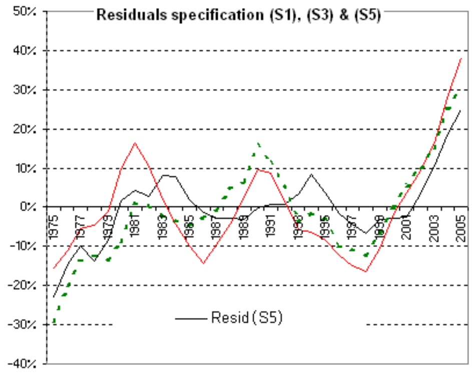
FE coefficient estimates				
Specification		(S1)	(S2)	(S3)
Dep. var.		$\frac{P_t}{R_t}$	$\ln P_t$	$\ln P_t$
	α_0	0.92 (13.81)	-0.06 (-0.58)	-0.06 (-0.60)
$r1_t$	α_{11}	-3.10 (-4.05)		
$r2_t$	α_{12}	-1.26 (-2.19)		
$\ln R_t$	α_2		0.29 (1.89)	0.42 (2.41)
$i1_t$	α_3		-2.41 (-3.30)	-2.8 (-2.08)
$i2_t$	α_3		-4.04 (-7.57)	-3.91 (-5.32)
π_t	α_4			0.05 (0.09)
δ_t	α_5			
$\frac{p_t^e - p_t}{p_t}$	α_6			
R^2		0.11	0.32	0.34
$Wald$		$\chi^2(2)$ =20.46	$\chi^2(3)$ =110.35	$\chi^2(4)$ =115.43
	p-lim	0.00	0.00	0.00

ANNEX 13: Residuals specification (S1), (S3) and (S5) by country

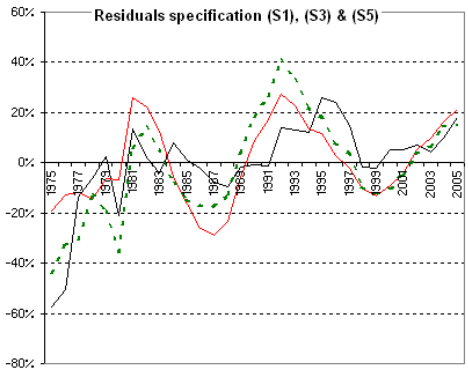
GERMANY



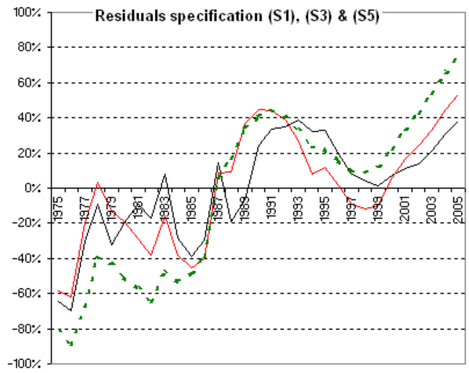
FRANCE



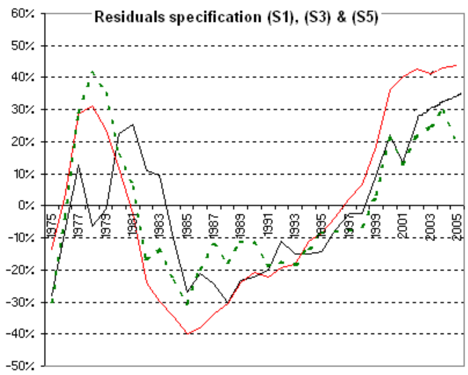
ITALY



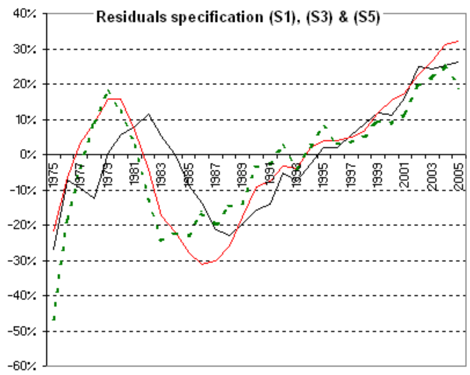
SPAIN



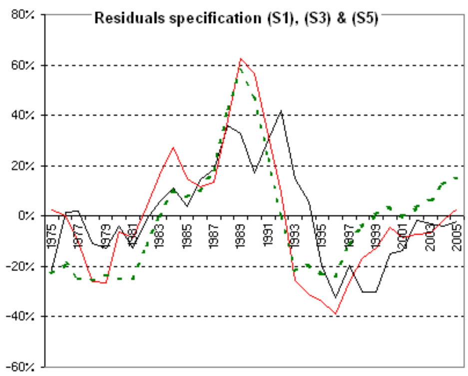
NETHERLANDS



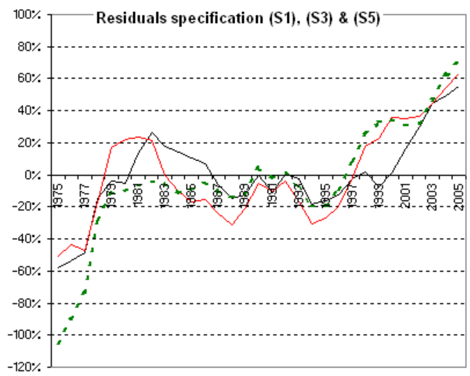
BELGIUM



FINLAND



IRELAND



House price dynamics, mortgage market and monetary policy in the euro area

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Abstract

This paper aims first at shedding more light on factors driving house prices and mortgage loan growth and, second, at evaluating the quantitative impact of an interest rate shock on house price dynamics in the euro area. The use of the Arellano & Bond (1991) dynamic panel estimator improves greatly the robustness of the estimation. In line with the literature on housing, the quantitative analysis shows, first, that disposable incomes and interest rates mostly drive the house price dynamics, while demographic proxies and housing rents are not significant; second, the house price growth rate is strongly persistent. As regards the mortgage market, collateral is the core factor and disposable incomes but to a lesser extent, while interest rate effect is benign. Mortgage loan is also a very strongly persistent process. In addition, the empirical estimates prove that the house market and the mortgage loan market interact significantly essentially through the collateral effect. Banks relax their lending standards by favorable house price prospects. Households can then capture more mortgage credit volume, which fuels further house demand. Higher house price in turn impinges positively again on households' wealth and banks requirements due to an increasing collateral value. This self-perpetuating process leads mortgage loan volume and house prices to track each other. A trigger event like monetary policy tightening can reverse the "vicious circle". An interest rate shock is simulated which sheds light on this interaction. As regards the quantitative effect: a 1% interest rate point increase in the long-term causes first, a steady real house price growth fall of roughly 1%, and second, a real mortgage growth decline of over 0.4%.

JEL Classification: C33, R21, R22, R31
Key words: Dynamic panel estimation, panel unit root tests, house price dynamics

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1 Motivation

Current soaring house prices have reached unprecedented levels for 30 years in almost all euro area countries, except in Germany (see Annex 3). Since 1996, Ireland has experienced a real house price growth rate in average larger than 10%. In the Netherlands, the upsurge also took place very early in the middle of the 1990's with a peak in 2000, since 2002 however house prices have grown moderately at 2%. In Spain, the dramatic increase occurred around 2000, since the real growth rate has been larger than 10% every year. In France and Italy the real house price has risen steeply since 1999 and 2001, respectively at 5% in average. Although the Italian and French ones increased more slowly, the pace of the French rate has nevertheless accelerated in the last three years overshooting 10%. Altogether, despite the falling house price in Germany accounting for roughly one third in the weighting, the euro area real house price has increased steadily since 1999 from 4 to 6.5% in 2005. The rise on its own is not as striking as the long lasting effect of the phenomenon. Indeed, during the bubble in the beginning of the 90's, euro area house price growth reached equivalent peaks. However, a real growth rate above 2% lasted roughly four years. In contrast, the ongoing current cycle shows a much larger duration. The strong real house price appreciation has already lasted for eight years. Questions have arisen regarding the sustainability of house price increase. Is there any fear of sharp decline? Rising commodity prices and the risk of abrupt decline, along with oil price shocks have become a center stage in monetary policy debate.

Dramatic asset price volatility can have significant effects on real economic activity, as witnessed by numerous historical episodes ranging from 1929 Wall Street crash to the more recent Tokyo housing and equity bubble. Boom-bust cycles in asset prices can eventually cause credit crunch or even a collapse of the entire financial system -systemic failure- via bank bankruptcy. Besides, strong asset price volatility can harm the real economy essentially through two other effects. First, households' housing wealth can have a strong impact on private consumption and aggregate demand (OECD, 2002; IMF, 2001). Second, asymmetric information in the credit market makes the supply of credit depend on households' collateral, the so-called financial accelerator (Bernanke, 1983; Bernanke & Gertler, 1995, 2000). Altogether, strong appreciations and subsequent rapid reversals in asset prices can harm output growth and jeopardize price stability. At least, they can convey information about future inflation not picked up by current indicators. As the primary objective of the ECB is to maintain price stability, the ECB pays attention to asset price movements, especially house prices, without targeting asset prices directly.[1] The central bank stresses the risk that an accommodative monetary policy might facilitate house price increase. More precisely, the ECB argues that strong monetary and housing credit growth fuel "strong house price dynamic" (ECB, 2005a).

This paper aims first, at shedding more light on the driving factors of house price growth and, second, at evaluating the quantitative impact of an interest rate shock on house price dynamics in the euro area. Thus, the interaction between house market, mortgage market and monetary policy transmission must be analyzed thoroughly to avert misspecification and spurious estimations. Households' strong dependency on mortgage

[1] Rents in the housing market account in the HICP for about 6.3% (ECB, 2003). However rents growth does not track house price growth, and the direct link between house prices and HICP is very weak, and about 2%. Consequently, a doubling of rents (100% increase) might lead to an increase of 2% of the HICP.

loans in order to purchase real estate is well-established. An outline of the paper is as follows: Section 2 depicts some stylized facts observed in the euro area house market and mortgage market. Section 3 presents a short review of literature on the housing market. Section 4 reviews basic theoretical aspects as regards the main determinants not only on house price demand and supply but also, on the mortgage loan market. Section 5 outlines, first the econometric methodology used in view of the purpose of the paper and the data availability. The issue of endogeneity is also addressed. Second, the empirical results are reported. In section 6 the estimated panel coefficients are used to highlight the factors driving house price dynamics in the euro area. Finally, an interest rate shock is simulated. Section 7 concludes.

2 Data and stylized facts

The euro area real house price growth rate has risen steadily from year to year since 1997 reaching more than 6.5% in 2004 and 2005 (see Figure 1). From 1975 to 2005,[2] such a large growth rate was only attained once, in the peak year of the well-known 90's bubble[3] which occurred in the majority of euro area countries (see Annex 3). The average real euro area annual growth rate for the period 1997 to 2005 is more than twice as large as the growth rate of the whole sample. This statement holds for all euro area countries except Germany. Indeed, the German real house price growth rate has been negative for the last 8 years, whereas Germany accounts for more than one third of the euro area house price (see Annex 2 where aggregation methodology is discussed). Despite this fact, euro area house prices have experienced a strong increase. As can be remarkably seen in Figure 1, the house price motions has lasted for a long time, a striking feature in this last cycle. House price movements in the last eight years correspond to a booming phase, which is nothing exceptional. However, never before 1975 had such a house price increase lasted so long, i.e. more than 8 years and that in so many countries. Countries which have experienced the last eight years outstanding real house price increase are: Ireland, Spain, France and the Netherlands with respectively: 11.5, 8.7, 6.4 and 6.2 on average. The other euro area countries have also experienced a strong house price increase[4] albeit to a lesser extent.

According to the literature on housing, the ratio of house price over real disposable income shows mean reversion. If the house price deviates relative to income, this misalignment tends to be corrected over time (Lamont & Stein, 1999; IMF, 2004; Lecat & Mesonnier, 2005). Thus, Figure 1 and Annex 4 depict the growth rate of real disposable income per capita (population aged from 15-64) together with house price for the in the euro area. At first glance both cycles co-move, although house price exhibits stronger volatility. Disposable income growth precedes upon one year booming house price. However, disposable income slowdown since 2001 has not depressed the housing market. As income does not seem to explain everything, an alternative and non-fundamental factor is investigated: mortgage loan development.

[2] Annex 1 gives inside on data sources and construction.

[3] The house price bubble at the beginning of the 90s was particularly sharp in Spain, Finland and Italy, and to a lesser extent in Ireland, France and Germany.

[4] Except Germany which is an outlier with regard to the rest of the euro area. The reunification provoked a booming house price which in turn surged housing supply. Thereafter, housing demand declined and the staggered house supply did not follow as quickly. Not only weak disposable income growth but also excess housing supply may explain the subdued German house price.

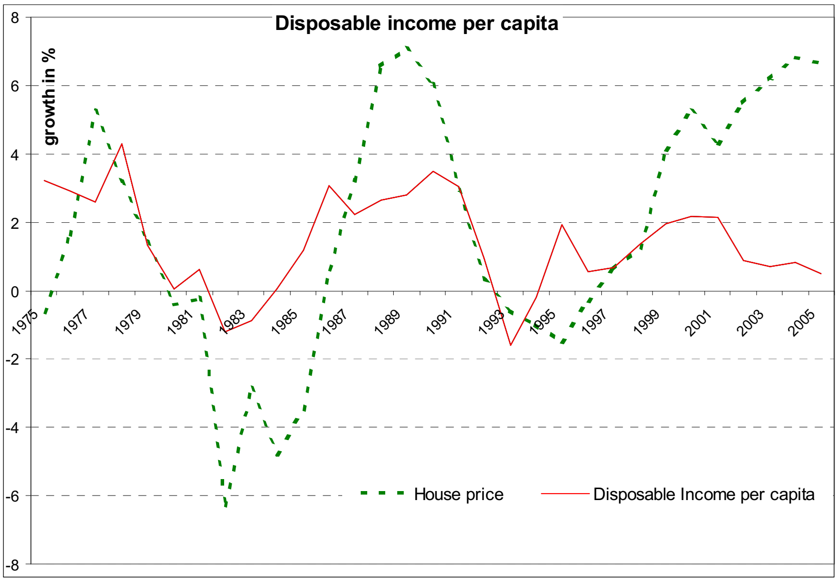


Figure 1:

Mortgage loan development might explain house price boom. Since 1997, the euro area mortgage loan market has displayed an average annual growth rate of roughly 7% with a peak of 11% in 1999, while the average growth rate before 1997 was only about 4%.[5] At the same time, euro area house price has shown a remarkable yearly increase of almost 5% on average between 1997 and 2005. Rapidly increasing house price coupled with expansionary outstanding mortgage debt means that the financial risks for the euro area households have increased significantly. On a micro-level, financial institutions and other lenders examine before approving a mortgage. The Loan To Value (LTV) ratio is one lending risk assessment amid manifold others (Jackson & Kasserman, 1980). Beside the prudential ceiling fixed by law, the LTV determines how conservative mortgage lending is. Typically, high LTV ratios are associated with higher risk. Maclennan, Muellbauer & Stephens (1999) show that countries with low LTV ratios and high transaction costs tend to experience lower house price volatility. One straightforward question worth asking is whether lax banking practises artificially fuel current dramatic house price increase. By the same token, on a macro-level total outstanding loans are divided by house price and the stock of dwelling, which yields the Current Loan To Value (CLTV).

The changes in the CLTV ratio over time might convey information on households' residential mortgage default risk exposure. Macroeconomic high risk exposure might be commensurate with large CLTV. The CLTV ratio has been detrended as the raw series exhibits a very strong time trend. Important structural reforms across euro area countries might explain this trend. Manifold countries embarked on extensive financial liberalization across the EU. Deregulation began in the early 80's and the pace varied markedly across countries. Liberalization typically led to more market-based mortgage markets, increased securization of mortgage loans, higher LTV ratio and an expansion in mortgage debt. This development spurt credit growth across numerous countries, which could reflect an

[5] This is the average growth rate of outstanding mortgage loan from 1976 to 1996.

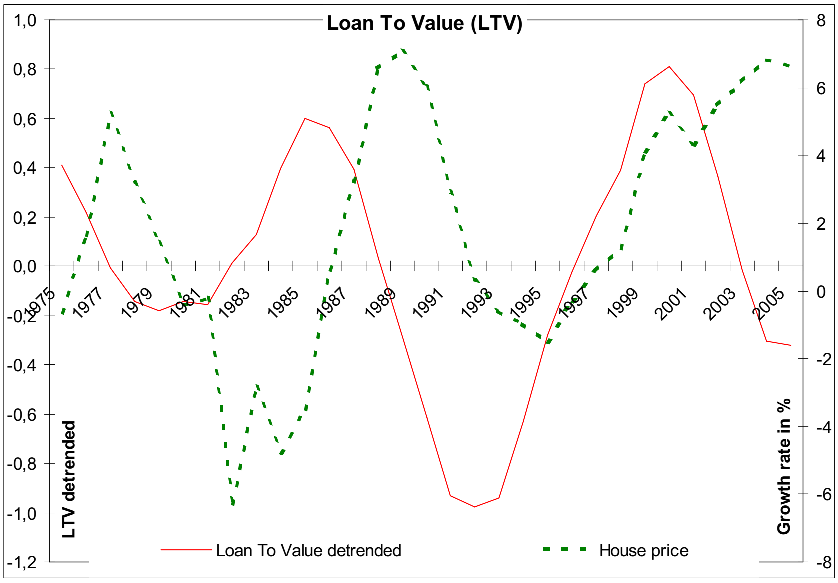


Figure 2:

equilibrium adjustment from repressed to liberalized financial markets. The detrended CLTV for the euro area captures well real house price movements roughly four years in advance. Figure 2 proves that the CLTV ratio was a reliable leading indicator to forecast house price in the past. If this leading indicator remains stable in the future, euro area house price should start decreasing in 2006. Annex 5 depicts country specific CLTV together with the real residential growth rate.

The alternative theory to measure default risk exposure is the ability-to-pay outstanding mortgage loans -the cash-flow approach. According to this approach, mortgages refrain from loan default as long as income flows are sufficient to meet the periodic payment without undue financial burden. Under the ability-to-pay model, the current debt servicing ratio, defined as the monthly repayment obligations as a percentage of current monthly income, which captures the repayment capacity of the borrower. The first crude affordability indicator (AFR) is measured by the ratio real disposable income per household over real residential property price. Since 1999, AFR has fallen dramatically and steadily as depicted in Figure 3 (and Annex 6 informs by country). Analyzing the historical curve, AFR seems to exhibit a forward of approximately 3 years over the real house price, although the regularity is sometimes tenuous. The fall of the ratio has not been followed by the residential property price even after 5 years, and so breaking the three years regularity. However, AFR does not take into account the mortgage financing conditions. Not only are households' disposable income a key factor but so are interest rates in determining the affordability of houses as regards mortgage loan payments.

The American National Association of realtors (www.realtor.org) instead proposes an interest rate adjusted affordability ratio (ARR). The median family income divided by the monthly mortgage payments of a typical home gives this ratio. It relies on three assumptions. First, the median family income grows at the same rate as the disposable income. Second, the mortgage covers 80% of the house price. Third, the price of the typical

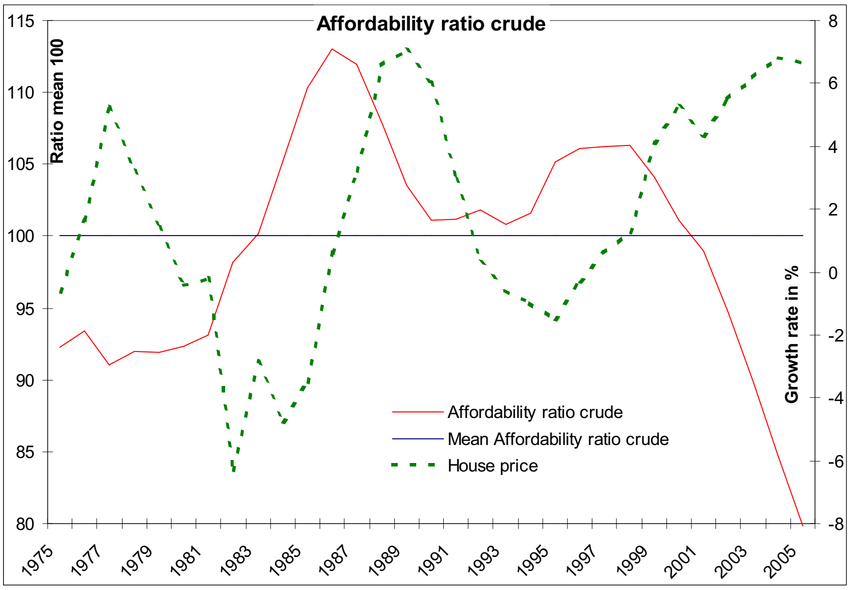


Figure 3:

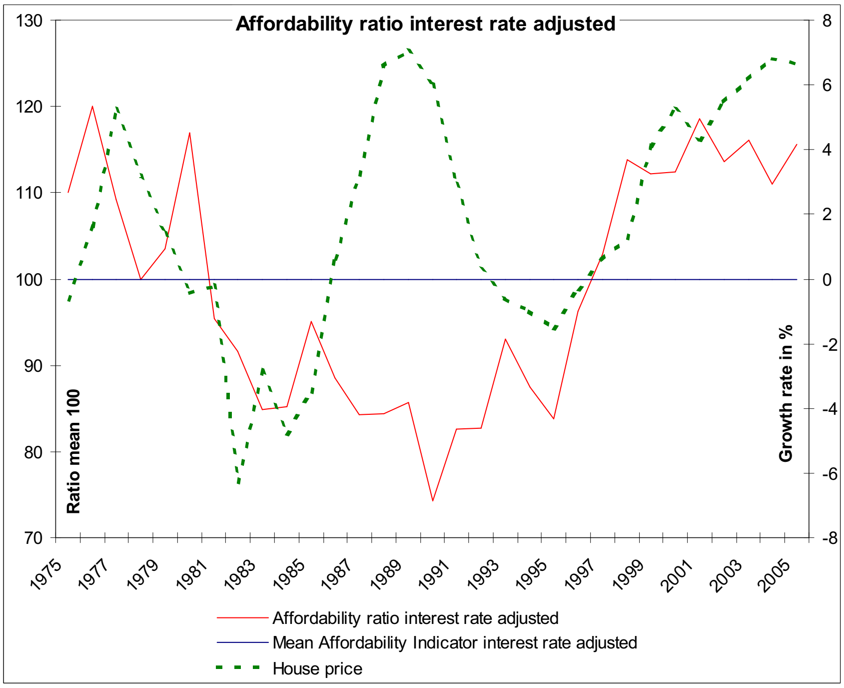


Figure 4:

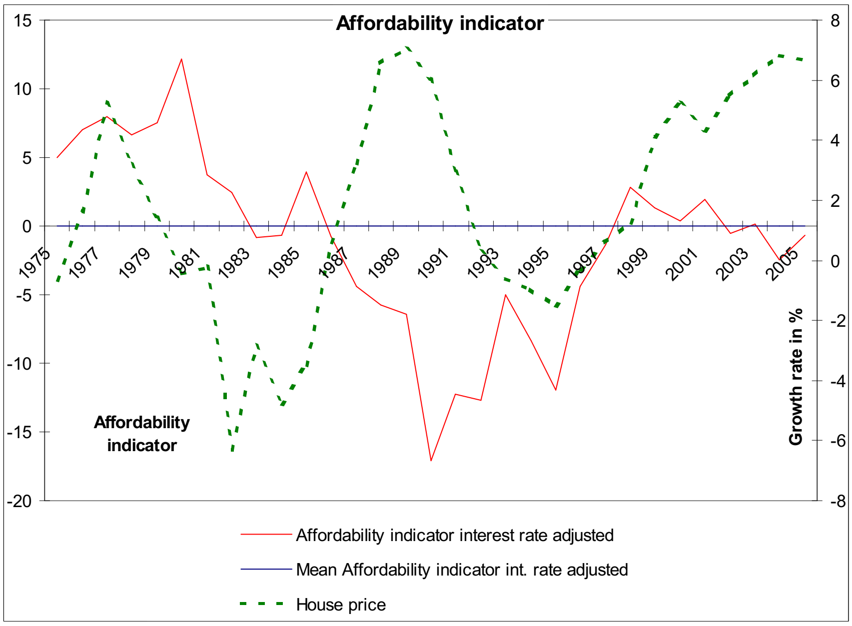


Figure 5:

home grows at the same rate as the residential property price. A detailed explanation of this ratio is given in Annex 9. This affordability ratio (ARR) shown in Figure 4 (by country in Annex 7) corroborates previous empirical findings. Household debt has remained affordable despite the economic slowdown since 2001. Low interest rates, i.e. the favorable mortgage financing conditions alleviated households' indebtedness and so fuelled mortgage loans. Indeed, the ratio has remained broadly unchanged at a relatively high level -around 115- for the last eight years. However, as depicted in figure 2, house capital value[6] increase outweighs real mortgage loan development. Indeed, CLTV has decreased since 2000. This might reflect the fact that fewer households borrow at very high LTV ratios. At the euro area level, the representative household's financial health remains strong.

In evaluating households' debt burdens, the direct measure is the residual income after servicing the monthly mortgage payment. Annex 9 explains an affordability indicator as the residual income left after mortgage payment. Figure 5 depicts this affordability indicator (AIR) for the euro area and country specific graphs are presented in Annex 8. AIR corroborates the conclusion drawn from the interest rate affordability ratio. Indeed, the strong economic growth after the mid-90's and the favorable financing conditions partially due to the launch of the EMU and the accompanying low interest rates alleviated households' indebtedness for current and past mortgage loan payments. Both measures prove that households' affordability reached its lowest level in the beginning of the 90's; thereafter, the economic recovery substantially alleviated the financial distress of households and even consolidated their financial position with the low interest rates. Despite the economic slowdown since 2001, the fall in the interest rates has offset this adverse effect. Both financial health indicators have remained stable since 1998 albeit AIR has shown a

[6] The real house price multiplied by the stock of dwelling gives the real house capital value.

downward trend but at a very moderate scale. While circumstances can change suddenly, both measures suggest that, by the standards of the past decade, relatively few households are currently close to a stressed position. The vast majority of indebted homeowners with mortgages appear to have few difficulties at present in serving it. At the euro level, the representative household's financial health is reliable.

3 Literature review

So far in the literature on housing, empirical house price estimation have been underpinned by the theory of asset pricing valuation or by a structural model. The former is based on the arbitrage opportunity between housing assets and alternative assets like bonds (Ayuso & Restoy, 2003; Bessone, Heitz, & Boissinot, 2005), while the latter model investigates the determinants of housing demand and supply (Kenny, 1999; McCarthy & Peach, 2004; Lecat & Mesonnier, 2005). The first approach of house price evaluation, however, is flawed by one major deficit. Indeed, house prices might not essentially be driven by arbitrage behaviors. Interpreting the residuals of the arbitrage equation as the deviation of the price rent ratios from their long-term valuation might be misleading. Omitted variable bias is of concern (Ott, 2006a). Consequently, the asset pricing approach is eschewed. In contrast, the second approach analyses the matches of housing demand and supply which in turn determines the price. Factors like land cost and availability, construction cost, and investments drive housing supply. Factors determining demand for housing, on the other hand, include households' disposable income, financing conditions (level of mortgage interest rate, access and conditions to mortgage loans), shifts in demographics, the institutional framework,[7] and arbitrage opportunities against house demand (housing rents, equities).

Equilibrium house prices, as in any other market is the match between demand and supply of housing. However, most estimates of house price equation are best viewed as inverted demand (IMF, 2004, 2005; Lecat & Mesonnier, 2005; Tsatsaronis & Zhu, 2004). The supply side factors are often absent. The first reason is the lack of reliable data on land costs and investment. The second is due to the problem of disentangling demand and supply (simultaneous equation bias). Construction costs index, when available can help estimating a supply in a time series VECM framework (Bessone et al., 2005; McCarthy & Peach, 2002; Martínez & Ángel, 2003; Kenny, 1998). Factor proxies of the inverted house price supply are residential housing investments, the building permits granted over time, the construction cost indices and the credit interest rates (Bessone, Heitz & Boissinot, 2005; McCarthy & Peach, 2002; Martínez & Ángel, 2003).

Demand side factors are investigated by numerous proxies. For instance Tsatsaronis & Zhu (2004) use the GDP per capita as proxy to capture households' income, unemployment and wage, while almost all authors (e.g. Lecat & Messonier (2005)) use the disposable income per capita in real terms. Nevertheless, some authors employ the permanent income as affordability variable, which in turn is proxied by consumption of non-durables and services and financial wealth (McCarthy & Peach, 2004, 2002; Bessone, Heitz & Boissinot, 2005). In Tsatsaronis & Zhu (2004) the link between GDP per capita and house prices is very tenuous while disposable income is highly significant in Lecat & Messonier (2005)

[7] As for example the legal tax scheme promoting home ownership against other type of wealth accumulation.

and IMF (2004). This may be due to the different choice of proxy. In Tsatsaronis & Zhu (2004), CPI inflation has the strongest impact on the real house prices. This can be explained especially in high-inflation countries where hedging against inflation risk is current practice.

As regards financial conditions proxies (the capability to borrow), authors also differ, distinguishing between short/long-term and between nominal/real. Tsatsaronis & Zhu (2004) use the short-term nominal interest rate while all other variables are expressed in real terms in their model specification. Frictions in the credit market and inflation expectations underpin the use of nominal interest rates instead of real ones. To take into account the real affordability of the household, they incorporate the consumer price growth rate (CPI) and the real spread (difference between 10 years bonds and 3 month treasury bills deflated by the CPI). The importance of property investments as a hedge against inflation is investigated by including the CPI in the model. Lecat & Messonier (2005) employ the same financial condition proxies as Tsatsaronis & Zhu (2004) except that the short-term interest rate is expressed in real terms and the CPI is excluded. An alternative proxy for financial conditions instead of interest rates, is the user cost of housing (Bessone et al., 2005; McCarthy and Peach, 2004; Martinez & Ángel, 2003). This user cost of housing depicts the cost of holding a dwelling, including taxation, the expected valuation (capital gain) of the asset and its depreciation. The last financial condition variables investigated in the literature on housing, are real bank credit (mortgage loans, housing credits to households, or credit to the private sector) and real stock prices, which respectively aim at proxying mortgage rationing and the effort of households to rotate their portfolio in favour of housing (Lecat et al., 2005; Martinez & Ángel, 2003; Tsatsaronis & Zhu, 2004).

The less controversial result among the surveys, is the strong significance of financial condition variables (interest rate either, real-nominal or short or long-term, or even the spread, but also credit), while stock market prices are insignificant. Borio & McGuire's results (2004) can be reconciled with the non-significance of equity market return by supposing that both house prices and stock market prices are pro-cyclical. According to Tsatsaronis & Zhu (2004) not only do interest rate changes matter but so do national financial features like variable versus fixed mortgage interest rate, maximum loan-to-value, the level of deregulation, equity withdrawal, securized mortgage assets. For instance, the link between credit growth and house prices is stronger in countries with more market-sensitive valuation methods (Tsatsaronis & Zhu, 2004). Lamont & Stein (1997) proved that credit constraint is a very important factor especially for indebted households. In the same stance, Lecat & Messonier (2005) show that financial conditions are essential factors explaining house price movements. They investigated the impact of structural changes. According to them, the deregulation of financial and credit markets mostly explain the house price bubble observed in the late 80's in France.

The third type of structural factors affecting housing demand may be the gradual shift in demographics, the change of the number of household proxied by the population aged from 15-65 years (IMF, 2004) or the total population (Lecat & Mesonnier, 2005). According to the cited literature, these variables change very softly and have a low explanatory power in the short-term. In the long-run, however, demographic factors have an influence (Ott, 2006b; Mankiw & Weil, 1989).

4 Model specification and estimators

4.1 House market

The model specification does not follow a thorough theoretical framework. Instead, the data are examined directly by using the basic house market relationship suggested by theory and by taking insights from the existing literature. Following for instance Poterba (1984) and Brueckner (1994), I suppose that a representative household maximizes its utility under budget constraint. The solution of this maximization problem is an inverted demand function (Muellbauer & Murphy, 1997), which can be written in log linear form:

$$p_t^d = -\alpha_2 dw_t + \alpha_3 y_t - \alpha_4 uc_t + \alpha_5 po_t + \alpha_6 rt_t + \alpha_7 lm_t + u. \tag{1}$$

Equation (1) expresses real house price demand at period t, p^d, as a linear function of the following variables, the stock of housing/dwelling dw, the real income per households y, the user cost of housing uc and a demographic variable, po. These four variables stem from the neoclassical framework. House prices react in opposite direction to the quantity of dwelling as in any demand function. Larger incomes alleviate budget constraints, which in turn allows households to purchase real estate. The user cost is born by the house owner and thus has a deterrent effect on house purchase. Empirical housing price models include the ratio population over stock of housing as a rule, for instance in Muellbauer & Murphy (1997). In this model, I prefer to split for the sake of estimation. Migration and population growth put house demand and so prices under pressure. Two other variables are added, rt which denotes housing rents and lm, a mortgage variable. The former is added on the ground of uncertainty (see Rosen, Rosen & Holtz-Eakin, 1984). Indeed, house renting is a substitute to owner occupancy. The latter is underpinned by the assumption of asymmetric information between financial institutions and households. Most households are not able to raise money from their own sources and so have to meet credit requirements. When a household purchase a real estate, it will typically rely on a financial institution like a bank to raise the needed funds. The relationship between financial institutions and households plays an important role in credit development and so in housing demand. As banks face asymmetric information about the moral rectitude and financial capabilities of the borrower, they screen the households.

The seminal paper of Stiglitz & Weil (1981) highlights how asymmetric information leads to credit/borrowing constraints. A few noteworthy theoretical and empirical studies have proved that borrowing constraints influence the house price equilibrium (Ortalo-Magné & Rady, 1999, 2005; Vigdor, 2004). Households are unable to maximize their intertemporal consumption path as there are liquidity constraints. In this respect, this sub-optimality depresses the house price equilibrium. Ortalo-Magné & Rady (1999) shed light on this negative relationship between credit constraints and house prices by appraising an empirical fact. They argue that deregulation of the mortgage market and the end of credit rationing especially for young households contributed to the house price boom from 1982 to 1989 in the UK. Euro area countries followed the liberalization and financial innovation policy pioneered in the UK, each country at its own pace. This institutional shift led to a spurt in mortgage loan growth in almost all euro area countries in the 90's albeit at different times (see ECB, 2003). The relaxation of borrowing constraint has quite a sizeable inflationary effect on house prices, according to Vigdor (2004). By appraising the

VA mortgage program,[8] he estimates that if 10% more of American households had access to the same credit conditions as war veterans, the house price over rent ratio would increase of about 6% nationwide. Since all credit constraints proxies failed to be significant in the empirical estimation, I followed IMF (2004) by proposing a positive relationship between house price and outstanding mortgage loan development.

The user cost in non log-linear form is commonly defined as:

$$UC_t = P_t \left(r_t + \delta - E_t \frac{P_{t+1}}{P_t} \right),$$

see for instance Muellbauer & Murphy (1997), McCarthy & Peach (2002); and r is the tax-adjusted interest rate, δ is the depreciation rate or the maintenance cost rate including property taxation, and the last term is the expected appreciation of house, while P_t is the real house price in non log-form. The risk free interest rate can be assimilated to an opportunity cost, whereas future house price growth is considered as a future capital gain. Assuming naive real house price expectation, i.e. the real expected house price is a weighting of the two previous realizations with weight γ and $1-\gamma$ respectively, the user cost in log-linear form can be rewritten thus:

$$uc_t = r_t + \delta + (1-\gamma)p_t - (1-\gamma)p_{t-1}. \tag{2}$$

I assume a naive backward expectation instead of a more realistic "semi-rational" one as in Muellbauer & Murphy (1997). In the light of the purpose of the estimation, another hypothesis regarding expectations would have been more cumbersome and useless. Substituting equation (1) into equation (2), yields the inverted demand function:

$$p_t^d = \frac{1}{1+\alpha_4(2-\gamma)} \left(\begin{array}{c} \alpha_4(1-\gamma)p_{t-1} - \alpha_2 dw_t + \alpha_3 y_t - \alpha_4 r_t \\ +\alpha_5 po_t + \alpha_6 rt_t + \alpha_7 lm_t + u - \alpha_4 \delta \end{array} \right). \tag{3}$$

House price demand exhibits persistence grounded on households' expectations. This staggered price adjustment stems from historic backward prices expectations. Indeed, when households expect real house price increase, they hasten to purchase real estate. Households typically fear not being able to afford a house in the future market during boom periods. The renewed rise will encourage first-time buyers, worried about missing out on the property ladder. This self-fulfilling effect shapes the persistence effect (serial correlation).

Housing supply[9] can be interpreted as an investment equation as in Kearl (1979) and McCarthy & Peach (2002):

$$iv_t = \beta_1 p_t - \beta_2 cc_t - \beta_3 r_t + \nu, \tag{4}$$

and cc is the construction cost borne by firms, and r the financial conditions (cost of credit). For the sake of simplification, I suppose that the interest rate of households and building firms is the same. The investment level depends on the current house price. When the house price increases, the profit margins increase as well before new entrants

[8] After the second World War, the US government implemented friendly legislative schemes for war veterans in order to facilitate their access to mortgage credits. The VA mortgage program refers to this legislative package.

[9] For a thorough theoretical investigation of housing supply, see Kenny (2003).

enter the market, making house construction more profitable, and the existing firms in the construction and building sector will start investing. The larger the price, the more important the amount invested. Finally, the construction costs and the financial burden of credit borrowing (interest rate) have a deterrent effect on investment. By definition, the law of motion of the stock of dwelling is:

$$dw_{t+1} = dw_t + iv_t - \delta dw_t.$$

By inserting this definition in the investment equation (3), the supply can be rewritten as a cobweb model:

$$dw_{t+1} = (1 - \delta)dw_t + \beta_1 p_t - \beta_2 cc_t - \beta_3 r_t + \nu. \tag{5}$$

The quantity supplied to the house market is determined by previous year price, a bygone. The stock of dwelling is not only determined by investments costs (construction costs and interest rates) but also by house prices. An increase of house prices will trigger a positive reaction (albeit sluggish) of the supply (simultaneous equation demand and supply, see Annex 10). Thus, the supply in the current period is perfectly inelastic. The literature on housing stresses that inertia is one salient feature of housing supply. Empirical investigations have proven that the supply is typically constrained (Muellbauer & Murphy, 1997; Kenny, 2003).

Assuming demand equals supply, and thus substituting equation (5) into (3) yields the reduced house market model in log-level:

$$p_t = \frac{1}{1 + \alpha_4(2 - \gamma)} \begin{pmatrix} (\alpha_4(1 - \alpha_2\beta_1))p_{t-1} - \alpha_2(1 - \delta)dw_{t-1} + \alpha_3 y_t + \alpha_4\beta_3 r_{t-1} \\ -\alpha_4 r_t + \alpha_2\beta_2 cc_{t-1} + \alpha_6 rt_t + \alpha_5 po_t + \alpha_7 lm_t + u - \alpha_4\delta - \alpha_2\nu \end{pmatrix}. \tag{6}$$

The literature on housing highlights two salient features of the house price process. First, house price is a highly persistent process due to backward looking expectations on the demand side and inelastic housing supply. Second, supply-demand interaction over time leads to a house price cycle, where short-term dynamics deviate from their long-term trend (Annex 10). In time series, Error Correction Model (ECM) is the most suited tool to disentangle long-term from short-term dynamics. One alternative is to estimate the model in two steps according to the Engle-Granger procedure. It consists in estimating the long-term cointegrated relationship in log-level, and then the short-term equation in first differences including the lagged residuals of the estimated long-term equation. In a panel framework, however, this would lead to inconsistency. Instead, I propose to frame the equations in first difference to cope with the unit root problem and to introduce an error correction term (ECT). This gives respectively equation (7), (8) and (9):

$$\Delta p_{i,t} = \frac{1}{1 + \alpha_4(2 - \gamma)} \begin{pmatrix} \alpha_4(1 - \gamma)\Delta p_{i,t-1} - \alpha_2\Delta dw_{i,t} + \alpha_3\Delta y_{i,t} \\ -\alpha_4\Delta r_{i,t} + \alpha_5\Delta po_{i,t} + \alpha_6 rt_{i,t} + \alpha_7 lm_{i,t} \end{pmatrix} + \tau_i - \lambda ECT_{d,i,t-1}, \tag{7}$$

$$\Delta dw_{i,t} = (1 - \delta)\Delta dw_{i,t-1} + \beta_1\Delta p_{i,t-1} - \beta_2\Delta cc_{i,t-1} - \beta_3\Delta r_{i,t-1} + \nu_i - \eta ECT_{s,i,t-1}, \tag{8}$$

$$\Delta p_{i,t} = \frac{1}{1+\alpha_4(2-\gamma)} \begin{pmatrix} (\alpha_4(1-\alpha_2\beta_1))\Delta p_{i,t-1} - \alpha_2(1-\delta)\Delta dw_{i,t-1} \\ +\alpha_2\beta_2\Delta cc_{i,t-1} + \alpha_3\Delta y_{i,t} + \alpha_4\beta_3\Delta r_{i,t-1} \\ -\alpha_4\Delta r_{i,t} + \alpha_5\Delta po_{i,t} + \alpha_6\Delta rt_{i,t} + \alpha_7\Delta lm_{i,t} \end{pmatrix} + \omega_i - \mu ECT_{i,t-1}. \tag{9}$$

In the testing strategy, I begin with 2 lags, the insignificant coefficients are dropped. Consequently, equation (9) can be written in generalized form:

$$\Gamma_0\Delta X_t = \Gamma_1\Delta X_{t-1} + \Gamma_2\Delta X_{t-2} + \omega_i - \mu ECT_{i,t-1} + \epsilon_{i,t}.$$

with $X_t' = (p_t, dw_t, cc_t, y_t, r_t, po_t, rt_t, lm_t)$.

The final forms of the three equations, i.e. the inverted house price equation (7), the housing supply (8) and the reduced house market (9) are all three characterized by an ARDL (Autoregressive Distributed Lags) process and a lagged mean reverting ECT as long-term equilibrium adjustment proxy. The indexes $i = 1.....8$ denote the 8 EMU countries investigated, $\tau_i = u_i - \alpha_{4i}\delta_i$, ν_i , and $\omega_i = u_i - \alpha_{4i}\delta_i - \alpha_{2i}\nu_i$ are country fixed effects, of respectively demand, supply and reduced house market equation, whereas t is the lag operator indicator (time) ; all growth rates are measured as first differences of logarithms except interest rate Δr , which is not expressed in logarithm. The growth rates are: Δp for the house price, Δdw for the stock of dwelling, Δcc for the construction costs, Δy for households' real disposable income, Δpo for the population, Δrt for housing rents and Δlm for the real mortgage loan.

The adjustment error correction terms reflect the dynamic adjustment to long-run equilibrium, i.e. the gap between actual house prices and the house price equilibrium. Following the literature (IMF, 2004; Lecat & Mesonnier, 2005), the ECT in the demand (7) and reduced equation (9) is proxied by affordability ratios and indicators. In the previous section, three different seemingly mean reverting variables were respectively investigated, i.e. the crude affordability ratio (AFR), the interest rate adjusted affordability ratio (ARR) and the affordability indicator (AIR). The first, i.e. AFR, supposes that solely income is the fundamental variable towards real house prices tend in the long-term (Lamont & Stein (1999), IMF (2004) and Lecat & Mesonnier (2005)). The last two, i.e. ARR, and AIR might be even better ECTs proxies as they include interest rates. It is not far-fetched to suppose that interest rates in level impinge on the long-term house price level (Ott, 2006b). Finally, the ECT in equation (8) is the construction cost index in level divided by the residential property price in level. Cost of land should be included, as scarcity of land is an essential determinant of long-term house prices. Once again, due to a lack of data, I am obliged to use this proxy. The stationarity properties of all ECT proxies are investigated in section 5.1

4.2 Mortgage market

To gain insight into the relationship between the house market and the mortgage market, it is important to expose a basic mortgage market model. Indeed, the mortgage market dynamics will also strongly influence house prices. Once again, instead of developing a thorough theoretical framework, the specification of the model will be taken from the existing literature, e.g. Brueckner (1994) but also Gary-Bobo & Larribeau (2003). In log-linear form, the demand of mortgage loan can be specified as:

$$lm_t = \varphi_1 lm_{t-1} + \varphi_2 y_t - \varphi_3 r_t^M + \varphi_4 rt_t + \upsilon. \quad (10)$$

The demand of credit for housing purpose, lm_t depends positively on the mortgage development of previous years, on households' disposable income and on housing rents but it will depend negatively on the mortgage interest rate, r_t^M (cost of financing the house). The decision to own a house and the size (value) of the house will depend positively on the affordability of the household. The direct cost borne by the borrower is the mortgage rate and will, of course, influence negatively the demand of mortgage loan. The rent variable is considered as an arbitrage decision as the tenant will aspire to ownership if the costs of renting increases relative to the house price. In contrast, mortgage supply is considered as a mark-up equation of monopolist banks (see Gary-Bobo & Larribeau, 2003 for instance):

$$1 + r_t^M = \phi_1 r_t + F(\frac{LM_t}{P_t DW_t}, y_t) + \varsigma. \quad (11)$$

The bank will charge a mortgage loan depending on the cost opportunity to invest in an alternative asset, which in our system of equations is a risk-free interest rate government bond yield of short or longer maturity, namely r. The ratio mortgage loan supplied over the value of the house is considered as the LTV ratio. Thus, the F function accounts for the default risk monitored by the bank; the decision to lend for a given mortgage rate depends positively on the current and expected income of the household which is proxied by the disposable income (y), and negatively on the LTV. Banks monitor households' global financial wealth including the property value (house price) considered as a collateral. Indeed, in order to reduce moral hazard financial institutions require households to pledge their property. If households are unable to meet mortgage interest payments, banks are entitled to sell the pledged collateral and to cash in the proceeds to cover the claims. This explains why mortgage loans are the most common and widespread practice as they reduce considerably moral hazard.

Mortgage loan supply and demand will not be estimated due to missing mortgage interest rate data, only the reduced mortgage loan market will be. The first step to derive a reduced equation consists log-linearizing the F function. The second step consists in inserting (11) into (10) and in solving the sub-system of mortgage equations with respect to lm in log-linear form, which yields the reduced mortgage market function:

$$\Delta lm_{i,t} = \frac{1}{1 + \varphi_1 \phi_2} \begin{pmatrix} \varphi_1 \Delta lm_{i,t-1} + (\varphi_2 + \varphi_3 \phi_5) \Delta y_{i,t} - \varphi_3 \phi_1 \Delta r_{i,t} \\ + \varphi_3 \phi_3 \Delta p_{i,t} + \varphi_3 \phi_4 \Delta dw_{i,t} + \varphi_4 \Delta rt_{i,t} \end{pmatrix} + \varepsilon_{i,t}. \quad (12)$$

The equation is framed in first difference to cope with unit root problems. As variables are expressed in log, the equation is expressed in growth rates except the interest rate; finally $\upsilon_i + \varsigma_i$ is the country fixed effect of the reduced mortgage market equation (12). I follow the same strategy by supposing first 2 lags[10] and then eliminating the insignificant coefficients. Consequently, equation (12) can be written in a generalized form:

$$\Omega_0 \Delta Z_t = \Omega_1 \Delta Z_{t-1} + \Omega_2 \Delta Z_{t-2} + \upsilon_i + \varsigma_i + \varepsilon_{i,t},$$

with $Z_t' = (lm_t, y_t, r_t, p_t, dw_t, rt_t)$.

[10] After verification, it came out that no coefficient variable lagged beyond 2 periods was significant. This is in line with what was expected with annual data.

4.3 Endogeneity and econometric methodology

Equations (3), (5), (10) and (11) establish a system of equation determining house prices, i.e. a simultaneous equation model (SEM) with four endogenous variables: p_t, dw_t, r_t^M and lm_t. Since mortgage interest rates data are not available, the reduced mortgage market equation (12) is considered and equation (10) and (11) cancel out. This reduces the system to three endogenous variables. First, the house price and the stock of dwelling are determined simultaneously by the supply and demand of housing. For instance an increase of house prices provoked by a demand push triggers a positive reaction (albeit sluggish) of the supply. Second, the volume of mortgage loan is endogenous to the house price via the lending collateral. As this collateral is the house itself, an increase of the house price will induce an increase of the mortgage loan. Third, the real disposable income may also be endogenous. This link is tenuous as the proxy disposable income does not include the house valuation, while households' wealth would. However, housing rents are included in disposable income, and house price movements might be coupled with rents growth through arbitrage. In fact, housing rents account for such a minor part in households' disposable income that it is not far-fetched to consider it exogenous. Fourth, bond and short-term interest rate are essentially monetary policy driven especially for short-term maturity. These interest rates will influence the supply and demand but they are exogenous to the mortgage market. It is assumed that monetary policy does not react (albeit exceptionally, see ECB 2005) to house price variations.[11] Fifth, in equation (3) and (6) the mortgage loan variable could be replaced by a credit constraint indicator characterized to be non-endogenous. Different credit constraint proxies were investigated during the empirical estimation, none of them were significant. Moreover, the credit constraint indicators might also be endogenous to the mortgage market, albeit to a lesser extent. Consequently, I suppose, instead, a positive endogenous relationship between mortgage loan growth and house price.

The equations fulfill the autonomous requirement as explained in Baltagi (1995). In a SEM, an equation is considered as autonomous if it has an isolated economic meaning independently from the other equations in the system. Furthermore, as at least one exogenous variable, i.e. construction cost, does not appear in the demand function, supply equation (5) is clearly identified under the condition that the coefficient is significantly different from zero. Instead, the concern focuses on endogeneity and more generally on the ARDL fixed effect models. The autoregressive term house price at time t-1 (R.H.S. regressor) is correlated with the error term and so OLS and Random Effect estimators are biased and inconsistent. Moreover, the country effect helps picking up omitted variables. Thus, it is likely that these country-specific characteristics are correlated with the other regressors, flawing the use of Pooled OLS and RE GLS. The within LSDV estimator (Least Square Dummy Variable) seems at first sight to be the perfect candidate as it allows to estimate the FE term and the within transformation cancels out the FE term. Unfortunately a correlation still arises with the error term since one regressor is a lagged

[11] Although the FED as well as the ECB have shown concern about house prices, it is realistic to suppose that house price movements are not included in the reaction function of the central bank. Monetary policy interest rate is mainly driven by output gap and CPI inflation movements. However, I understand that interest rate is endogenous to inflation and output gap. Indeed, a house price increase has a positive impact on households' wealth, which in turn puts the aggregated demand and inflation under pressure. Since monetary policy reacts to inflation and to output gap, interest rate is indirectly endogenous to house price. I suppose interest rate weakly exogenous to house prices.

dependent variable, even if the other variables were exogenous. Although the within FE estimator will be biased, as T tends to infinity the bias dies out. Nickel (1981) derives a rigorous formulation of the bias of the within FE estimator in a dynamic panel data model. In dynamic panel econometrics, where the R.H.S. of the equation contains lags of the dependent variables, the within-country estimator can be severely downward biased when the time dimension is short. Thus, the LSDV estimator only performs well when the time dimension of the panel is relatively larger with respect to the number of cross-sections.

To obtain consistent parameters any estimation technique requires instrumental variable methods like two-stage least squares (2SLS). Several estimators were proposed to estimate equations (7), (8), (9) and (12) when T is not large. Anderson & Hsiao (1981) propose two instrumental variable procedures. First, they remove the FE term by differencing the model. Second, they suggest to use as instrumental variables the dependent variable lagged two periods (in level) or its first differences. These instruments will not be correlated with the first differenced error terms as long as they are not themselves serially correlated. Thus, this IV estimation method leads to consistent, but not necessarily efficient estimates of the parameters. Arellano (1989) proves that Anderson & Hsiao estimator that uses difference rather than level for instruments has a very large variance. In the same stance, Arellano & Bond (1991) also differentiate the model to remove the FE terms and produce an equation that is estimable by instrumental variables. They derive a GMM (Generalized Method of Moments) estimator. The orthogonality between lagged values of the dependent variables and other endogenous variables is ensured by the use of all the lags at each period as instruments for the equation in first differences. The GMM procedure gains in efficiency by exploiting additional moment restrictions. Finally, Arellano & Bond (1991) confirm the superiority of using the lagged level as an instrument (instead of first difference), since the lagged difference as an instrument results in an estimator that has a very large variance.

Keane & Runkle's solution (1992) to estimate dynamic panel data models will not been used. They propose a test strategy to determine endogeneity. The starting point is to estimate the model with three different estimation techniques: FE 2SLS, first-difference FD 2SLS and 2SLS using the exogenous variables, the lagged values of the exogenous variables and the predetermined variables as instrument. To test the null hypothesis of strict exogeneity of the lagged house price, stock of dwelling and mortgage loan, Keane & Runkle (1992) propose two Hausman tests except that the variances are complicated because Keane and Runkle do not use the efficient estimator under the null. If the Chi square statistic rejects the null hypothesis, it means that explanatory variables are not strictly exogenous, i.e. FE-2SLS is not consistent. If Ho is rejected, Keane & Runkle propose a second type Hausman test to determine whether FD-2SLS or 2SLS should be used. Under the null hypothesis of the Hausman test, it is supposed that the explanatory variables are correlated with fixed effects. If this hypothesis is not rejected, the FD-2SLS should be used. The Keane & Runkle (1992) strategy does not apply to the case studied here as I can assert that the variables are endogenous. The FD-2SLS is the only consistent estimator and the Anderson & Hsiao is a first differenced two stage least square model. Finally, three stage least square estimator is averted. Although the systems methods are asymptotically better, they have two problems. First, any specification error in the structure of any equation will be propagated throughout the system by 3SLS. Second, in the same fashion as the SURE (Seemingly Unrelated Regressions) model, the finite-sample variation of the estimated covariance matrix is transmitted throughout the system. Thus, the finite-sample variance of 3SLS may well be as large as or larger than that of 2SLS. The advantage of the systems estimators in finite samples are more modest than the asymptotic results would suggest. As a result, a 2STLS estimator is used despite the relatively low time dimension.

After all, the choice of the best estimator depends on the panel dimension. As T gets larger, the efficiency of the LSDV estimator might outweigh the bias depicted in the mean squared error of the estimator. Judson & Owen (1997) simulate a Monte Carlo experiment and analyze dynamic panel estimator performance with respect to the panel dimension (time and cross-sectional). They conclude that "when T=30, the average bias becomes significantly smaller" but the bias can still be significant, ranging from 3% to 20%. Haque, Pesaran & Scharma (1999) have an even larger confidence in non IV type estimators. Indeed, they argue that for "models where T(=22) is reasonably large and the same order of magnitude as (N=21)", the application of instrument variables to a first differenced models like equations (7), (8), (9) and (12), does not seem necessary, and can even lead to considerable loss of efficiency. According to them, Anderson & Hsiao (1981) or Arellano & Bond's GMM estimators (1991) should only be applied to estimate dynamic panel data fixed effect models when the time dimension is short, ranging from 3 to 10, and cross-sectional relatively large, about 50 or more. It is well-known that the GMM Arellano & Bond (1991) procedure is usually employed in estimation of panel with a large number of individuals and short time series. Nevertheless, there are two procedures to estimate with GMM Arellano & Bond (1991), the one step estimator and the two step procedure. The latter can lead to overidentification, it is necessary to perform an Sargan-type overidentification restriction test as it uses the full set of instruments. This actually increases consistency but at the cost of efficiency. The former however is a restricted GMM estimator since it uses a subset of the available lagged values as instruments. Judson & Owen (1997) conclude that the one-step GMM procedure outperforms the two-step GMM estimator by producing smaller bias and smaller standard deviation of the estimates. This holds of course in macro panel data where the time dimension is typically larger than the cross-sectional dimension. This result is in line with Arellano & Bond (1991) who show that increasing the number of instruments creates a trade-off between the average bias and the efficiency.

To summarize, the choice of the econometric methodology is based on four considerations. The first involves panel econometrics. The time dimension of the available data on a country level is too short for robust estimates. Indeed, the annual data available ranges from 1975 to 2005 (T=31 observations). Panel econometrics allows a substantial gain in power. Moreover, panel estimators are proven to deal with the problem of measurement bias better (see Baltagi, 1995). Second, according to the theoretical framework and earlier empirical studies on house market (Muellbauer & Murphy, 1997; McCarthy & Peach, 2004; IMF, 2004; Lecat & Mesonnier, 2005), house price dynamics is a highly persistent process due to the staggered supply and households' house price expectations. Third, the interaction between mortgage market and house market but also between demand and supply within the markets render some explanatory variables endogenous. Fourth, as described in ECB (2003) and by Tsatsaronis & Zhu (2004), house and mortgage markets differ widely across EU countries, i.e. strong heterogeneity is observed between adjustable versus fixed mortgage loan interest rate, required LTV ratio, practice of mortgage equity withdrawal, legal scheme concerning house renting etc. Although the use of the estimated coefficient on a euro area aggregates assuages the heterogeneity problem, a fixed effect term in the estimation equation is the minimum heterogeneity to specify. Altogether, the two most used consistent estimators which tackle all four issues are first differenced IV estimator developed by Anderson & Hsiao (1981) and the dynamic panel GMM estimator developed by Arellano & Bond (1991) denominated respectively AH and AB. Nevertheless, there is a trade-off between efficiency and consistency as stressed by Haque, Pesaran & Sharma (1999) and Judson & Owen (1997). As a result, to check the robustness of the results two more efficient but biased estimators are investigated, i.e. the panel within fixed effect estimator (Least Square Dummy Variable) and a fixed effect two stage least square, respectively called LSDV and FE-IV. The former is a simple one way within FE estimator whereas the latter is a within FE estimator with IV. To conclude on the asymptotic properties of the chosen estimators, Judson & Owen (1997) show that among AH, AB and LSDV estimators, for sufficiently large N and T, the differences in efficiency and bias vanishes. Alvarez & Arellano (2003) also prove the closeness of the GMM relative to the within group FE estimator as N and T tends to infinity, contrary to the 2SLS estimators.

5 Empirical investigations

5.1 Unit root tests

The major caveat of classical time series unit root tests (e.g. ADF or KPSS tests) applied individually to each country (group or section) is the lack of power. Indeed, the relatively short time span (T=31) gives too few observations. However the time span is long enough to be concerned by the stationary proprieties of the series. As a consequence, to gain power, panel unit root tests are used. The first generation of panel unit root tests do not take into account possible cross-sectional correlations. The first test was developed by *Levin, Lin & Chu* (1993). Beside omitting the problem of cross sectional correlation, this test only allows for heterogeneity across sections (countries) by a fixed effect. The problem of heterogeneity is better taken into account by *Im, Pesaran & Shin* (1997) and *Maddala & Wu* (1999) tests. These tests allow under H_1 not only heterogeneous autoregressive coefficients among sections, but also divergent cases among sections in view of stationarity. Im, Pesaran & Shin propose an average ADF test over the sections, and under H_0 all sections have a unit root without fixed effect.

A new generation of panel unit root tests[12] have been developed, taking into account the problem of cross-sectional correlation: *Bai & Ng* (2001), *Moon & Perron* (2003), *Choi* (2002) and *Pesaran* (2003). Monetary union and the convergence process imply a very strong cross-sectional correlation among the series. This is particularly true for the interest rates. All four tests perform a unit root test only on the idiosyncratic component. The Bai & Ng test supposes to know the number of common factors in a total factor model. On the other hand, Moon & Perron, but also Choi, eliminate the common components of the series, and so perform a unit root test on the transformed series. These last two tests are certainly the most relevant ones in this empirical study in view of their asymptotic properties. Finally, Pesaran's test (augmented Dickey-Fuller) does not transform the data. Instead the test is performed on the raw data.

[12] The new generation of unit root tests were performed thanks to the matlab codes developed by Christophe Hurlin.

The number of lags were chosen automatically section by section based on the SIC (Schwartz Information Criteria). The null hypothesis for all tests is unit root. All variables are in log level, except the ECTs proxies and interest rates. First generation panel unit root tests, (1) *Levin, Lin & Chu*, (2) *Breitung*, (3) *Im, Pesaran & Shin*, (4) *ADF Fisher* (Fisher Chi-square, Choi Z-stat), (5) *Phillips Perron* test (Fisher Chi-square, Choi Z-stat), but also second generation: (1) *Bai & Ng*, (2) *Moon & Perron*, (3) *Choi* (4) *Pesaran*'s test have been performed. All tests were performed with maximum lag order of 4. As depicted in Annex 11, according to the second generation of panel unit root tests, all variables are found to have a unit root, except real interest rates (r) which are I(0). These results are in line with the theory and with what was expected. Indeed, inflation as well as nominal interest rates are found to be I(1) by the new generation of panel unit root tests. According to Fisher's theory, both are cointegrated, and so the residual of the nominal interest rate minus the inflation rate must be I(0).

Finally, the log of residential property price is found to be trend-stationary according to all three old generation tests (see Annex 12). The log of dwelling is also found to be trend-stationary according to the *Levin, Lin & Chu* and *Breitung*'s tests. On the other hand, *Choi* and *Moon & Perron*'s tests conclude to a unit root process for both series. I rather trust the new generation of panel unit root, as there might be strong cross-sectional correlation. For these two series, however, I also performed a country specific ADF tests (see Annex 13). Once again, the lag order chosen is based on SIC. According to the ADF test with or without trend, unit root process cannot be rejected at 5 %. In first difference, the unit root is clearly rejected (see Table 1) for all these series. Thus, I conclude that all series investigated are I(1) except real interest rates, which is in line with what was expected.

Table 1: Choi and Moon & Perron unit root test (first differenced series)

Var	Test	Deterministic terms	Statistics Z(Choi), tb (M&P)	p-limit
Δp	Choi	c	-5.49	0.00
	M&P	c	-5.18	0.00
Δdw	Choi	c	-3.57	0.00
	M&P	c	-3.62	0.00
Δy	Choi	c	-8.69	0.00
	M&P	c	-10.5	0.00
Δpo	Choi	c	-4.87	0.00
	M&P	c	-5.37	0.00
Δrt	Choi	c	-8.49	0.00
	M&P	c	-7.15	0.00
Δi	Choi	c	-9.76	0.00
	M&P	c	26.5	0.00
Δlm	Choi	c	-4.25	0.00
	M&P	c	-4.43	0.00
Δsp	Choi	c	-7.40	0.00
	M&P	c	-8.91	0.00
Δcc	Choi	c	-9.21	0.00
	M&P	c	-6.63	0.00
AFR	Choi	c	0.70	0.76
	M&P	c	-3.09	0.01
ARR	Choi	c	-0.40	0.35
	M&P	c	-3.90	0.00
AIR	Choi	c	-4.08	0.00
	M&P	c	-4.38	0.00
ECT_s	Choi	c	-0.15	0.44
	M&P	c	-3.36	0.00

The ECTs stationarity properties must also be checked. On the house market, three different ECT proxies will be investigated. First, the AFR (crude affordability) should show mean reversion. Indeed, residential property price and households' income should be cointegrated. Besides, as residential property price and households' disposable income per capita are both I(1), the ratio of two unit roots should be I(0). Second, the AFR and the AIR are found to be non stationary process. Indeed, *Choi* and *Moon & Perron* unit root tests fail to reject the null hypothesis at common levels. I suspect that trends in some countries explain this result. However, with a deterministic trend, the result of the two unit root tests is the same. It is not surprising, as a trend in one country offsets the other. Consequently I perform *Hadri* unit root test (Table 2). Indeed, the null hypothesis which assumes that all 8 time series in the panel are stationary processes is strongly rejected. This might prove that only some countries exhibit no-mean reverting ratios in a non time deterministic framework. It is preferably to detrend AFR and ARR ratios in Germany and Spain. Indeed, once these two countries are detrended, the new ratios contain no unit root according to *Moon & Perron* unit root test (see Table 1).

Table 2: Hadri panel unit root test					
Var		Z(mu)	P-value	Z(tau)	P-value
AFR	Homo	26.5	0.00	26.5	0.00
	Hetero	21.3	0.00	19.9	0.00
	Ser. Dep	4.12	0.00	4.54	0.00
ARR	Homo	25.9	0.00	27.2	0.00
	Hetero	23.7	0.00	21.4	0.00
	SerDep	3.86	0.00	4.49	0.00

Homo: homoscedastic disturbances across units

Hetero: heteroscedastic disturbances across units

SerDep: controlling for serial dependence in errors (lag trunc = 6)

5.2 Empirical results

5.2.1 House market demand and reduced form

Appendix 1 gives a detailed explanation of data construction and their sources. All series employed are of course I(0) as checked in the previous section, including the different ECTs proxies. I estimate equation (7), (8), (9) and (12) with a considerable number of alternative regarding proxies, lag structure and estimators. The maximum lag order is two, which is enough for annual data, and lagged variables with insignificant coefficients are dropped from the final estimated equations. The time span of the available number of households per country was too short. Consequently, two other demographic variables were investigated, i.e. total population and population aged from 15 to 64. The occurrence of right sign of the total population was far above the population aged from 15-64. Both demographic proxies were used to scale disposable income. Real disposable income per capita aged from 15 to 65 gave better results, and thus was chosen in the final specifications. Following Muellbauer & Murphy (1997) and Pain & Wesstaway (1996), I experimented as credit constraint proxy, the rate of acceleration of outstanding mortgage loan volume, and different CLTV. None of them turned out to be significant. The difference between mortgage rate and interbank interest rate would have certainly been a good proxy. This option could not be tested, due to missing data. In contrast, the growth rate of mortgage loan volume was frankly significant for almost every specification and almost every estimator. Mortgage loan growth rate has to be interpreted as a credit access indicator. This interpretation also has its silver lining, it gives a clearer understanding of the interaction between mortgage market and house market since the same variable is used in the mortgage market equation. Moreover, IMF (2004) used the same proxy.

Table 3 and 4, respectively, summarize the coefficient estimates of the demand and the reduced model. In both tables, the three first columns contain the estimates based on the LSDV estimator, simple one way linear within FE estimator, according to all three demand ECTs proxies. The fourth (D1) and the fifth (E1) column, respectively, refer to the within 2SLS estimator (IV-FE) and the Anderson & Hsiao first differenced 2SLS estimator (AH), respectively. Columns sixth (F1) to eight (H3) depict the Arellano-Bond estimates according to the different ECT proxies.[13] Concerning the IV-FE, AH and AB estimators, I followed the model specification and instrumented in first difference the following variables: the stock of dwelling and the lag order 1, of the real residential property

[13] Demand ECTs and reduced form ECTs proxies are alike.

price, of the real mortgage loan, and of the stock of dwelling. All exogenous variables were used as instruments. To meet the required size of the set of instrument variables, more instrument variables were needed for the IV-FE and AH estimators. In IV-FE estimations, the first difference of construction costs and the first difference lag order 3 of, residential property price, stock of dwelling, mortgage loan were added, while in AH estimations, first difference of construction costs, but lag 2 of variables in level, residential property price, stock of dwelling and mortgage loan were also used. Finally, I privileged the one step estimation procedure in the AB estimation with robust estimator of the variance-covariance matrix of the parameter estimates. Arellano & Bond (1991) already found that the two-step standard errors tend to be biased downward in small samples. Furthermore, Judson & Owen (1997) highlighted the efficiency loss due to many instruments for macro-data. Although the null hypothesis of Sargan-type for overidentifying restrictions might be rejected, AB two step estimator perform poorly in small samples. In our empirical estimation, the Arellano & Bond Sargan-type test for overidentification restriction strongly rejects the null hypothesis in any specification, as expected since the one step procedure is used. Levels of the endogenous variables lagged two are used to serve as instruments. I also performed Arellano & Bond (1991) autocorrelation test. For all six AB estimates, the null hypothesis of no first-order autocorrelation in the differenced residuals is rejected at 5%, while the null hypothesis of no second-order autocorrelation is never rejected. Second-order autocorrelation would imply that the estimates are inconsistent, while first-order autocorrelation in the differenced residuals does not.[14]

To check the robustness of the results, I will first examine whether the different estimators give similar coefficient estimates. Haque, Pesaran & Sharma's caveat (1997) considering the use of IV-type estimators seems justified. Despite the bias, the LSDV estimator yields very realistic estimates, while the AH and specially FE-IV do not render satisfactory results. Referring to the description of the FE-IV estimator in previous section, the weird results of the FE-IV estimator were expected. It is worth noting that coefficient estimate of the lagged dependent variable is above 1, which raises a stationary problem (see column D1 in Table 3 and 4). As proved by Arellano & Bond (1991) the efficiency gains of the GMM AB estimator against the AH estimator is substantial. Consequently, the AB estimates are the benchmark results, where standard errors are robust. Interestingly, there is little difference between the coefficient obtained on the focus variables between the LSDV and the AB estimator. Indeed, between the two estimators, the lagged dependent, the income, the interest rate, and the ECTs have similar coefficient estimates. Second, from column (A1) to (C3) as well as from (F1) to (H3), I investigate whether the main results are robust when I account for different ECTs proxies. Obviously, the ECT coefficient estimates differ across the different specification, but not between the different estimators. Moreover, the focus variable estimates also remain stable across the specifications. Third, coefficient estimates are very narrow between Table 3 and Table 4 which is not surprising as demand and reduced house price equations are very close. Altogether, the three points prove that the results are robust to changes in the baseline, including lag structure, adding different variables and using different estimators (especially between AB and LSDV).

[14] See Arellano & Bond (1991, pp. 281-82) for a discussion on this point.

Table 3: Coefficients estimates reduced house market (9)								
Dependent variable: Δp_t Real residential property price growth								
Var	LSDV	LSDV	LSDV	FE-IV	AH	AB	AB	AB
	(A1)	(B2)	(C3)	(D1)	(E1)	(F1)	(G2)	(H3)
Δp_{t-1}	0.51 (8.41)	0.48 (8.06)	0.49 (8.01)	1.56 (1.31)	0.59 (0.79)	0.50 (21.15)	0.48 (19.38)	0.49 (10.64)
Δdw_{t-1}	-0.53 (-2.16)	-0.79 (-2.04)	-1.08 (-1.98)	12.1 (0.51)	-1.54 (-0.61)	-0.62 (-3.19)	-0.51 (-2.67)	-0.34 (-1.88)
Δy_t	0.39 (2.07)	0.48 (2.97)	0.36 (2.17)	-0.50 (-0.38)	1.62 (0.69)	0.41 (2.57)	0.46 (3.94)	0.40 (2.86)
Δy_{t-1}	0.33 (2.14)	0.36 (2.97)	0.41 (2.59)	-0.32 (-0.33)	0.98 (0.66)	0.34 (3.65)	0.42 (4.71)	0.37 (5.85)
r_t	-0.30 (-2.57)	-0.18 (-1.79)	-0.13 (-1.61)	-0.71 (-0.65)	-1.45 (-1.41)	-0.41 (-2.01)	-0.28 (-1.82)	-0.32 (-2.05)
Δi_{t-1}	0.06 (0.33)	0.08 (0.39)	0.08 (0.39)	-0.53 (-0.38)	1.25 (0.79)	0.07 (0.28)	0.09 (0.54)	0.05 (0.88)
Δpo_t	1.77 (1.24)	1.75 (1.22)	1.75 (1.83)	-13.0 (-0.42)	-4.68 (-0.29)	0.43 (0.57)	-0.12 (-0.09)	0.59 (0.90)
Δlm_t	0.28 (4.36)	0.20 (3.21)	0.24 (3.64)	0.98 (0.65)	-2.13 (-0.61)	0.25 (4.83)	0.17 (3.54)	0.21 (4.26)
Δsp_t	0.06 (3.97)	0.06 (3.21)	0.06 (3.85)	0.09 (1.50)	0.07 (0.85)	0.06 (4.92)	0.07 (4.38)	0.06 (6.52)
Δcc_{t-1}	0.13 (1.09)	0.05 (0.64)	0.09 (0.63)	0.48 (0.01)	0.21 (0.86)	0.04 (1.08)	0.05 (1.59)	0.06 (6.52)
AFR_{t-1}[15]	-0.11 (-4.37)			-0.29 (-0.89)	-0.29 (-0.89)	-0.15 (-4.09)		
ARR_{t-1}		-0.09 (-3.79)					-0.11 (-6.39)	
AIR_{t-1}			-0.06 (-3.21)					-0.05 (-3.00)
cst	0.09 (4.19)	0.06 (3.21)	-0.00 (-0.36)	0.15 (1.43)	0.01 (1.08)	0.00 (1.78)	0.00 (1.37)	0.00 (1.04)

[15] The inverse of the AFR, ARR and AIR enter the specification.

Table 4: Coefficients estimates demand house market (7)								
Dependent variable: Δp_t Real residential property price growth								
Var	LSDV	LSDV	LSDV	FE-IV	AH	AB	AB	AB
	(A1)	(B2)	(C3)	(D1)	(E1)	(F1)	(G2)	(H3)
Δp_{t-1}	0.49 (8.31)	0.47 (13.8)	0.47 (7.71)	1.38 (1.92)	0.60 (0.75)	0.49 (10.84)	0.48 (6.93)	0.49 (3.19)
Δdw_t	-2.43 (-1.67)	-2.17 (-2.51)	-2.84 (-1.89)	-21.02 (-0.81)	-13.3 (-0.26)	-2.71 (1.67)	-2.31 (-1.06)	-1.94 (-1.53)
Δdw_{t-1}	2.10 (1.36)	2.22 (2.16)	1.53. (0.83)	28.90 (0.76)	8.37 (0.19)	1.26 (6.10)	2.16 (1.53)	2.05 (1.40)
Δy_t	0.39 (2.39)	0.50 (3.38)	0.41 (2.56)	0.54 (0.50)	1.62 (0.69)	0.44 (2.53)	0.50 (2.94)	0.40 (1.13)
Δy_{t-1}	0.32 (2.07)	0.41 (4.21)	0.42 (2.61)	0.42 (0.51)	0.98 (0.66)	0.33 (3.20)	0.43 (3.20)	0.47 (1.54)
r_t	-0.36 (-2.85)	-0.17 (-1.71)	-0.14 (-1.46)	-0.52 (-0.89)	-1.45 (-1.41)	-0.34 (-1.82)	-0.21 (-0.23)	-0.12 (-0.30)
Δpo_t	1.46 (1.01)	1.33 (1.08)	1.58 (0.98)	-0.23 (-0.56)	-3.88 (-0.29)	-1.91 (-0.92)	-2.01 (-1.02)	-1.51 (-0.63)
Δlm_t	0.30 (4.70)	0.19 (4.62)	0.23 (3.64)	0.83 (0.88)	-2.01 (-0.58)	0.20 (1.15)	0.15 (0.09)	0.15 (0.47)
Δrt_t	-0.01 (-0.10)	0.01 (0.08)	0.01 (10.07)	0.08 (0.19)	-0.01 (-0.02)	-0.12 (-0.76)	-0.16 (-0.94)	-0.08 (-0.38)
Δsp_t	0.06 (4.06)	0.07 (5.06)	0.07 (4.15)	0.08 (1.98)	0.07 (0.85)	0.06 (4.78)	0.07 (3.89)	0.07 (2.05)
AFR_{t-1}[16]	-0.13 (-4.37)			-0.26 (-1.36)	-0.45 (-3.24)	-0.14 (-3.51)		
ARR_{t-1}		-0.09 (-3.32)					-0.11 (-2.24)	
AIR_{t-1}			-0.06 (-3.12)					-0.06 (-3.41)
cst	0.87 (4.11)	0.00 (1.75)	0.00 (0.38)	0.16 (2.05)	0.13 (1.08)	0.00 (1.66)	0.00 (1.43)	0.00 (1.04)

Table 3 and 4 report the preferred specifications and proxies. I choose the preferred estimates with regard to statistical significance and theoretical plausibility. The results are quite satisfactory, both from the view point of the sign and level of significance of the coefficients. In particular, the regression coefficients are broadly statistically significant at conventional significance levels, with the exception of the coefficients on the population and housing rents, which were never significant for any specification. Consequently, I left them out in the reduced model. Dropping these two variables did not alter the other coefficient estimates markedly. Furthermore, coefficients are all signed according to expectations except once again population and rents, but they are not significant anyway. Finally, I consider AB estimates as benchmark models, column F1 and G2 in Table 4. Two reasons explain this choice. First, the standard errors of the coefficients are corrected to be robust. Second, importantly, AB is a consistent estimator in view of the specification, and LSDV estimates are used to check the robustness of the AB estimates.

[16] The inverse of the AFR, ARR and AIR enter the specification.

Population does not count in the short-term dynamics of house prices, while it has a significant and measurable effect in the long-term (Ott, 2006b) even if the link is more complicated than what was expected at first sight. In 1989, Mankiw & Weil (1989) forecasted that real house prices in the USA would drop of over 3 % per year for the next 15 years because of the elderly boom. In reality, real house prices in the USA increased on average over 3.5% in the same period. Housing is a superior good where wealth and income effects play an important role. The average square meters of dwelling tends to increase even though the size of household shrinks as long as they can afford it. Hereinafter the present study focuses on the dynamics of house price, the non-significance of population is no surprise despite the importance of demographic shifts in the long-term.

Two household arbitrage variables were included -as exogenous variables- to measure whether households rotate their portfolio by changes in stock prices and rents.[17] These two portfolio variables were used by McCarthy & Peach (2004) and IMF (2004), respectively. First, housing rents are not significant. The arbitrage theory between ownership and tenancy is flawed by Government intervention. Indeed, tax relief to promote homeownership and on the other hand social policy in favor of low housing rents explain this result (Ott, 2006a). Furthermore, the lagged of stock price is not significant either. However the stock price index growth shows contemporaneous correlation with house price growth; the correlation around 0.06 is twice as large as the one estimated in IMF (2004). The positive sign is in line with Borio & McGuire (2004). The positive sign was criticized by Tsatsaronis & Zhu (2004) who argued that this is a spurious relationship. Both, house price movements and stock prices are pro-cyclical, consequently a third factor, i.e. the business cycle renders the correlation between both apparent even if there might be no link between house prices and stock price movements. Newspaper journalists and especially *The Economist* (2005) challenged this view as they argue that after the burst of the "new economy" stock prices, traders invested in housing, fueling another bubble. If this statement held, the relationship would be negative and lagged. The positive contemporaneous correlation between stock prices and residential property prices are at odds with *The economist* view. The empirical result rather suggests that both house prices and stock prices might be correlated positively with the output (and so households' disposable income), as argued by Tsatsaronis & Zhu (2004). An alternative explanation is the link between households' wealth, stock prices and house price. Indeed, sharp growing stock prices have a positive wealth effect, and so promote real estate purchase. Borio & McGuire (2004) housing booms tend to lag equity booms with the lag length depending on interest rates.

House price is a highly persistent process and roughly half of today's house price is explained by last's year house price growth. The autocorrelation is in any specification and estimator always highly significant. This is consistent with the main theoretical literature and earlier empirical findings. The quantitative importance of the serial correlation of approximately 50% is in line with IMF (2004) while Lecat & Messonier (2005) find a lower persistence, around 35%. The economic interpretation means that there is a strong tendency for real house prices to rise tomorrow if they rise today. House price inertia stems from the strong supply inelasticity and households's expectations based on past prices, as already mentioned.

The models point towards strong relationships between residential property price and households' disposable income. The growth rate of house prices is positively affected by

[17] Housing rents revenues are included in households' disposable income.

real disposable income growth per capita –as this increases households' purchasing power and borrowing capacity. The contemporaneous relationship between house price growth and real disposable growth ranges from 0.41 to almost 0.50 depending on the specification between the two benchmarks. These quantitative results are in line with the studies already mentioned. According to the coefficient estimates, a 1% real income growth will roughly result in a 1 % increase in the real house price over two periods by taking into account the autoregressive effect of the real house price. Indeed, the cumulative impact in the first benchmark model is calculated as follow: 0.41+0.34+0.5*0.41≈0.96.[18]

In estimating the demand equation, the first difference of nominal interest rates, short and long, were never significant for any specification. This corroborates the empirical findings in Ott (2006b): interest rates did not count in short-term house price dynamics. Hereinafter, short-term real interest rate in level which is I(0) is included in the specification, and it turned out to be significant at conventional levels. In estimating the reduced model, the lagged first difference of the short nominal interest rate belonging to the supply is not significant. Nevertheless, the sign is positive. On the other hand, the short-term real interest rate in level which stems from the demand is again significant and is right signed; this coefficient in absolute values is larger than in the demand specification. This is a logical result, as interest rates belonging to the supply react in opposite to the demand related interest rate. Comparing the estimates of the demand model with the reduced model, the overall effect of interest rates on house prices are very similar. The negative impact of interest rates on real residential property prices largely dominates the positive supply effect. The predictions of the model concerning an interest rate shock will be investigated in the next section.

As already explained, in my estimation strategy I first allowed two lags. Thereafter, I dropped the insignificant lags. Stock of dwelling at time t and lag 1 together are significant and that in both specification, demand as well as reduced form. This does not exactly fit into the theoretical equation, where only the stock of dwelling at time t enters in equation (7), respectively lag 1 in equation (9). Consequently, I estimated the reduced form without stock of dwelling at time t to be in line with the theory (see Table 3). In the demand model (Table 4) the contemporaneous negative coefficient pertains to the demand, whereas the positive coefficient belongs to the supply. Indeed, as in every demand-supply framework, the relationship between price and quantity is negative with respect to the demand while positive with respect to the supply. Furthermore, supply reacts with delay relative to demand changes, as already argued. The order of the estimated coefficient: at time t negative and t-1 positive corroborate this salient feature of house market functioning. A house price increase triggers residential investments. The stock of dwelling can only increase one period following the investment. Finally, the absolute value of the demand coefficient outweighs systematically the supply coefficient. This proves a structural excess of demand.

Mortgage loan growth development is positively correlated with real residential prop-

[18] I rewrite equation (9) : $\Delta p_t = \alpha \Delta p_{t-1} + \lambda_1 \Delta y_t + \lambda_2 \Delta y_{t-1} + ...$By iteration, it yields: $\Delta p_t = \alpha^n \Delta p_{t-1} + \lambda_1 \Delta y_t + (\alpha\lambda_1 + \lambda_2)(\Delta y_{t-1} + \alpha \Delta y_{t-2} + \alpha^2 \Delta y_{t-3} + ... + \alpha^{n-1} \Delta y_{t-n-2}) + ...$ Suppose: $\Delta y_t = \Delta y_{t-1} .... = \Delta y_{t-n-2}$. Thus, house price growth becomes: $\Delta p_t = \alpha^n \Delta p_{t-1} + \left(\lambda_1 + (\alpha\lambda_1 + \lambda_2)\left(\frac{1-\alpha^n}{1-\alpha}\right)\right) \Delta y_t + ...$, and the derivative with respect to income yields: $\frac{\partial \Delta p_t}{\partial \Delta y_t} = \left(\lambda_1 + (\alpha\lambda_1 + \lambda_2)\left(\frac{1-\alpha^n}{1-\alpha}\right)\right)$. Over two periods (lag n=1), the derivative is: $\frac{\partial \Delta p_t}{\partial \Delta y_t} = \lambda_1 + (\alpha\lambda_1 + \lambda_2)$.

erty price growth. This relationship is strongly significant, as expected. The causality is not established, as mortgage loan is endogenous. Surprisingly, the coefficient found is more than twice as large as in IMF (2004). This difference might be explained by the fact that a variable is missing concerning important frictions on the credit market. Indeed, IMF (2004) includes a bank crisis variable which aims at capturing periods of credit crunch where the supply of credit shifted back (Gertler & Lown, 1991); in the same stance, Lecat & Mesonnier (2005) include a financial liberalization variable which accounts for the end of credit rationing.

Finally, the ECT coefficients are negative for each specification, indicating that in the long-run house prices move in line with their fundamentals. In other words, the growth rates of real house prices show fundamental mean reversion, if house prices are out of line with the fundamentals, there is gradual tendency for this misalignment to be corrected. The crude affordability assumes that income is the only fundamental value, whereas the two proxies take also into account interest rate. However, these coefficients differ markedly across the three different specifications. Indeed, the speed of adjustment is 7 years for the crude affordability ratio (F1), 9 years for the interest rate adjusted affordability ratio (G1), and even 16 years for the affordability indicator (H3). Also IMF (2004) and Lecat & Mesonnier (2005) estimate a speed of adjustment of roughly 7 years. Although 9 years may seem a long period of time, it is still realistic. However, the 16 year adjustment span casts serious doubts on the validity of the affordability proxy indicator. For these reasons, specification (H3) in Table 4 is not included in the benchmark model.

5.2.2 House supply and mortgage market

Housing supply typically depends on investment, which in turn are constrained by urbanization schemes and land availability. In addition, the law of motion of the stock of dwelling, where future stock depends on previous year stock generates an inertia on its own. Supply of new housing can only respond sluggishly to demand shocks. On the other hand, demand might move faster as it depends on factors characterized to be more volatile, like income and interest rates. As a result house price may overshoot or undershoot its long-term trend for a given period. Thus, the house price cycle is also a consequence of supply inertia not only backward demand expectations as depicted in Annex 10.

The most suited econometric tool to disentangle together not only long-term from short-term but also supply from demand is the VECM. Indeed, the dynamics of the process is picked up by the first differenced equation while the long-term adjustment is captured by the ECT. Moreover, supposing that the identification of two cointegrating vectors (cointegration rank of two) is established: one stands for the supply and the other for the demand. Together, this modelling strategy fulfills all requirements in view of the functioning of the house market. Kenny (1999), McCarthy & Peach (2002, 2004) and Bessone & Heitz & Boissinot (2005)[19] succeeded in estimating demand and supply beside long- and short-term dynamics in a time series VECM setting. Kenny (2003) sheds light on the sluggish adjustment of the supply by estimating asymmetric non-linear equilibrium ECM, once again in a time series framework. To the best of my knowledge, I have no literature to cite as regards the estimation of a supply equation in panel econometrics.

[19] Bessone et al. (2005) are obliged to impose a cointegration rank of two.

In the long-term, house price supply tracks land costs due to the scarcity of land, as already explained. Unfortunately, land costs data are not available. As a rule, construction cost index is used. It is a weighting of wage costs in the sector and house building material. Construction cost index is not available either. I used instead the sectorial nominal unit wage cost divided by productivity in the building and construction sector. Thus, this indicator only partially captures construction costs since it does not include either land costs or construction material costs. Consequently, long-term house price supply cannot be estimated due to the scarcity of data. The only alternative is to estimate equation (8) in its raw form by means of a dynamic panel estimator. I include an ECT proxy, the ratio of residential house price over construction costs might be a poor proxy, but actually it is the only one available.

Table 5 reports the preferred estimates according to all four estimators already discussed. Difficulties arise to identify the supply. A myriad of different specifications have been tested, and construction costs proxy, interest rate and the error correction term were never significant at any common level. For all three IV estimators, the instrumented variables are lag 1 of both, stock of dwelling and residential property price. The instrument matrix differs however, except the exogenous variables of the specification: interest rate and construction costs which are common to all IV estimators. As regards the FE-IV estimation, I added all exogenous variables of the SEM to the set of instruments, i.e., disposable income, population, rents, stock index. The estimates worsened when I used the same instrument matrix in AH estimation procedure. Consequently, I followed the recommendation of Arellano & Bond (1991) and added, as instruments, lag two periods in level, the stock of dwelling and house prices. Finally, in AB estimation one step procedure as well, levels of the endogenous variables lagged two are used to serve as instruments (Arellano & Bond, 1991).

Interestingly, the IV-FE estimator performs barely better than the LSDV, AH and AB estimators, while it was the opposite in estimating the reduced model and the demand. To find instrument variables orthogonal to price vector is much less challenging since the demand equation includes many exogenous variables. In the opposite, construction cost is the only exogenous variable which does not enter the demand equation. Thus, the quality of the instrument matrix might explain the better results of IV-FE estimator in estimating the supply relative to the demand. Furthermore, the need of identification the supply is very strong since it relies only on construction costs. An FE-2SLS procedure and the corresponding instrument matrix may be better suited for this task. Besides, AB estimates provide better results than AH estimates while they have the same set of instruments. It confirms Arellano & Bond's argumentation (1991) in favour of AB estimator. GMM estimators are more efficient as they rely on more moment conditions.

The short-run supply points towards a strong persistence of housing stock, which is in line with the theory of inelastic supply. For every estimate, the coefficient is systematically higher than 80% (except AH). Aggregated house depreciation does not exceed 3% per year. The coefficient estimated by AH exactly matches the theoretical model, unfortunately, the coefficient is not significant. The other coefficient estimates are lower but significant. The silver lining is that coefficients are significantly different from one, averting unit root process. In addition, the collateral value (lagged real house price) is also significant at conventional levels except in AH estimates. However, the coefficient is very low. According to the estimates, investors' sensitivity to house price movements is quite nil. Indeed, a

1% real house price increase, ceteris paribus, fosters a gross investment of 0.01% at most (including depreciation). Finally, construction cost proxy, interest rates and the ECT are not significant at any common level and the coefficients are very low.

Table 5: Coefficients estimates supply house market (7)				
Dependent variable: Δdw_t Stock of dwelling growth				
Var	LSDV	FE-IV	AH	AB
Δp_{t-1}	0.01 (2.39)	0.01 (3.53)	0.005 (0.49)	0.004 (2.64)
Δdw_{t-1}	0.85 (22.07)	0.92 (12.48)	0.97 (1.01)	0.82 (14.31)
Δi_{t-1}	-.001 (−0.21)	-.001 (−0.33)	-.001 (−0.39)	-.001 (−0.10)
Δcc_{t-1}	0.00 (0.20)	-0.01 (−1.53)	-0.00 (−0.36)	-0.00 (−1.17)
$ECT_{s,t-1}$	-.001 (−1.04)	-.000 (−0.53)	-.000 (−0.11)	-.007 (−1.42)
cst	0.00 (2.63)	0.00 (0.61)	0.00 (−0.21)	0.00 (−1.39)

The reduced mortgage loan equation (12) was estimated to shed more light on the interaction between house market and mortgage loan. I applied the same estimation strategy as previously. I estimated the generalized equation with a maximum number of two lags, lagged variables with insignificant coefficients were left out of the final estimation. To choose the preferred models, I tried manifold alternative specifications and selected the model that best fitted the data and the theory. Again, to check the robustness of the results, the coefficient estimates of the four estimators are reported in Table 6. Growth rate of stock of dwelling was never significant in any case and even deteriorated the results. Consequently, I eschewed it. The endogenous variables are instrumented, i.e. the lagged one and two of the dependent variable (mortgage loan growth), and the house price. As regards both 2SLS estimations (FE-IV and AH), all exogenous variables are included in the set of instruments. Growth rate of, population, rents, and stock of dwelling, respectively growth rate of income lagged one, residential property price lagged two and mortgage loan in level lagged three have been added in the instrument matrix of the FE-IV, respectively AH, estimation. Finally, in AB estimation one step procedure as well as levels of the endogenous variables lagged two are used to serve as instruments in line with Arellano & Bond (1991) recommendations.

Table 6 reports the preferred specification with regard to the four estimators. The estimation technique based on the one step AB procedure gives similar coefficient estimates to those obtained by the LSDV. AB estimates are the benchmark since AB is a non biased estimator and is more efficient than the AH estimator. AB coefficients are very narrow with respect to LSDV coefficients, this proves the robustness of the results. Mortgage loans exhibit strong serial correlation, since mortgage loan development depends on previous mortgage lending two periods back. Over two periods, the cumulative persistence ranges from 50% (benchmark) to 60% (2SLS). Housing rents is hardly ever significant, the results do not corroborate the arbitrage theory. According to the estimates, households do not essentially rotate their portfolio in favor of real estate by asking for a mortgage credit when housing rents increase. In contrast, the interest rate, the disposable income and the residential property price are core factors explaining mortgage loan development. A nominal interest rate increase (short) of 1% point leads to a mortgage loan decline of 0.3%. Similarly, a 1% increase in the disposable income, or in the residential property price respectively cause an increase in the real mortgage loan of 0.4% and 0.2%. All these coefficients are significant at any common level. The strong significance of the house price coefficient in the mortgage market but also mortgage loan in the house market model proves that the mortgage market and the house market interact.

Table 6: Coefficients estimates reduced mortgage market				
Dependent variable: Δlm_t Real mortgage loan growth				
Var	LSDV	FE-IV	AH	AB
Δlm_{t-1}	0.74 (11.52)	0.58 (1.76)	0.74 (4.57)	0.73 (6.31)
Δlm_{t-2}	-0.15 (−2.37)	0.12 (0.36)	-0.24 (−3.30)	-0.16 (−3.10)
Δi_t	-0.28 (−1.71)	-0.35 (−1.52)	-0.14 (−0.20)	-0.24. (−2.08)
rt_{t-1}	0.06 (0.62)	0.05 (1.16)	-0.01 (−0.08)	0.06 (0.49)
Δy_t	0.38 (2.96)	0.21 (0.77)	0.59 (4.60)	0.41 (2.74)
Δp_t	0.23 (5.25)	0.34 (1.57)	0.15 (1.07)	0.21 (3.24)
cst	0.02 (3.73)	0.04 (2.46)	0.00 (0.20)	0.00 (0.76)

The adjusted R square of LSDV estimates respectively prove that the reduced house market model and the mortgage market model explain approximately 65% and 75% of the total variance. The overall goodness of fit is quite satisfactory. Annex 16 and 17 depict the residuals by section (country) of the two reduced house market models (F1 and G2) and Annex 18 shows the reduced AB mortgage market model.

6 Euro area house prices and mortgage loan dynamics

6.1 Determinants of euro area house price

This section derives conclusion on a euro area level. Deriving country specific conclusions based on panel estimates raises the problem of homogeneity assumptions. Instead, in line with the purpose of the paper, I suggest to infer insights on a euro area level. National series were aggregated to euro area series and Appendix 2 gives a detailed explanation of the aggregation methodology. The euro area series are depicted in Annex 15. Given the set of coefficient estimates of the two house market benchmark reduced models and the reduced mortgage market model, I use respectively euro area series to generate euro area fitted values, residential property price and real mortgage loan. Figure group 1 and 2 depict the growth of actual euro area house price and fitted of both benchmark specifications (in-sample forecast). The second specification which includes interest rate adjusted affordability ratio, does not capture well the development of the house price bubble at the end of the 80's. Apart from that, the two models perform fairly well in explaining euro area house price movements except at the end of the sample from 2002 to 2005. Interestingly, in Ott, (2006b) exactly the same problem arose when explaining the last four years from 2002 to 2005. Indeed, the first model with omitted mortgage loan and excess demand predicted a fitted house price 4% below the actual price 2005 and the second fully specified model predicted 1.6% below (see Ott, 2006b). Hereinafter, the former model (which includes crude affordability ratio) undervalues house prices at 2% below the actual (Figure group 1), while the latter does so at 1% below (Figure group 2). However, the former outperforms the latter over the entire sample especially from 1975 to 1997. Despite the relative lackluster in forecasting euro area house prices at the end of the sample, the crude affordability ratio model explains fairly well the history of euro area house prices.

Both models indicate that *disposable income* and *persistence* (autoregressive term) mostly explain the house price cycle. This corroborates earlier empirical findings and the theoretical discussion. Each house price boom phase was triggered by a strong disposable income increase which in turn is linked with the business cycle. Thereafter, with an accelerating house price growth, persistence builds up and extends the house price dynamic beyond the business cycle. The two other underlying factors which drive the real house price cycle are *interest rates* and *mortgage loan* developments. Since real interest is specified in level the impact on house prices is constantly negative over time. To assess more precisely the role of interest rate over time, I added to the interest rate effect the constant of the specification. Thus, Figure group 1 and 2 display a better understanding of the current positive impact of interest rate on house prices. They also show the beneficial effect of the launch of the euro and the ECB policy on house prices on two aspects. First, there is clearly a regime shift in 1997 from negative to positive effect corresponding to EMU convergence. In the wake of the EMU process, the eventual ECB reputation allowed for a structural real interest fall. Second, the slow down of the business cycle (and so disposable income) since 2001 is offset by favorable financial conditions. This optimal "leaning against the wind" policy with respect to economic activity has no pedigree in the euro area according to our data.

Furthermore, real mortgage loan development gained pace from the mid-90's to 2000, and so accompanied the dramatic house price increase. As mortgage loan is endogenous, there is no causality but rather a correlation in our estimates. Mortgage loans and house price growths are fueling each other. In the wake of the recession and the 2001 terrorist attack, mortgage loans depressed but since 2002 they have gained pace again, partially explaining the new house price rise thereafter. Although mortgage loan development is not directly managed by the central bank, it is however a counterpart of M3, and to some extent it can be considered as a monetary policy stance indicator. The ECB might try to keep the lid on mortgage loan development to deter households from taking excessive risk on real estate purchase. With only one instrument policy, it is challenging, on the one hand to foster economic activity with favorable interest rates and, on the other hand to maintain a subdued mortgage market. Moreover, mortgage loan growth rates are constantly positive over the entire sample. Nevertheless, Figure group 1 and 2 depict a relatively strong increase from 1996 tp 2000 and moderate since 2002. Finally, with both models, construction costs proxy and population impact on house price are benign.

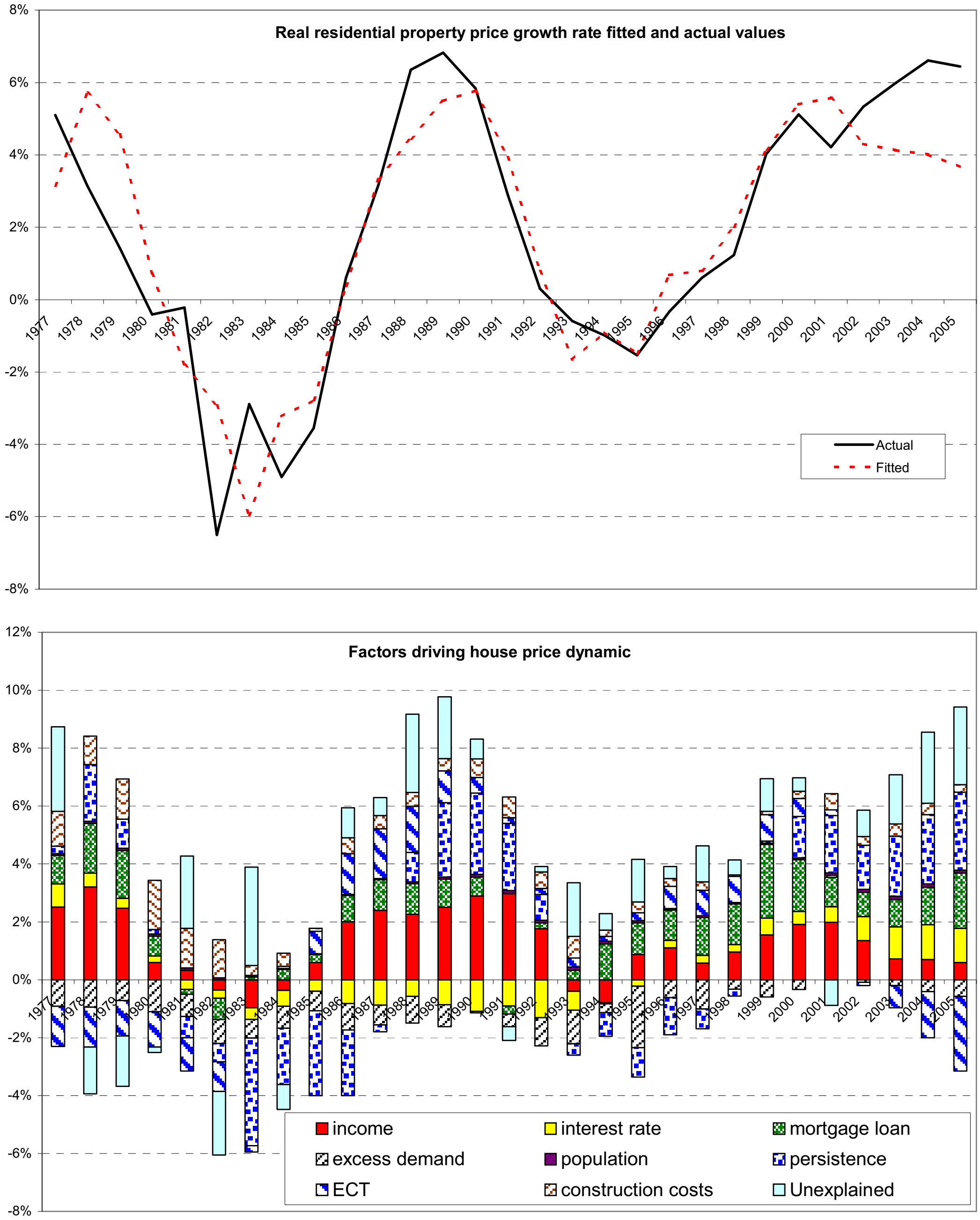


Figure group 1:

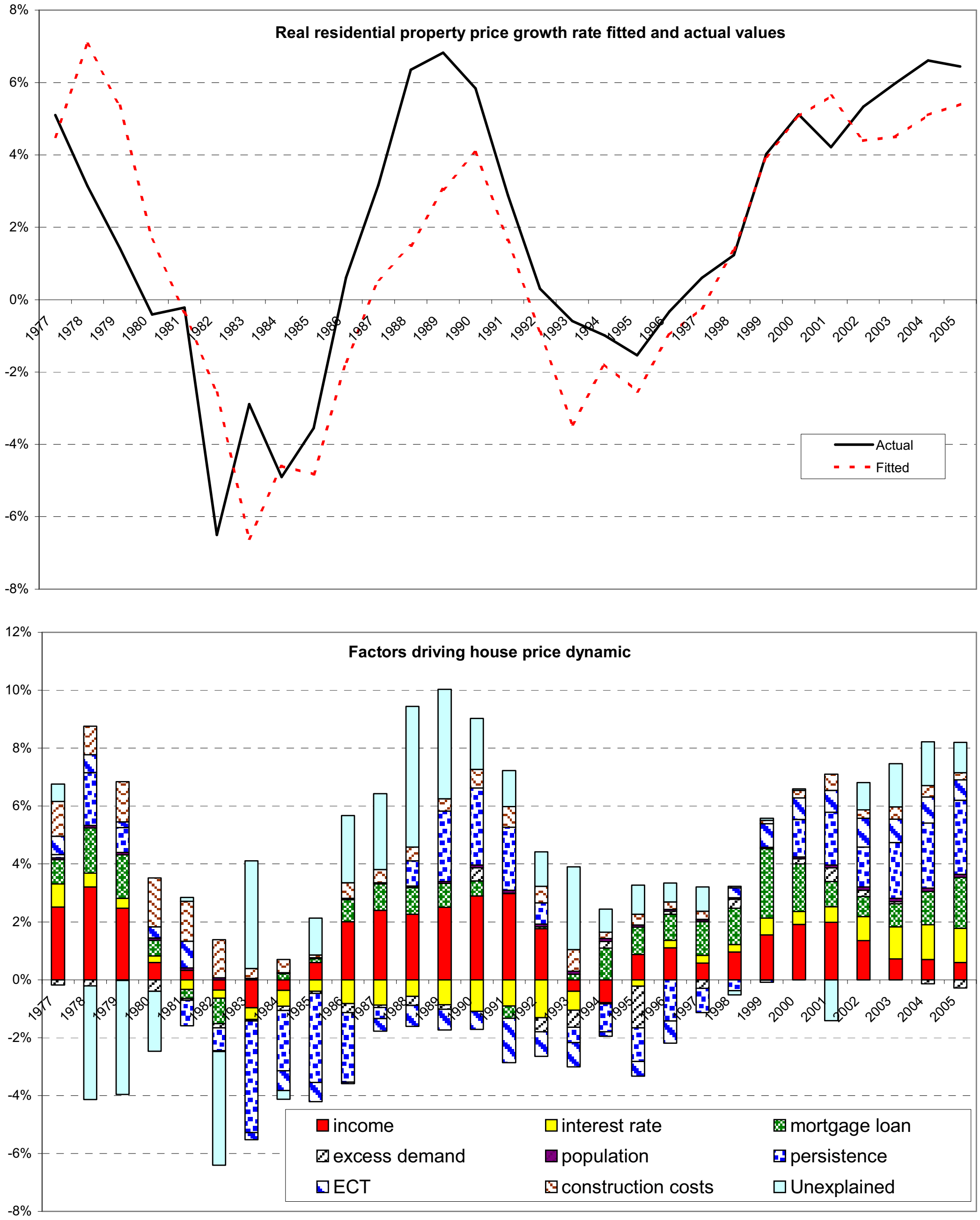


Figure group 2:

Nevertheless, the two model predictions differ in long-term adjustment estimates, which was expected since the ECT proxies are different. The second model ECT is interest rate sensitive while the first is not. This explains why the second model performs better at the end of the sample and worst during the previous house price cycle. The second model undervalues house prices during the last house price cycle (mid-80's to the mid-90's), which corresponds also to an interest rate cycle. The Bundesbank raised its discount rate in 1988, and kept tightening it until 1992 due to the German monetary reunification, thereafter it decreased smoothly until the mid 90's. The other member countries of the

ERM[20] and since the EMU members had to follow, which means that euro area interest rates increased dramatically. Beyond the cyclical component, the overall interest rate level was excessively high due to the German reunification. Amid rising real estate prices, sharp rises and high levels of interest rate increased the inverse of the adjusted affordability ratio while the crude affordability ratio not. Consequently, the latter model predicted a lower euro area house price growth than the former. On the other hand, thanks to the EMU, euro area interest rates decreased at the end of the sample. For the same reason the second specification captures better (albeit not completely) euro area house price movements at the end of the period under consideration. Finally, *excess demand* (stock of dwelling) story between benchmark one and two is alike, and the difference lies in the coefficients.

6.2 Determinants of euro area mortgage loan

Mortgage loan growth depends predominantly on previous developments in mortgage lending itself. Last year mortgage loans explain two thirds of current mortgage loans. The predicted value accurately follows one year behind current mortgage loan movements. This characteristic is due to the strong two period back autoregressive terms. Indeed, Figure group 3 states that past mortgage loan realizations mostly explain current mortgage loan over more than 50% (cumulative impact over two periods). The real house price (collateral) is the center stage variable driving mortgage loan. This proves the strong economic (after the statistical significance established in section 5.2.2) interaction between the mortgage market and the house market. The second most important variable explaining mortgage loan development is disposable income. Interestingly, interest rates do only account for a very tiny effect on mortgage loan development. Finally, the effect of housing rents as explanatory factor is benign, quite nil, and actually statistically not even significant.

Large year to year swings in mortgage lending growth rates lead to large residuals. The spurt in credit from 1982 to 1983 or from 1998 to 1999, or in the opposite the dramatic fall from 1990 to 1991 cannot be explained by the core variables like house collateral value, income or interest rate. At least one volatile variable is missing in the specification. Also the strong persistency might be due to a missing variable. Indeed, the model specification does not capture the credit channel directly. The unexplained large swings in mortgage loan can be explained by the financial accelerator which amplifies the credit cycle (Bernanke & Gertler, 1995). During booming house price periods, growing households' wealth capture more mortgage volume banks as banks relax their standards. House prices and mortgage loans fuel each other through the collateral effect leading to a self-perpetuating effect. Changes in expectations or falling business cycle can trigger a reverse in the vicious circle. Banks adopt suddenly a more conservative lending policy, ceteris paribus. Finally, structural factors like liberalization, deregulation and innovation might also play an important role, not only in level, but also in growth short-term dynamic. They are not included in the specification either.

As regards the mortgage market the last 4 years, the upsurge in mortgage credit is not well explained by the model. Interest rates in 2002 and 2003 had a tiny positive impact on mortgage loans. At the end of 2005 interest rates were rising but this new rising trend is not covered in the sample. House price collateral explains only partially the acceleration

[20] European Exchange Rate Mechanism, introduced by the European Community in March 1979, as part of the European Monetary System (EMS).

in mortgage loan growth at the end of the sample. The supply of credit might explain the strong growth rate. Banks might have eased their credit standards for the approval of mortgage loan. According to ECB (2006), bank credit standards depend on economic activity, house market prospects, expectations regarding the general economic activity, competition from other banks, and balance sheet constraints.

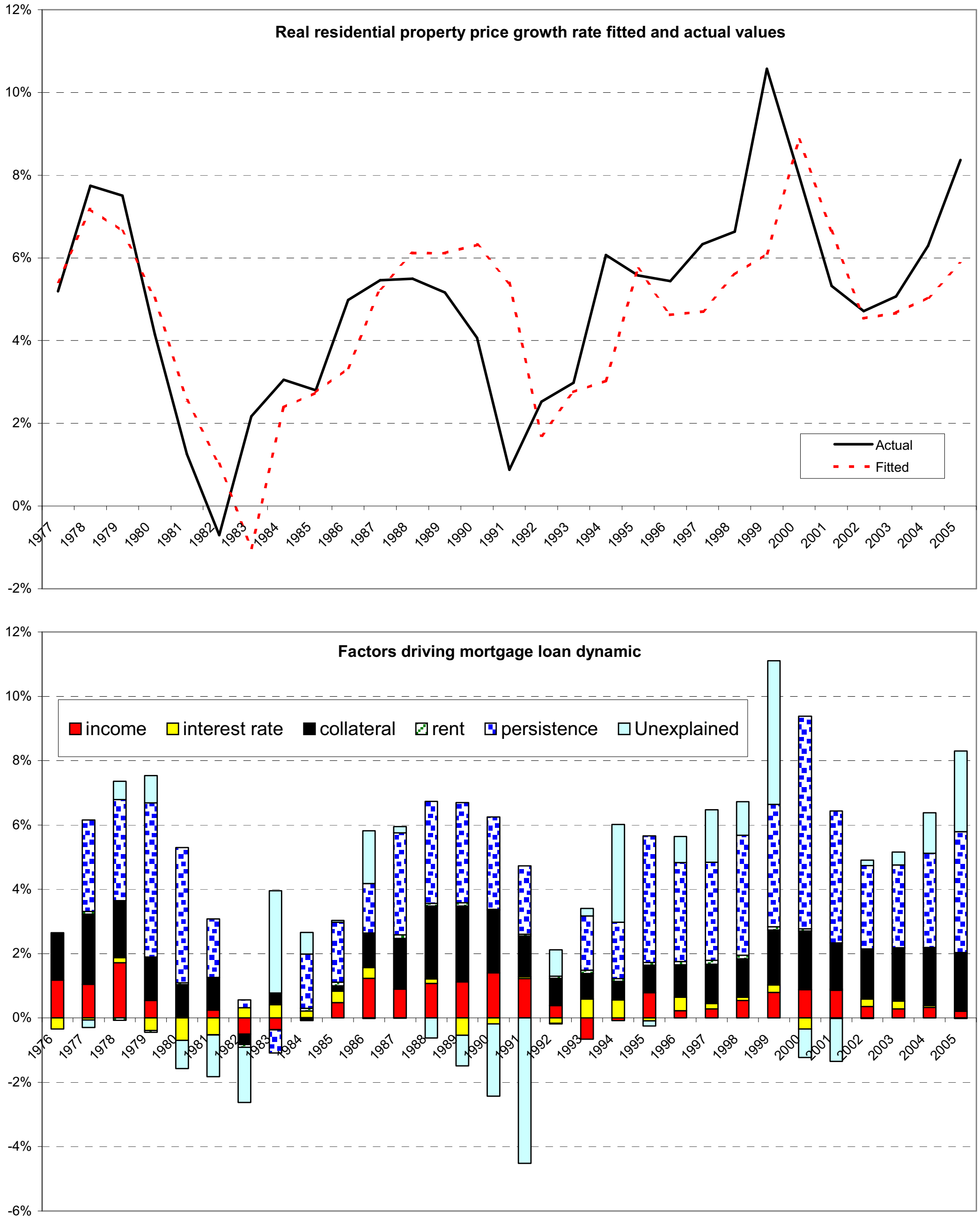


Figure group 3:

6.3 Monetary policy shock

In this sub section, simulation of real interest rate shocks are designed to assess the knock-on effect on house price, mortgage borrowing and stock of dwelling. I apply the well-known Cholesky's decomposition to orthogonalize the shock. I use the two reduced models, i.e.

Table 3 (F1) and Table 6 (last column). Thus, I have only two endogenous variables: *house price* and *mortgage loan*. At time 1, the monetary authority raises its short-term interest rate of 1% and inflation expectations remain unaltered.[21] I suppose house price decline affects negatively the following period mortgage loan volume instead of simultaneously rate. Two shocks are simulated. The first supposes an increase of 100 basis point in short-term lasting for ever (permanent), while the second only lasts for 5 years (temporary). Since real interest rate enters in level in reduced model (F1), and has the property of being stationary, a permanent increase might be challenged. Consequently, both are proposed. Figure group 4 (respectively Figure group 5) shows the consequence of a permanent[22] 1% interest rate increase (respectively temporary).

Monetary policy tightening directly impinges on house prices through two effects. First, commercial banks or mortgage institutions pass-through the interest shock instantaneously. Thus, households' affordability decreases with the rise of mortgage interest payments (income effect). Also households' debt burden increases with the rise of mortgage interest payments. Households with adjustable mortgage interests are even hit by outstanding loans (wealth effect). Thus, households' housing demand falls, and consequently house prices decline. As a result, the demand of mortgage credit shifts leftward (ceteris paribus). This describes in outline the traditional view of mortgage loan demand and monetary policy transmission without friction. In contrast, the credit channel view (Bernanke & Gertler, 1995) assume asymmetric information between credit institutions and households. First, on the one hand, the collateral declines, on the other hand, the debt burden increases. Consequently, households' net worth, which equals house value minus outstanding debts, declines on both sides (wealth effect as previously). Together, the decline of households' affordability and the fall of households' net worth bring to the fore the problem of asymmetric information. Credit institutions focus then on expected repayment capacities and harshen their lending standards. On a macro-view, banks adopt a more conservative lending policy and eventually reduce the supply of mortgage loan. This is called the balance-sheet channel.[23] Leftward shift of credit supply and of demand squeeze loan volume in the mortgage market. Liquidity constrained households depress even more housing demand, which in turn decreases house price further. An even lower collateral shrinks households' net worth further which prompts credit institutions to squeeze the mortgage supply even more. This self-perpetuating effect is called the financial accelerator. The financial accelerator of the credit channel only amplifies the effect of the traditional demand transmission mechanism.

On the empirical side, as regards the estimates of this paper, the mortgage loan and the supply were not identified separately due to a lack of data. The reduced mortgage market estimates do not allow to disentangle toxic supply side effects relative to demand movements. However, a mortgage loan squeeze is shown in Figure group 4, first graph based on Table 6 estimates. Indeed, monetary policy has an impact on house prices through the mortgage market. Following the negative interest rate shock, credit institutions pass-through mortgage rate (equation 11). The cost of financing a house changes (income

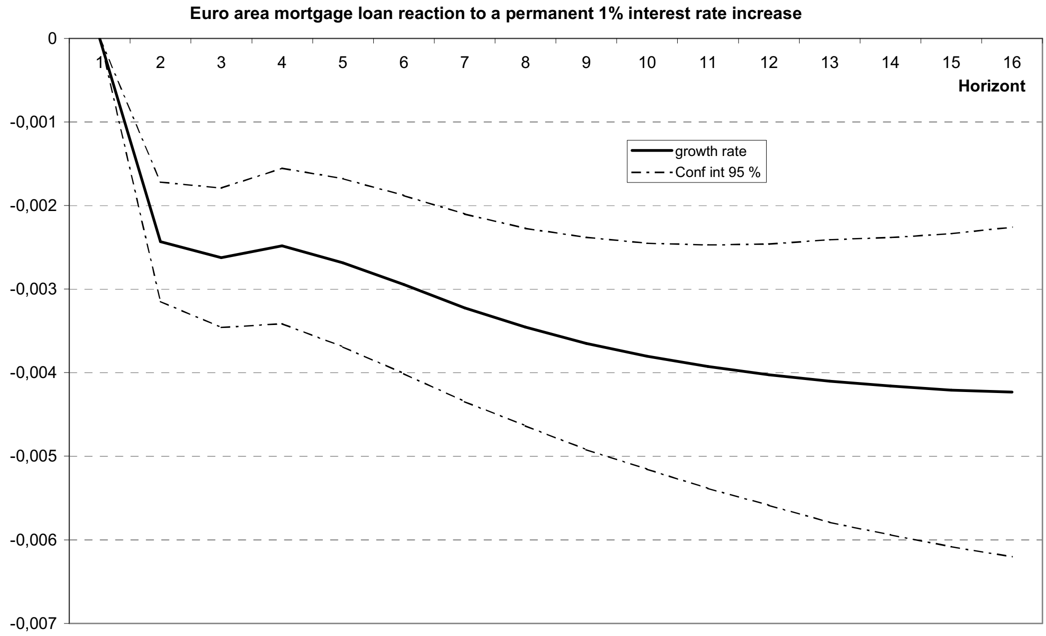
[21] Consumer price expectations might change following a monetary policy move. The purpose here is to appraise the knock-on effect of interest rate move and to derive some quantitative informations.

[22] A permanent interest rate increase means that it increases 1% in level once and for all, i.e. at time t=1 the first difference equals one, thereafter 0 for the rest of the period under consideration.

[23] Credit institution balance sheet variation can also affect credit supply, which is called the bank lending channel.

effect) and the debt burden increases (equation 3). Consequently mortgage loan demand (equation 10) and the accompanying housing demand (equation 3) declines sharply at time t=2. I can suppose that the fall in residential property price, i.e. lower collateral triggers uncertainty bringing to the fore the problem of asymmetric information. Banks will focus more severely on their lending standards and eventually squeeze their credit supply (equation 11), depressing even more the subdued house market. However, the basic theoretical model of this paper does not deal with asymmetric information problems and the estimates of SEM do not allow this conclusion so exactly. Instead, a "collateral effect" at t=3 reinforces the preceding year effect on house prices movement slightly. Thus, from t=3 until the end of the simulation the "collateral effect" on mortgage and house price keeps working. Furthermore, at time t=3, also, supply (equation 5) starts reacting and so offsets partially the second round "collateral effect". Indeed, falling house prices and higher interest rates have a deterrent effect on investment. Consequently, the quantity of dwelling supplied shifts left next period. However, first difference interest rate enter as supply side element in the reduced house market model (and so has only a temporary shock), besides the coefficient is very low and is not even significant.

According to the estimates, the supply does not account for much. Instead, the interest rate which enters in level in the house market has a long lasting effect on house price growth. The interest rate shock in the house market impinges on the mortgage market, causing a long lasting squeeze in mortgage volume through the "collateral effect". Thus, households strong dependency on mortgage loans in order to purchase real estate is well established. As can be seen in Figure group 4, the negative interest rate shock would be temporary and mortgage loan would be bottoming out after one or two years (t=3) and eventually converge back to the zero line over time, if the mortgage market was isolated. Indeed, all variables are in first difference, including interest rates in the mortgage loan specification. The negative impact of the permanent interest rate shock does not die out in the mortgage market because house price growth rates fall in the house market (Table 5, AB coefficient estimates).



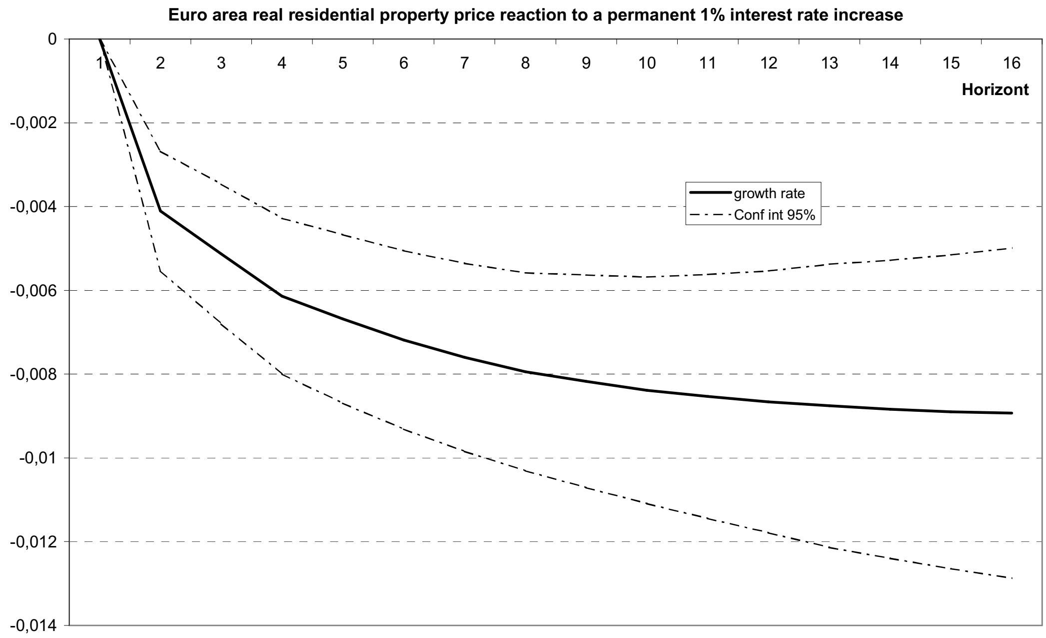


Figure group 4:

Suppose now that the monetary authority raises the short-term interest rate of 1% and after 5 years decrease it of 1%. Euro area real residential house price drops quickly following the tightening of monetary policy, bottoming out exactly 5 years after the monetary policy shock, as a sheer matter of shock pattern implementation. The dynamics are the same as previously and can be assimilated to a negative interest rate shock followed five years later by a positive shock. This temporary interest rate shock was implemented, because the real interest rate is I(0) according to the unit root test. Supposing that the real interest rate remains at 1% above its steady state value once and for all is not realistic, since the real interest rate is stationary.

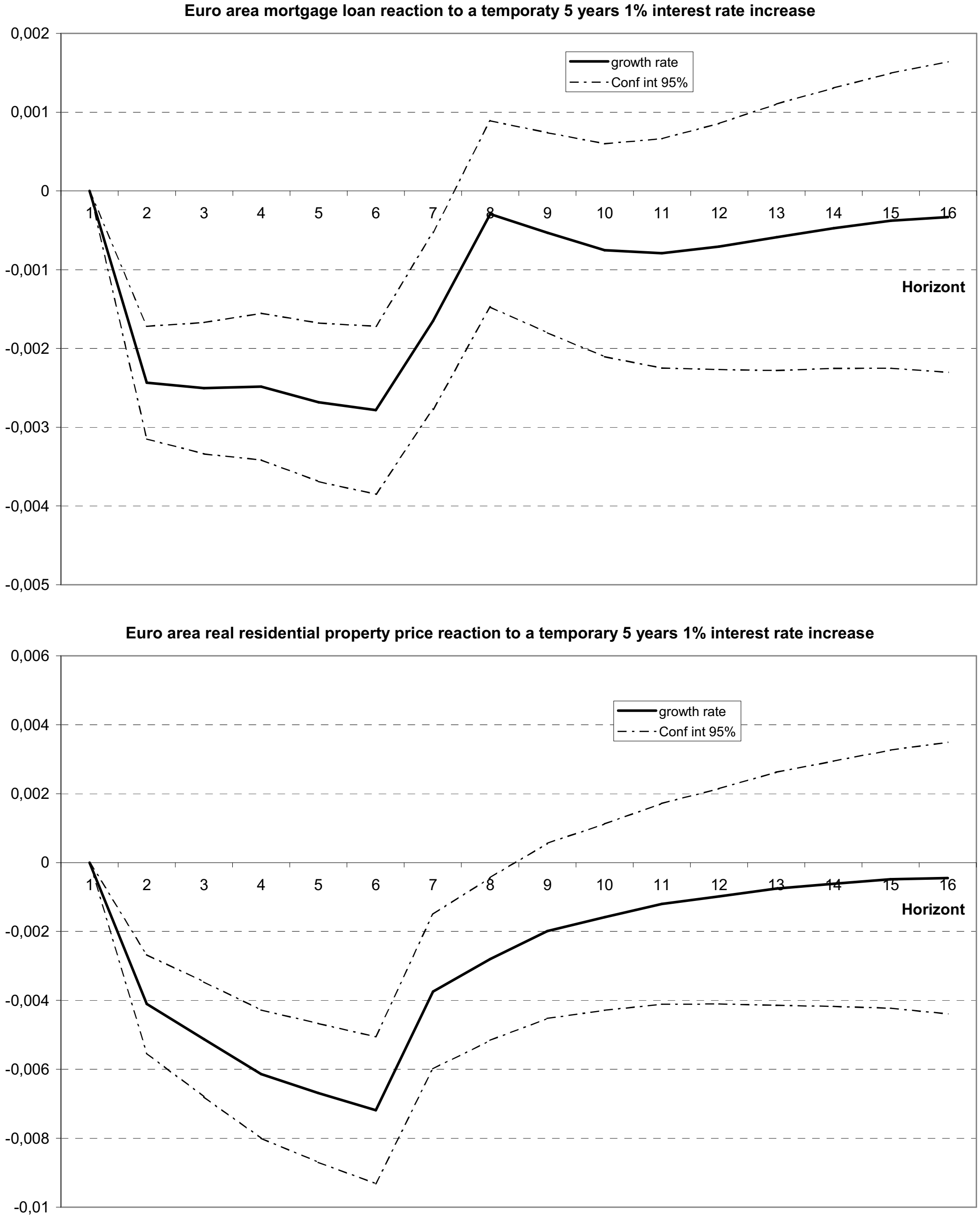


Figure group 5:

7 Conclusion

This empirical survey investigates house price and mortgage loan determinants. To shed more light on the interaction between the mortgage credit market and the house market, a basic theoretical model was set up. The theoretical model underpins the set of variables and their characteristics (endogenous/exogenous) included in the specification. The choice of the estimators is based on four aspects. First, the theoretical part but also earlier empirical finding indicate that house price might be an autoregressive process. As a rule, this paper focuses on short-term dynamics rather than long-term relationships. Second, the time span is short and does not allow robust estimates on a sectional level. Third, the purpose of the paper is clearly to derive conclusions on a euro area and not on a country level. Fourth, coefficients must be estimated in a SEM as mortgage and house market interact. Not many estimators fulfill all requirements. However, potential good estimators in order of importance are: Arellano & Bond (1991) GMM one step procedure, the within fixed effect estimator LSDV, the Anderson & Hsiao (1981) 2SLS estimator and finally the within fixed effect 2SLS estimator. All four estimators are used to assess the empirical relationship of house prices with the mortgage and house market determinants. First, it allows to check the robustness of the estimated coefficients with regard to the estimation technique. Second, as regards the estimators, there is a trade-off between consistency and efficiency. In the framework of the study, to obtain consistent estimates, any estimation technique requires instrument variables methods like GMM or 2SLS. Consequently, only the Arellano & Bond (1991) and Anderson & Hsiao (1981) are consistent. Indeed, both FE estimators are biased due to the autoregressive term. However, the asymptotic properties in view of the panel dimension proved that consistent panel estimators are inefficient. Indeed, when the time dimension is larger than the cross-sections GMM estimators or first differenced estimators may be inefficient.

Arellano & Bond (1991) and LSDV proved to be the best estimators in view of the results. The SEM estimates provide overall good results as regards the sign, the significance of coefficients and the explanatory power of the regressions. The residuals do not exhibit abnormal patterns. The coefficient estimates of both reduced models, mortgage and house markets, as well as house demand, are quite sensible with a strong economic meaning. The empirical results confirm earlier empirical finding. First, house price is a strong persistence process due to the staggered supply but also to households' expectations. Second, disposable income is the most important fundamental value in house price determination. Disappointingly, interest rate changes have no direct impact on house price, unlike real interest rate in level. Thus, a shift in households' borrowing capacity in the medium term has been detected since the launch of the euro, and has a measurable impact on house price dynamics. Moreover, the demographic variables (total population, population aged from 15-64) do not account in the short-term house price dynamic according to the estimates. In the long-term, however, migration and population growth rate might have a substantial effect on the house price level. In addition, housing rents are not found to be significant, proving that the arbitrage between ownership and tenancy is more elaborated than in a simple portfolio framework. Government regulations to keep the lid on housing rents evolution and tax relief for homeownership might explain this result. Finally, stock of dwelling and so excess demand and its interaction with supply side elements play a role in house price determination. The robustness of the coefficient estimates of stock of dwelling across estimators and specification are lower relative to the other coefficients.

The supply side elements in the reduced house market model (construction costs, interest rate) are not significant. In addition, the estimation of a supply equation on its own is rather poor. The lackluster performance in estimating a supply equation is due to missing data like construction cost index and land costs.

Real house prices show mean reversion to both affordability ratios, crude and interest rate adjusted. The estimated adjustment speed of 7 years for the former is realistic, while 9 for the later is relatively low (interest rate adjusted affordability ratio). The first model with the crude affordability ratio tracks actual house price fairly well except from 2002 to 2005. In this paper, I suggest that the crude affordability ratio does not capture the falling interest rates due to the euro effect. The second benchmark model which captures better the long-term shift in euro area interest rate explains partially actual real house price the last 4 years. Indeed, with regard to the unprecedented house price boom which began in the mid 90's, lower interest rates in level partly explain it. In addition strong disposable income growth, especially in the beginning of the boom phase as usual, drove real house price growth. The slowdown of the economy since 2001 has been offset by an accommodative policy. Monetary policy stance indicators like interest rate levels and mortgage loan development prove a leaning against the wind policy which sustained strong demand. Excess demand factor indicates that sticky supply did not react quickly enough, the overshooting of demand kept soaring house prices. Altogether, all these factors explain mostly the boom which began in the mid 90's. Nevertheless, the fitted values of both models undervalued actual euro area house price from 2002 to 2005 of 1 to 2%. Interestingly, the latter benchmark model performs better because the mean reversion term (ECT) does not drive the fitted values down, on the contrary, it has still a positive effect. This is not only explained by the lower adjustment speed (9 years) but also and mostly by the sensitivity to interest rate. As interest rates are low, there is no misalignment with respect to the fundamentals according to the interest rate adjusted affordability ratio.

One important subsidiary result, is the strong interaction between the mortgage and the house market. Both markets are linked through the collateral value (essentially the house price). This might prove that asymmetric information arises between households and financial institutions. Banks credit requirements will determine households' capacity to raise funds, which in turn determines house demand and price. In addition, to ensure moral rectitude, financial institutions require households to pledge their house as collateral, which in turn influences the amount of credit. As a result, the house price and the mortgage loan volume can feed each other in a self-perpetuating process. An interest rate shock sheds light on the interconnection between both markets. Indeed, a 1% interest rate increase causes a 1% house price inflation drop and a 0.4% decline in mortgage loan growth rate in the long-term. The interest rate shock has only a temporary effect on the mortgage market on its own but the collateral (house price) drop leads to a long lasting fall in mortgage loan volume. To conclude, interest rate increase impinges negatively on real house price growth, proving that demand outweighs supply. As a result, monetary policy can influence house price growth. This empirical study however does not allow for any statement about price misalignment with respect to long-term house price equilibrium. Instead of proxying ECTs with affordability ratios, future research should try to disentangle better long-term from short-term dynamics by means of a panel ECM, for instance.

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ANNEX 1: Data

Annual data from 1975 to 2005 are used covering the longest available common period restricted to 8 EMU countries: Germany (DE), France (FR), Italy (IT), Spain (ES), the Netherlands (NL), Belgium (BE), Finland (FI) and Ireland (IE). As Residential Property Price is not available for the period under consideration, Luxembourg, Portugal, Greece and Austria were excluded. As a result, the sample consists of 31 observations in the time dimension and 8 cross-sections. The panel series are: *residential property price, consumer price index, interest rate short-term, long-term, stock of dwelling, household disposable income, population aged from 15-64, outstanding mortgage loan volume, credit to households, housing depreciation rate, housing rents* and *stock price index, construction cost.* Real series were constructed by deflating the nominal series by the corresponding domestic CPI indices, except household real disposable income, which is GDP deflated.

The ECB provided the residential property price, which was calculated from the national central banks and private agencies like the BulwienGesa AG in Germany and the European Mortgage Federation, for instance. The database of Claudio Borio from the Bank of International Settlement helped completing the ECB database. The collection is a weighted average of series for new dwellings and existing dwellings. Note that data before 1995 include only West-Germany. Concerning the year 2005, I completed the dataset on residential property price thanks to Livia Figà-Talamanca of the European Mortgage Federation (2006).

The CPI is the yearly average of the monthly HICP (Harmonized Index Consumer Price) from 1980 to 2005. ECB database uses Eurostat data and national CPI with a fixed euro conversion rate. The database was filled by the cost of living index for all households, all items, provided by the BIS. The source of the Irish CPI however is the National Central Bank of Ireland as the BIS cost of living index is not available.

For all countries including Germany, the ECB Desis database was used for the nominal short- and long-term interest rate which is the 5 year government bond yield and the 3 month interbank offered rate, respectively. Once again, the data set was filled by the European commission DG-ECFIN AMECO database for data prior to 1990 except for Germany, where I used the International Financial Statistics of the IMF for the long-term interest rate and the OECD Main Economic Indicator for the short-term interest rate.

The sectorial Housing CPI was chosen as proxy for rents, except for Finland prior to 1995, where a rent index provided by the Finish National Statistic Office (Veli Kettunen) was used. The ECB database on rents was also filled for Spain, from 1976 to 1984, for Ireland from 1975 to 2004. These data were provided by respectively the Instituto Niacional de Estadística (Web site) and the Irish Central Bank (McQuinn Kieran). As 1975 was missing for Germany, Spain and the Netherlands, I projected the missing value by linear extrapolation over approximately the last 10 years (depending on the pattern of the series).

The housing depreciation rate (δ_t) was calculated according to the following formula:
$\delta_t = \frac{GFCF_t - (NCS_t - NCS_{t-1})}{NCS_{t-1}}$

GFCF and NCS stand for Gross Fixed Capital Formation and Net Capital Stock in housing sector, respectively. National sources but also the European Mortgage Federation database were used.

Three different demographic indicators were investigated: the number of households, the population aged from 15 to 65 and the total population. Data scarcity on the number of households obliged me to deal only with the other two variables. The source of the data is Eurostat (European Labour Force Survey) but completed by OECD database. The German database required some arrangements. The reunification caused a structural break, i.e. the OECD database jumps roughly from 60 millions to 80 millions around 1990. From 1990 to 2005, the new database provided by Eurostat was taken. Prior to 1990, the West-German population growth rate was applied backward to the new Eurostat database.

The consumption of non durables and services and financial wealth was not available for many countries and GDP is a too broad aggregate to proxy households' affordability and purchasing power. As a result, households' real disposable income provided by the OECD, the current issue was used. To settle the German reunification data break, I took the raw data from 1991 to 2005 and then calculated until 1975 by assuming the West-German growth rate. Two sources were used: from 1975 to 1989, OECD database, and prior to 1990, ECB internal database (Forecasting section) except for Spain, Belgium and Ireland where only nominal data were available. The OECD database does not provide data for Ireland before 1977. Consequently, the database was filled by deflating the nominal disposable income (source: Central Bank of Ireland) with the GDP deflator from the IFS database (IMF).

Two proxies for housing credit were chosen: loans for house purchasing over 1 and up to 5 years maturity and total loans to households. The former is the mortgage loan and is the most accurate variable which theoretically impacts the house price, while the latter encompasses credits including non housing purchases like consumption credits. Unfortunately, the ECB by using data from National Central Banks provides mortgage loan data only from 1995 to 2005. Consequently, I calculated the series backward by using the growth rate of housing loans which stems from the BIS. The source of the second credit series: loans to households, is also published by the BIS. Unfortunately these series do not cover the entire sample either. Consequently, the total loans to households was calculated, backward and sometimes forward when necessary by the credit to private sector growth rate also provided by the BIS. Counterpart of the credit to private sector includes households but also individual enterprises. Italy, the Netherlands, Belgium and Finland are concerned by this arrangement. The series for Italy in 1989, Spain in 2002 and especially Belgium in 1994 (more than 140% credit mortgage increase) used to show measurement errors. Consequently they were corrected by assuming the growth rate of the next closest and broader credit series. In the empirical study of this paper, only mortgage loan series were used.

The sectorial Housing CPI (source: ECB) was chosen as proxy for housing rents, except for Finland prior to 1995, where a housing rent index provided by the Finish National Statistic Office (Veli Kettunen) was used. The series housing rents were also filled for Spain, from 1976 to 1984, for Ireland from 1975 to 2005. These data were provided by respectively the Instituto Niacional de Estadística (Web site) and the Irish Central Bank (McQuinn Kieran). As 1975 was missing for Germany, Spain and the Netherlands, I projected the missing value by linear extrapolation over approximately the last 10 years (depending on the pattern of the series).

Stock price indices stem from both, International Financial Statistics (IMF) and the Main Economic Indicator (OECD), which are almost identical. Both sources were used as, for example, the OECD index covers a larger time dimension for Germany but smaller for Italy, Spain, Finland. The longest stock price index available for Belgium is provided by the Bank of International settlement which starts in 1980 while IFS stock index is not available and the Main economic Indicators only starts in 1986. Frans Buelens (University of Antwerp) and Stijn Nieuverburgh (University of New York) provided the missing data (source: National Bank of Belgium).

Construction costs as a rule is a weighted average of house building materials prices and labor costs at current prices in this sector. The traditional construction cost index was either only available for a very small time span or not available at all for many countries. The only indicator I found was the nominal unit wage cost divided by productivity in the building and construction sector published by the OECD. This indicator was used as proxy for construction costs index.

ANNEX 2: Euro area aggregation

Currently 12 EU countries have joined the EMU, the member states are: Belgium (BE), Germany (DE), Greece, Spain (ES), France (FR), Ireland (IE), Italy (IT), Luxembourg, the Netherlands (NL), Austria, Portugal and Finland (FI). However, in this empirical study the euro area was restricted to 8 countries due essentially to the lack of data for the remaining countries. The weightings were recalculated for the eight countries (see Table A2.1) by following ECB methodology (see ECB, 2005b) concerning the Residential Property Price (RPP) and the Harmonized Consumer Price Index (HICP).[24] National series of interest rates and CPI, respectively RPP were aggregated to euro area series by applying HICP weighting, respectively RPP weighting. First, the HICP for the euro area is published by Eurostat. However, as the study only uses the national data set of 8 countries, for congruence reasons an artificial euro area CPI was constructed according to the European consumer basket for the entire sample (euro area HICP). Second, contrary to the CPI, the national RPPs are not harmonized. Despite the possible error margins, price trends and movements are correctly reflected (see BIS, 2005). The GDP weighted index applied to aggregate the national RPPs (Table A2.1) is an acceptable solution given the available data. Overall, the reliability of the euro area RPP is strong. Finally, the euro area depreciation rate was calculated with respect to the formula given in Annex 1. For this purpose national Gross Fixed Capital Formation and Net Capital Stock in housing sector were added up to euro area series.

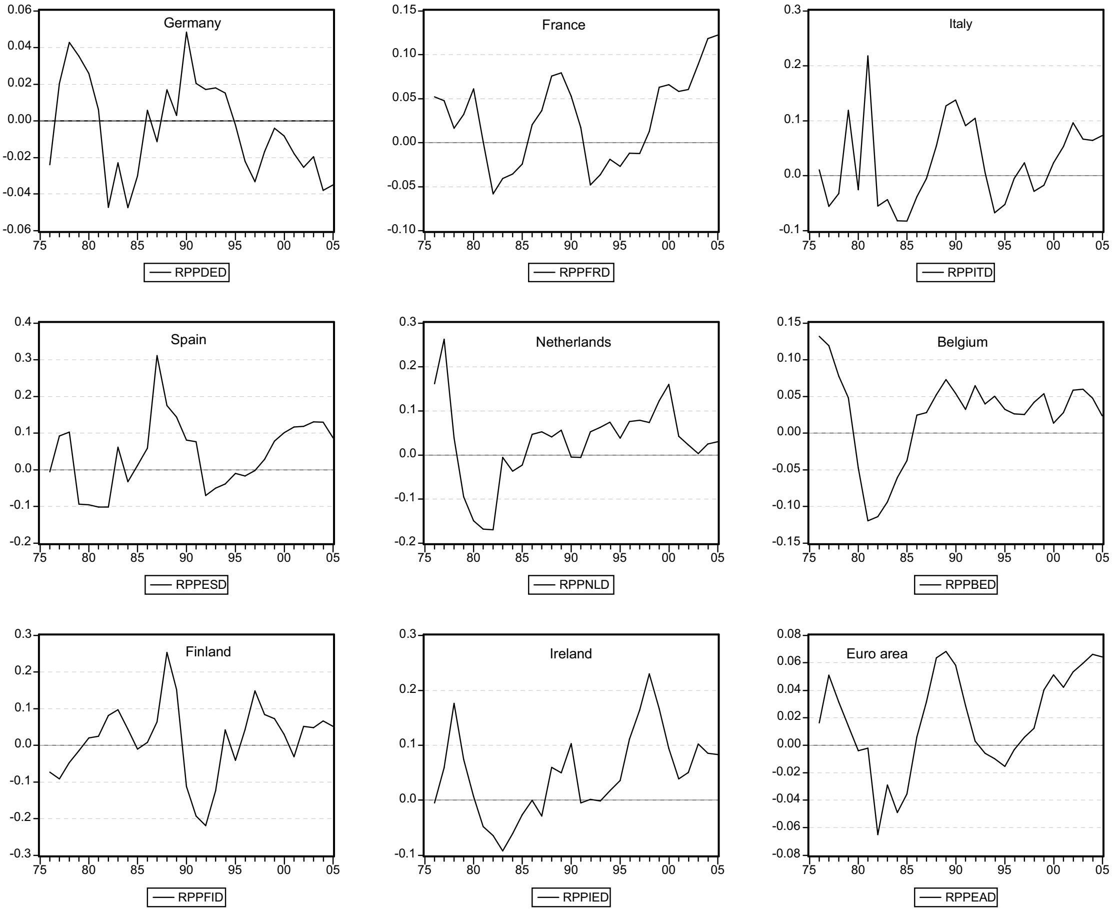
Table A2.1: **Weightings euro area series (%)**

Country	% in HICP	% in RPP	% in LM
DE	32.46	31.61	46.65
FR	22.26	23.13	24.12
IT	20.85	19.32	5.41
ES	11.84	11.06	9.33
NL	5.86	6.75	8.59
BE	3.58	4.00	3.32
FI	1.74	2.13	1.59
IE	1.41	2.00	1.00

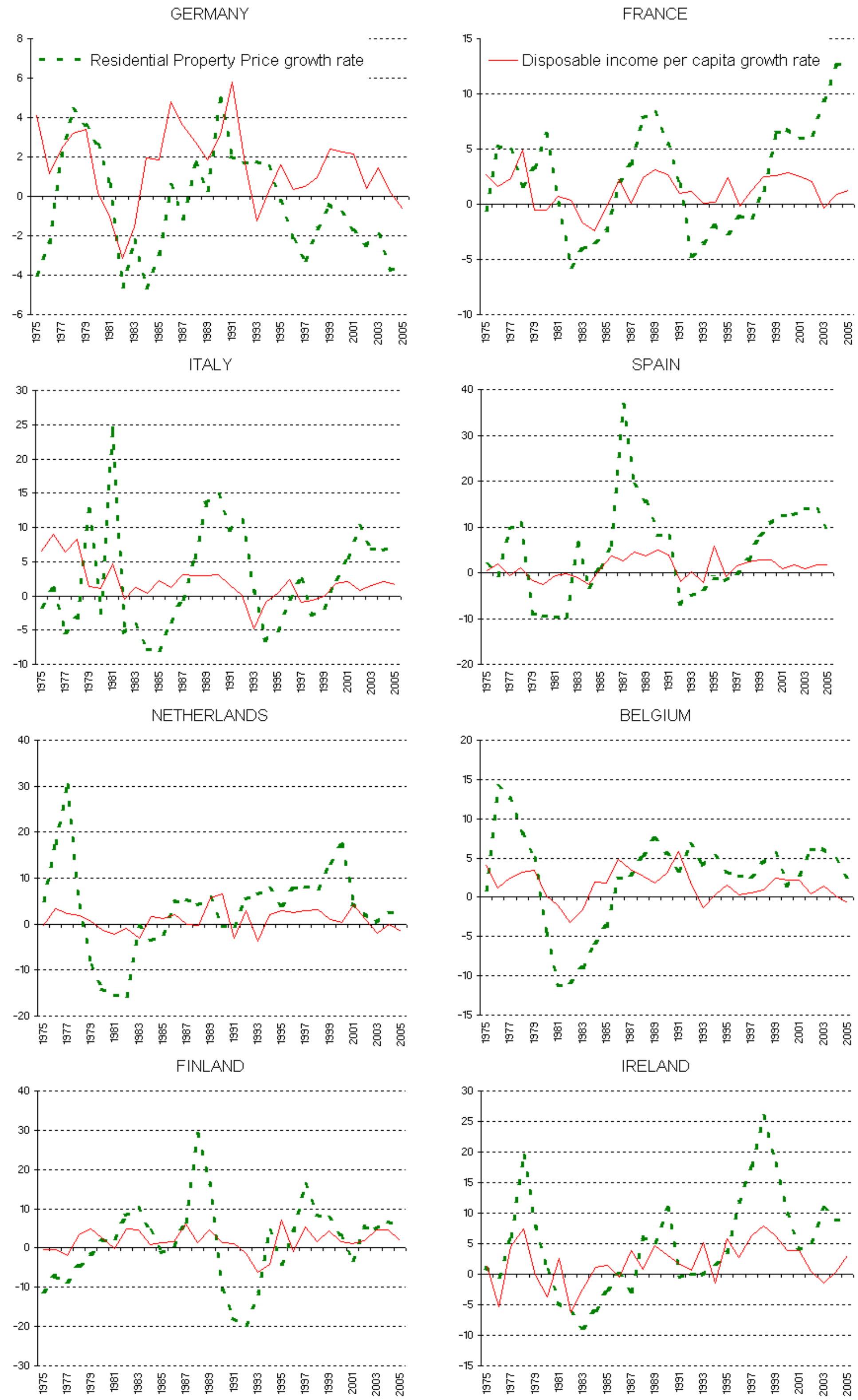
National series were aggregated to euro area series in three different ways depending on the series. Stock of dwelling, population and real loans were added by countries. Two different euro area real disposable income were calculated by aggregating the national series. The former was divided by total population while the later by population aged from 15-64. In contrast, the other variables are indices, consequently a weighting was applied (see Table A2.1 above) as already explained. The euro area HICP and the nominal residential property price were constructed. The real euro area residential property price is the ratio nominal index over HICP. The HICP weighting was applied to the interest rate. The euro area series can been seen in Annex 15.

[24] see "Compendium of HICP reference documents (2/2001/B/5)" under http://forum.europa.eu.int

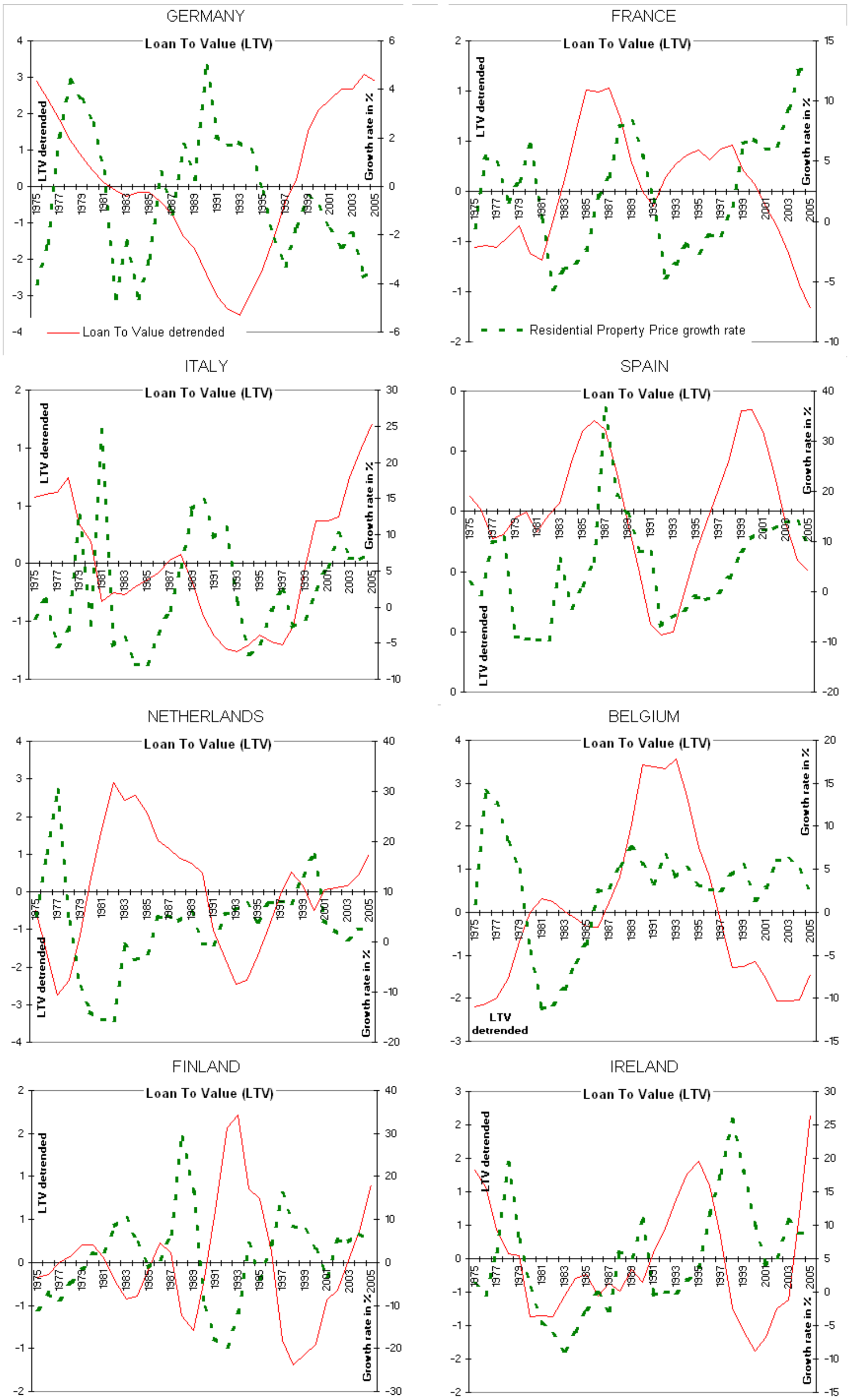
ANNEX 3: Real residential property price growth rate by country



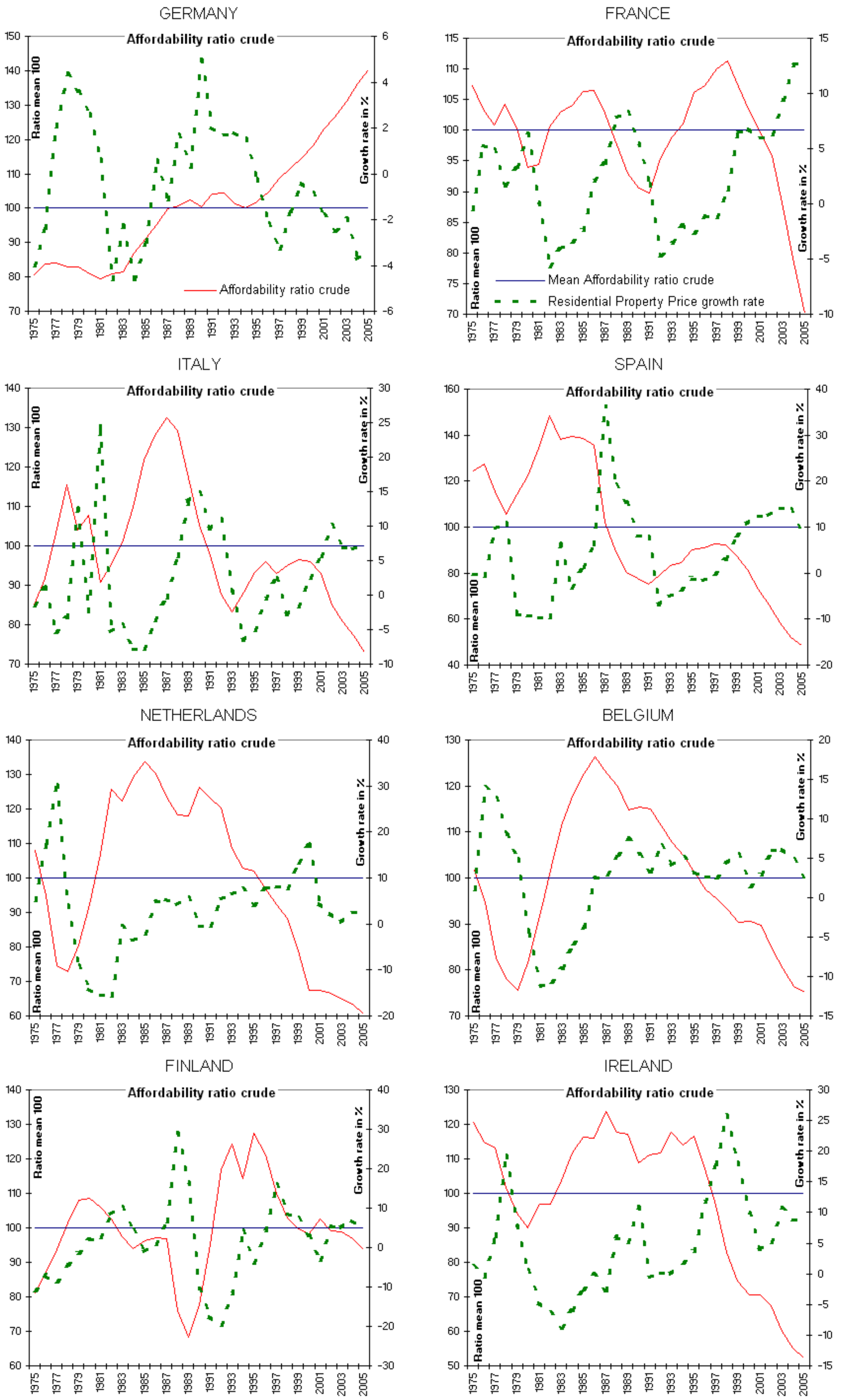
ANNEX 4: Real disposable income and real residential property price growth rate (in %)



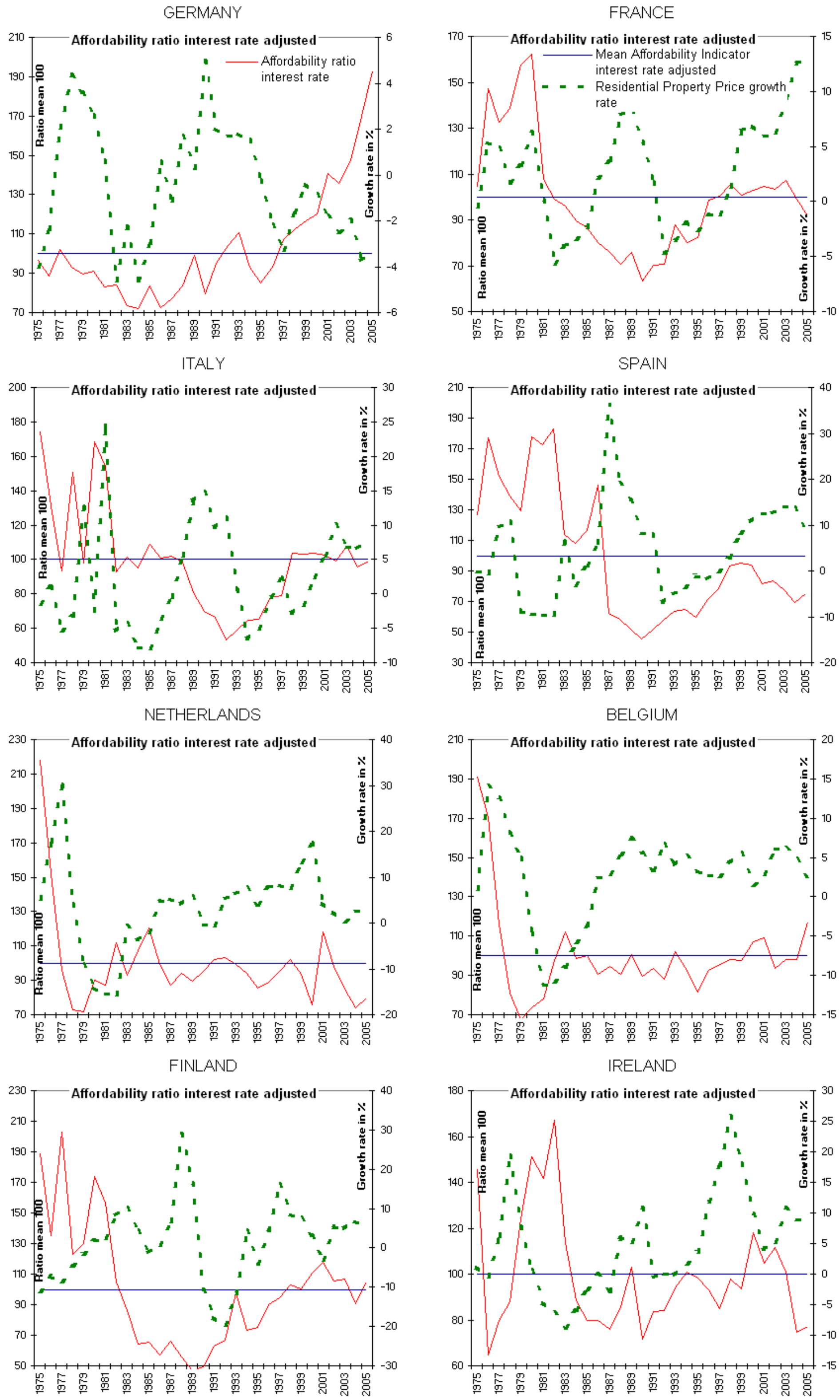
ANNEX 5: CLTV detrended and residential property price growth rate



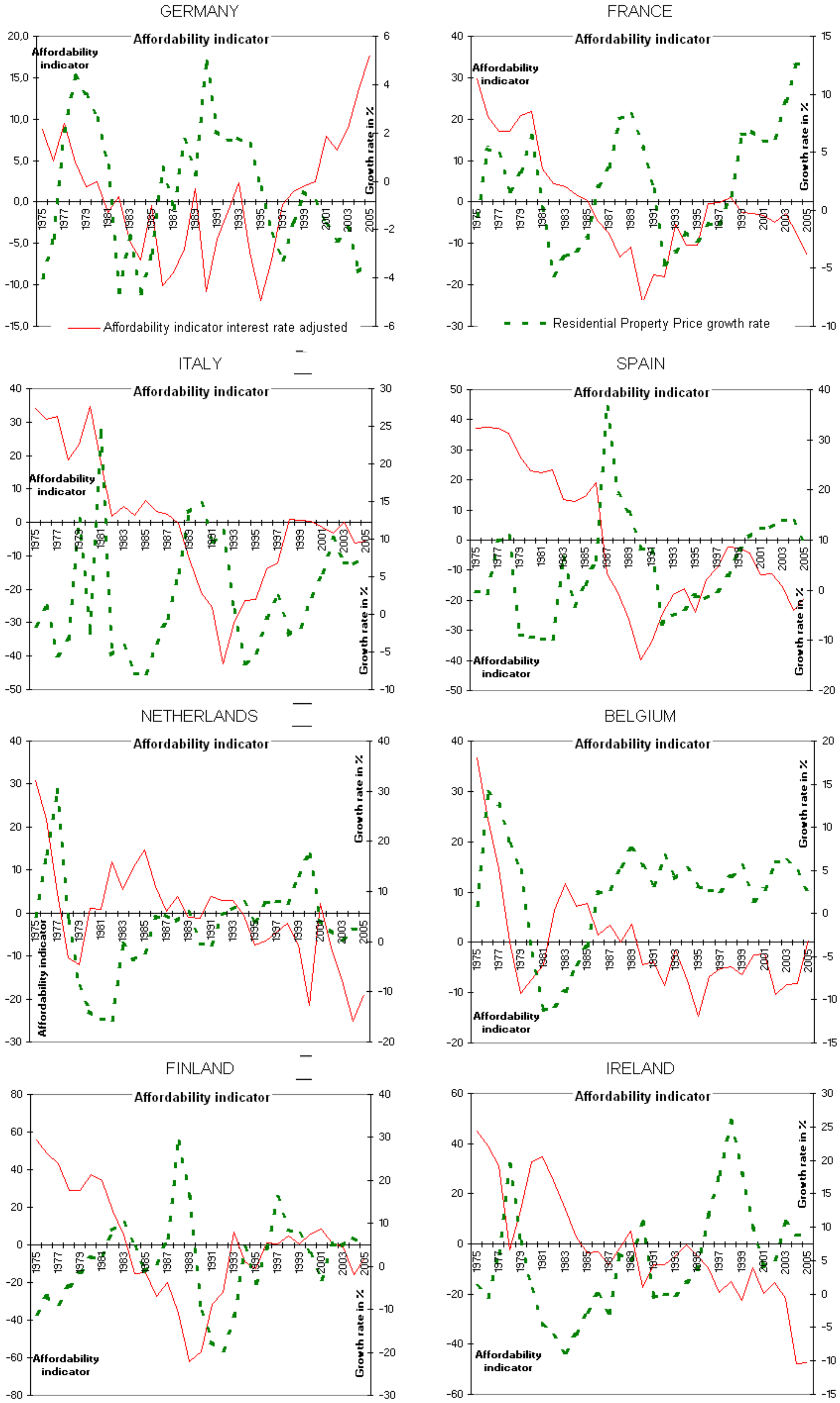
ANNEX 6: Affordability ratio crude and residential property price growth rate



ANNEX 7: Affordability ratio interest rate adjusted and residential property price growth rate



ANNEX 8: Affordability indicator and residential property price growth rate



ANNEX 9: Affordability ratio interest rate adjusted and indicator

1. AFFORDABILITY RATIO INTEREST RATE ADJUSTED

The US National Association of realtors[25] defines an interest-adjusted affordability. The ratio consists in the median family income to the monthly mortgage payments on a typical home. Hereafter, the ratio relies on three assumptions. First, the median family income grows at the same rate as the disposable income. Second, the mortgage covers 80% of the house price. Third, the price of the typical home grows at the same rate as the residential property prices. More precisely, considering a Monthly Payment (MP) for home of representative household in country i, under the assumption that 80% of house price must be covered by the mortgage loan, Monthly Payment can be rewritten as:

$$MP1_{i,t} = 0.8P_{i,t}\frac{r_{i,t}}{12}\frac{\left(1+\frac{r_{i,t}}{12}\right)^n}{\left[\left(1+\frac{r_{i,t}}{12}\right)^n - 1\right]},$$

and where index i, t respectively account for country and time. While $P_{i,t}$ denotes the real house price index, $r_{i,t}$ is the annual real interest rate (government bond maturity 10 years) expressed in %/100, and finally $Y_{i,t}$ is the annual real disposable income per capita.[26] Consider a Qualifying Income: $QI_{i,t} = 4 \times 12 \times MP1_{i,t}$, as the annual income necessary to qualify for a job. Thus, the interest rate affordability ratio is:

$$A1_{i,t} = \frac{Y_{i,t}}{QI_{i,t}} = \frac{Y_{i,t}\left[\left(1+\frac{r_{i,t}}{12}\right)^{360} - 1\right]}{3.2r_{i,t}P_{i,t}\left(1+\frac{r_{i,t}}{12}\right)^{360}}.$$

2. AFFORDABILITY INDICATOR

Again, home buyers in the real world secure financing from a financial institution in the form of home mortgage loan, and hence interest rates play a role in determining the affordability of houses. The affordability indicator however, informs the agent of what monthly payments they could expect to make when considering purchasing a specific property. Thus, Monthly Payment (MP) for home of representative household in country i yields:

$$MP2_{i,t} = P_{i,t}\frac{(\gamma_{i,t} - 1)}{1 - \gamma_{i,t}^{-n}},$$

and $\gamma_{i,t}$ denotes the amortization factor, while n stands for the number of months to repay the mortgage loan:[27]

$$\gamma_{i,t} = 1 + \frac{r_{i,t}}{12}.$$

Thus, the formulas used to calculate the housing affordability indicator give:

$$A2_{i,t} = \frac{Y_{i,t}}{4}\frac{1}{12} - MP_{i,t} = \frac{Y_{i,t}}{4}\frac{1}{12} - \frac{P_{i,t}\frac{r_{i,t}}{12}}{1-\left(1+\frac{r_{i,t}}{12}\right)^{-n}}.$$

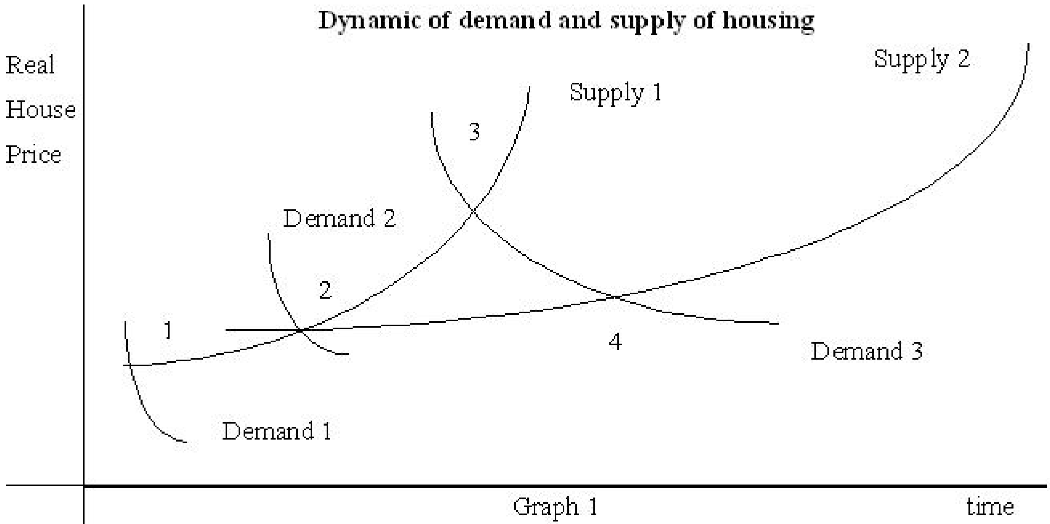
[25] see www.realtor.org

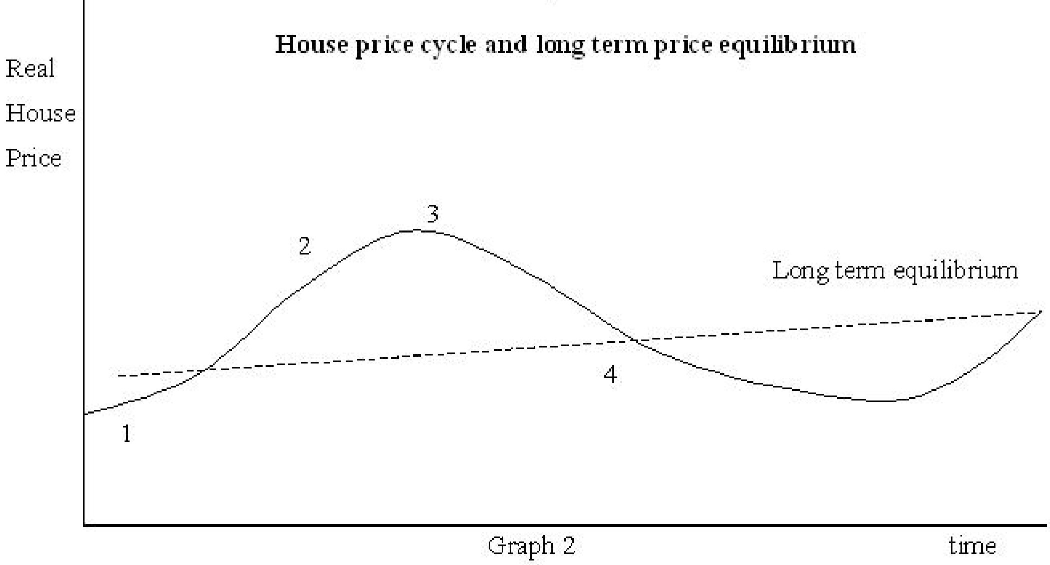
[26] P (respectively Y) denotes the theoretical house price (respectively disposable income per capita), while RPP (DY) refers to the proxy: residential property price (respectively disposable income per capita population aged from 15-64).

[27] As a rule n is set to 360, meaning 30 years repayment.

ANNEX 10: House price dynamics and cycle

Empirical investigations have proven that the supply is typically constrained (Muellbauer & Murphy, 1997; Kenny, 2003). The demand (equation 1) responds to the usual forces (disposable income, user cost of housing etc.) and determines an equilibrium price (graph 1), which feeds the following supply. Thus, the supply reacts with delay (Supply 2) relative to demand which typically moves much faster (demand 1 to demand 3). There always remains the possibility for house prices to overshoot their long-run equilibrium level following a sudden increase in housing demand (Kenny, 1999). This supply-demand interaction (Graph1) over time leads to a house price cycle (Graph 2).





ANNEX 11: Moon & Perron (2003), Choi (2002) panel unit root tests

Var	Test	Deterministic terms	Statistics Z(Choi), tb (M&P)	p-limit
$logRPP$	Choi	c,t	1.90	0.97
		c	-0.12	0.45
	M&P	c,t	-0.45	0.32
		c	-2.25	0.01
$logDW$	Choi	c,t	-0.91	0.18
		c	4.29	1.00
	M&P	c,t	0.02	0.51
		c	-3.34	0.42
$logY$	Choi	c,t	1.10	0.86
		c	0.97	1.00
	M&P	c,t	-0.14	0.44
		c	-1.63	0.14
$log\ PO$	Choi	c,t	-2.51	0.00
		c	0.12	1.00
	M&P	c,t	-0.20	0.42
		c	-3.94	0.41
r	Choi	c	10.3	0.02
	M&P	c	-14.2	0.01
$logLM$	Choi	c	0.28	1.00
	M&P	c	-2.18	0.02
$\log RT$	Choi	c	0.70	0.76
	M&P	c	-3.09	0.01
$\log SP$	Choi	c	-0.40	0.35
	M&P	c	-1.90	0.48
$\log CC$	Choi	c,t	0.82	0.77
		c	-2.38	0.01
	M&P	c,t	-0.15	0.44
		c	-1.36	0.40

ANNEX 12: Levin, Lin & Chu (1992), Im, Pesaran & Shin (1997)

Var	Test	Deterministic terms	Statistics, t*(LLC), W(IPS)	p-limit
$\log RPP$	LLC	c,t	-1.68	0.05
		c	1.10	0.87
	IPS	c,t	-3.21	0.00
		c	-0.83	0.80
$\log DW$	LLC	c,t	-2.07	0.02
		c	0.45	0.70
	IPS	c,t	2.02	0.98
		c	1.79	0.96
$\log Y$	LLC	c,t	-0.79	0.21
		c	-0.64	0.26
	IPS	c,t	-0.15	0.44
		c	2.37	0.99
$\log PO$	LLC	c,t	1.11	0.87
		c	0.63	0.74
	IPS	c,t	-0.96	0.17
		c	6.10	1.00
r	LLC	c	-5.18	0.00
	IPS	c	-4.57	0.00
$\log LM$	LLC	c	3.13	1.00
	IPS	c	6.81	1.00
$\log RT$	LLC	c	-0.27	0.39
	IPS	c	-1.64	0.06
$\log SP$	LLC	c	-1.04	0.15
	IPS	c	-5.73	0.00
$\log CC$	LLC	c,t	-0.74	0.23
		c	-1.07	0.14
	IPS	c,t	-5.60	0.24
		c	0.53	0.30

ANNEX 13: Time series ADF tests of series $\log RPP$ and $\log DW$

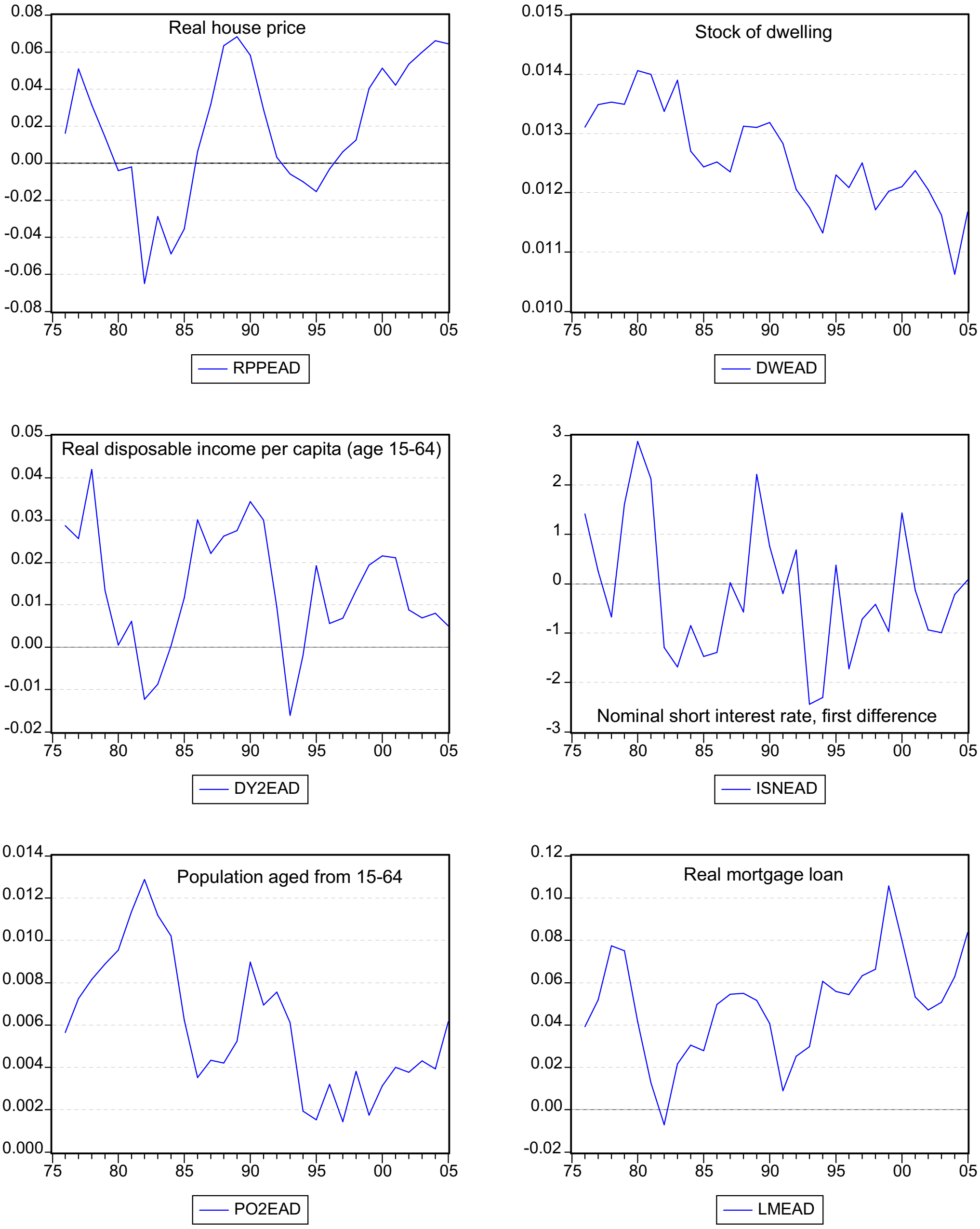
Var	Count	Lags	Deterministic terms	Statistics ADF	5% critical value
$\log RPP$	DE	1	c,t	-2.72	-3.58
		1	c	-2.25	-2.97
	FR	1	c,t	-3.62	-3.58
		1	c	0.03	-2.97
	IT	4	c,t	-5.98	-3.60
		1	c	-1.47	-2.97
	ES	0	c,t	-7.01	-3.57
		1	c	-0.52	-2.97
	NL	1	c,t	-2.33	-3.58
		1	c	-1.26	-2.97
	BE	2	c,t	-2.12	-3.59
		2	c	-0.32	-2.98
	FI	2	c,t	-3.18	-3.59
		1	c	-2.80	-2.97
	IE	2	c,t	-2.92	-3.59
		1	c	-0.28	-2.97

Var	Count	Lags	Deterministic terms	Statistics ADF	5% critical value
$\log DW$	DE	1	c,t	-2.53	-3.58
		3	c	-1.63	-2.98
	FR	1	c,t	-2.83	-3.58
		1	c	2.08	-2.97
	IT	1	c,t	-1.04	-3.58
		1	c	-2.55	-2.97
	ES	1	c,t	-2.15	-3.58
		1	c	1.38	-2.97
	NL	1	c,t	-1.44	-3.58
		1	c	-3.44	-2.97
	BE	1	c,t	-1.45	-3.58
		1	c	-1.03	-2.97
	FI	4	c,t	-0.13	-3.60
		4	c	-1.96	-2.99
	IE	1	c,t	-1.77	-3.58
		1	c	3.10	-2.97

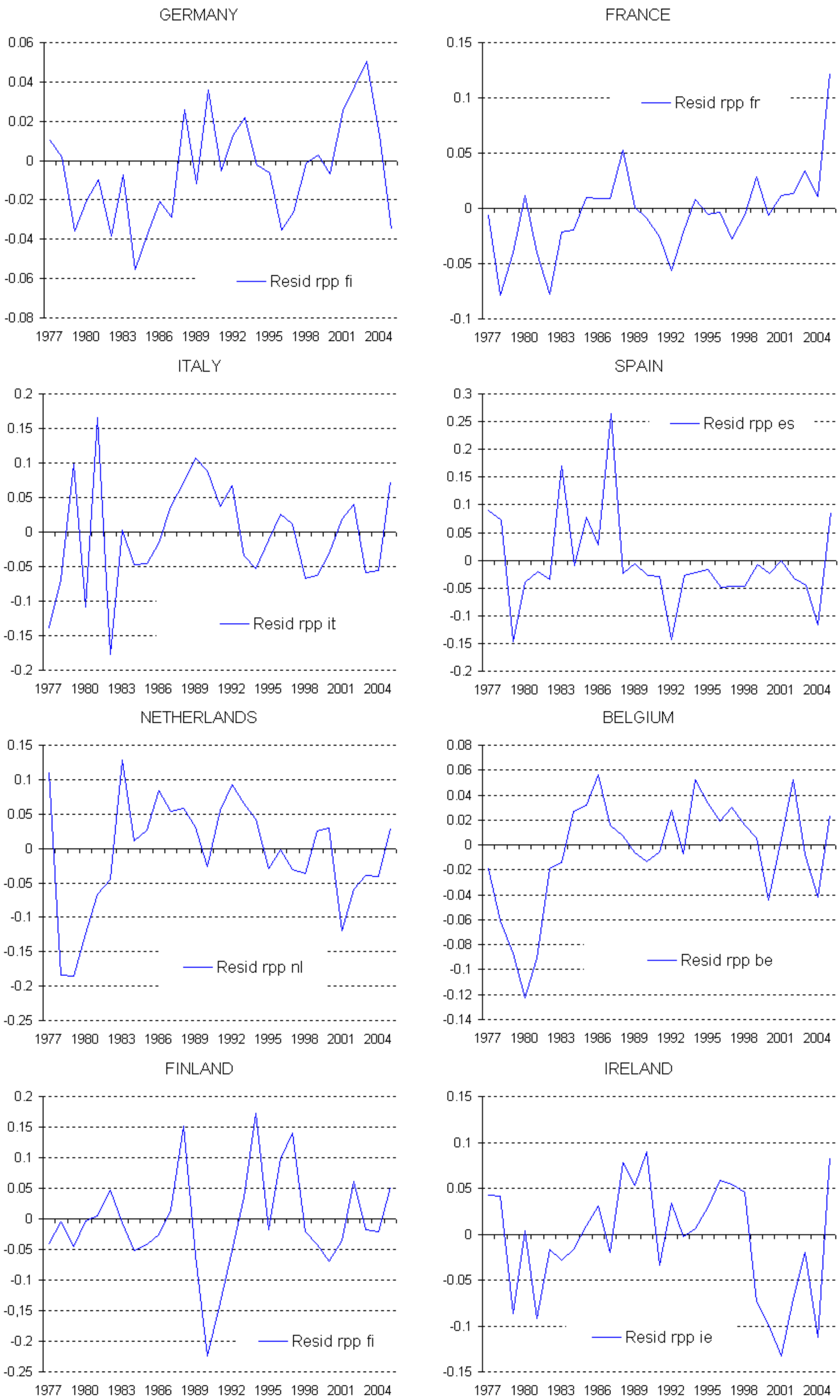
ANNEX 14: Time series ADF tests of series AFR

Var	Count	Lags	Deterministic terms	Statistics ADF	5% critical value
AFR	DE	1	c,t	-3.77	-3.58
		1	c	0.23	-2.97
	FR	1	c,t	-1.98	-3.58
		1	c	-1.10	-2.97
	IT	1	c,t	-1.84	-3.58
		1	c	-2.06	-2.97
	ES	1	c,t	-2.06	-3.58
		1	c	-0.44	-2.97
	NL	1	c,t	-1.84	-3.58
		1	c	-1.28	-2.97
	BE	1	c,t	-2.37	-3.58
		1	c	-2.40	-2.97
	FI	1	c,t	-3.59	-3.58
		1	c	-3.559	-2.97
	IE	1	c,t	0.12	-3.58
		1	c	1.00	-2.97

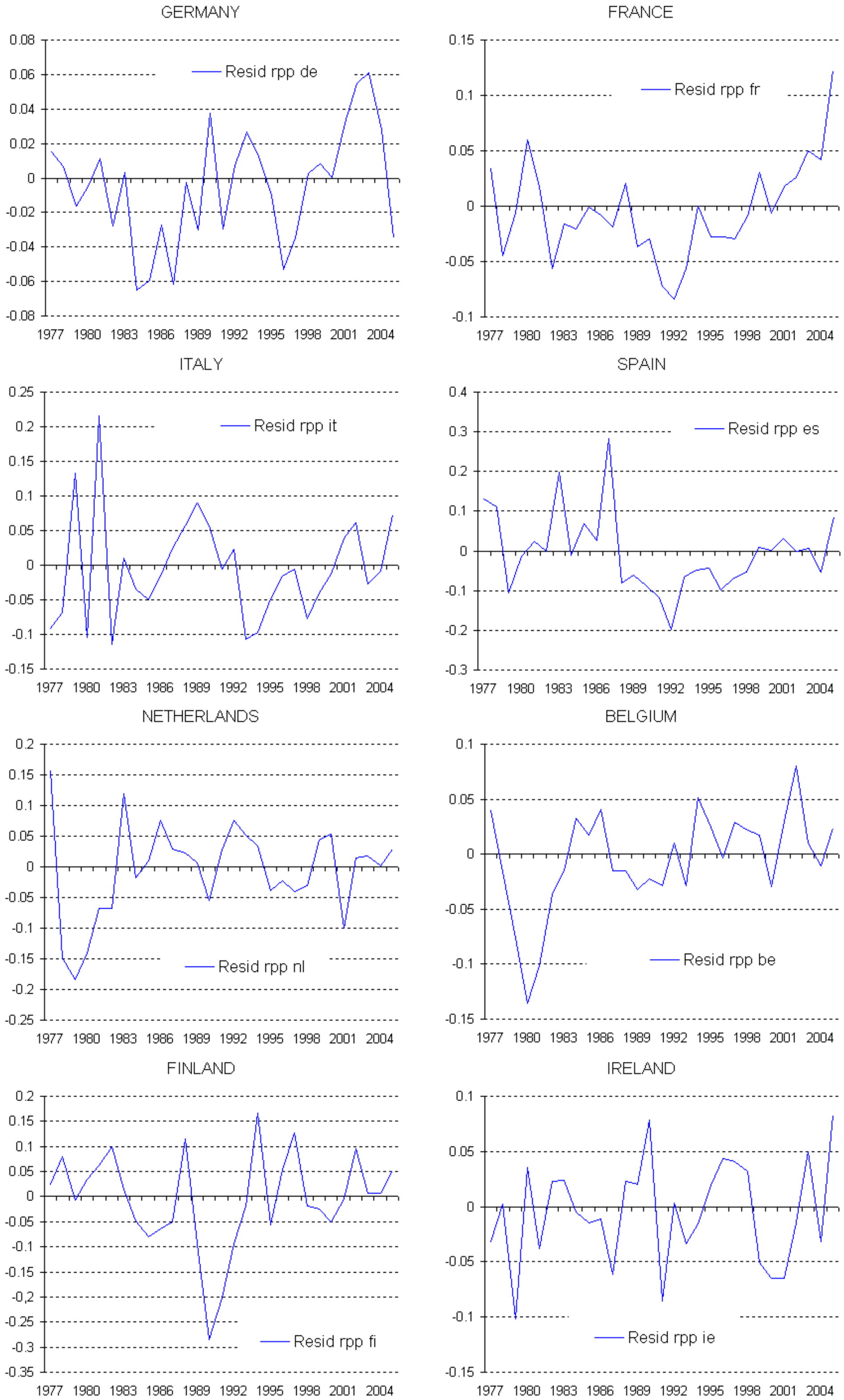
ANNEX 15: Euro area time series, growth rates except interest rate



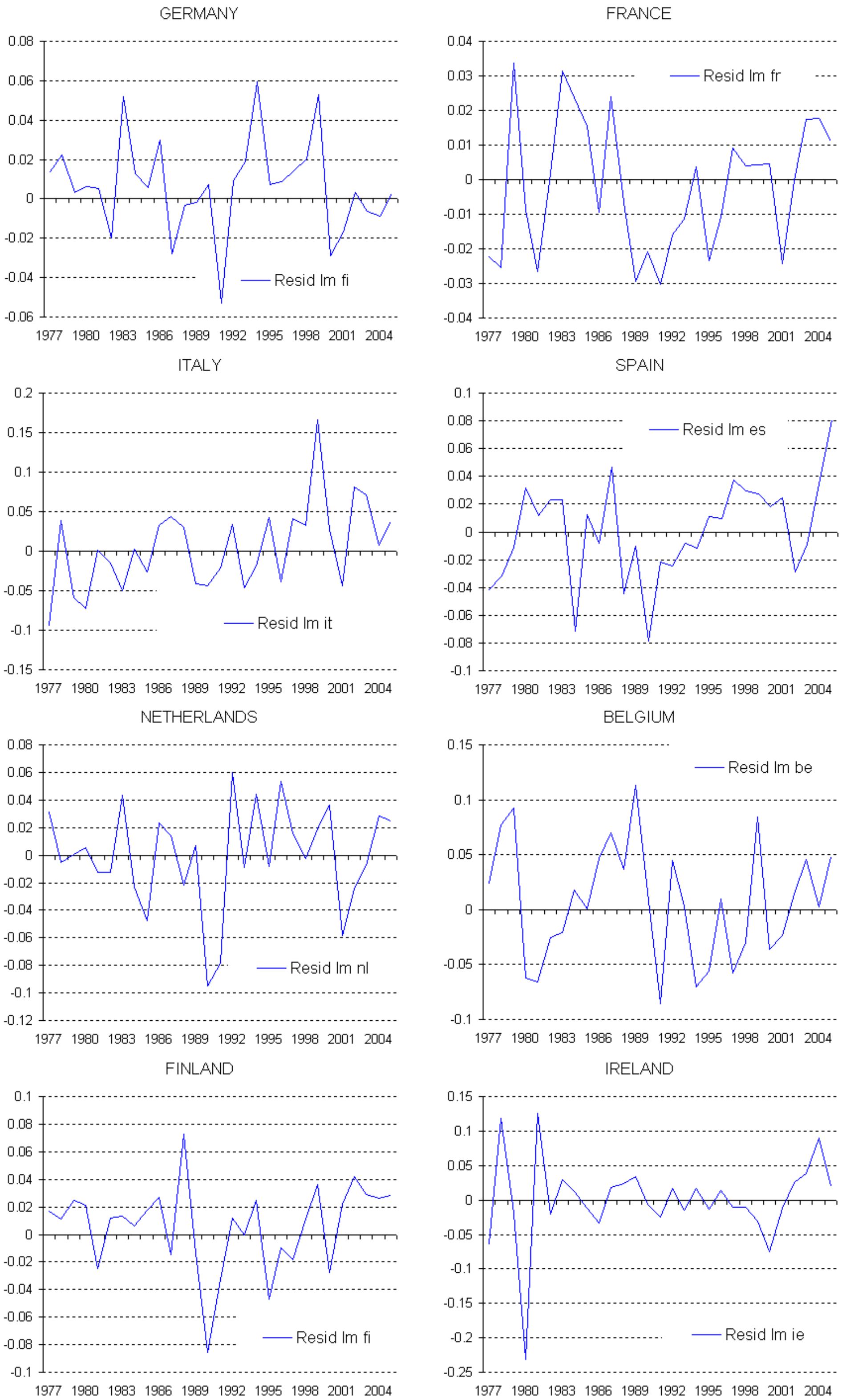
ANNEX 16: Residuals house market benchmark model crude affordability ratio (F1)



ANNEX 17: Residuals house market benchmark model interest rate adjusted affordability ratio (G2)



ANNEX 18: Residuals mortgage loan market benchmark model



Long-run house price equilibrium and short-term dynamics in the euro area

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Abstract

The European central bank (ECB) has shown concern about real house price appreciation in some countries of the euro area. Indeed, large real house price movements might cause adverse shocks on the economy via the wealth effect and the bank lending channel, which in turn impinge on the consumer price. This raises the question whether current house prices are in line with the fundamentals. Thus, the present paper aims at shedding more light on house price movements in the euro area. The purpose of the paper is threefold: (1) to estimate a euro area long-term house price equilibrium and to compare it with current prices, (2) to determine which factors drive long-term house prices and short-term dynamics, (3) if there is currently a disequilibrium, to depict how house prices would convergence back to their long-term equilibrium. The use of panel econometrics improves substantially the robustness of the estimation. More precisely, the PMG (Pooled Mean Group) estimator developed by Pesaran, Shin & Smith (1997) is used to disentangle long-term from short-term dynamics. House price equilibrium is mainly driven by disposable incomes and interest rates. In the short-term, however, house prices are strongly persistent and mostly driven by disposable incomes. About the ongoing house price cycle which has started in 1996, the following conclusions are drawn. The steady growth of the European household's disposable income coupled with the decline of the nominal interest rate explain largely the strong house price growth from 1996 to 2001. However, current euro area house prices have overshot long-term price equilibrium since 2001 according to the estimates. Mortgage loan developments might have fueled house prices and the sluggish supply reacting too slowly relative to the strong demand. If the tide started to turn, it would take five to six years for the current house price to catch up with its equilibrium level.

JEL Classification: C13, C23, R21, R22, R31
Key words: Heterogeneous dynamic panels, pooled mean group estimator, panel unit root and cointegration tests, house price equilibrium

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1 Motivation

Current soaring house prices have reached unprecedented levels for 30 years in almost all euro area countries, except in Germany (see Annex 3). Since 1996, Ireland has experienced a real house price growth rate in average larger than 10%. In the Netherlands, the upsurge also took place very early in the middle of the 90's with a peak in 2000, since 2002 however house prices have grown moderately at 2%. In Spain, the dramatic increase occurred around 2000, since then the real growth rate has been larger than 10% every year. In France and Italy the real house price has risen steeply since 1999 and 2001, respectively at 5% on average. Although the Italian and French ones increased first at a lower extent, the pace of the French rate has nevertheless accelerated in the last three years overshooting 10%. Altogether, despite the falling house price in Germany accounting for roughly one third in the weighting, the euro area real house price has increased steadily since 1999 from 4 to 6.5% in 2005. The rise on its own is not as striking as the long lasting effect of the phenomenon. Indeed, during the bubble in the beginning of the 90's, euro area house price growth reached equivalent peaks. However, a real growth rate above 2% lasted roughly four years. In contrast, the ongoing current cycle shows a much larger duration. The strong real house price appreciation has already lasted for eight years. Questions have arisen regarding the sustainability of house price increase. Is there any fear of sharp decline? Rising commodity prices and the risk of abrupt decline, along with oil price shocks have become a center stage in monetary policy debate.

Dramatic asset price volatility can have significant effects on real economic activity, as witnessed by numerous historical episodes ranging from the 1929 Wall Street crash to the more recent Tokyo housing and equity bubble. Boom-bust cycles in asset prices can eventually cause credit crunch or even a collapse of the entire financial system -systemic failure- via bank bankruptcy. Besides, strong asset price volatility can harm the real economy essentially through two other effects. First, households' housing wealth can have a strong impact on private consumption and aggregate demand (OECD, 2002; IMF, 2001). Second, asymmetric information in the credit market makes the supply of credit depend on households' collateral, the so-called financial accelerator (Bernanke, 1983; Bernanke et al., 1995, 2000). As a result, strong appreciations and subsequent rapid reversals in asset prices can harm output growth and jeopardize price stability. At least, they can convey information about future inflation not picked up by current indicators. As the primary objective of the ECB is to maintain price stability, the ECB pays attention to asset price movements, especially house prices, without targeting asset prices directly.[1] The central bank stresses the risk that an accommodative monetary policy might facilitate house price increase. More precisely, the ECB argues that strong monetary and housing credit growth fuel "strong house price dynamic" (ECB, 2005a).

The primary task the ECB has to tackle, however, is to gauge whether current euro area house price increases are sustainable, i.e. in line with the fundamentals. If the caveats are clearly understood, a valuable study can have a potentially useful role in policy-makers' information set. So far in the literature, empirical house price estimation has been either underpinned by the theory of asset pricing valuation or by a structural model.

[1] Rents in the housing market account for about 6% in the HICP (ECB, 2003). However rent growth does not always follow house price growth, and the direct link between house prices and HICP is very weak, about 2% according to an internal ECB estimate. Consequently, a doubling of rents might lead to 2% increase of the HICP.

The former is based on the arbitrage opportunity between housing assets and alternative assets like bonds (Ayuso & Restoy, 2003; Bessone, Heitz, & Boissinot, 2005), while the latter model investigates the determinants of housing demand and supply (e.g. Kenny, 1999, 2003; McCarthy & Peach, 2004; Lecat & Mesonnier, 2005). The first approach of house price evaluation, however, suffers from a major drawback. Indeed, house prices may not essentially be driven by arbitrage behavior (Ott, 2006a). Interpreting the residuals of the arbitrage equation as the deviation of price rent ratio from their long-term valuation may be misleading. Omitted variable bias is of concern, as, empirically, it is very unlikely to have solely non fundamental elements in the residuals. As a consequence, this theory is flawed by major deficits and thus eschewed. The second approach, in contrast, analyses the matches of housing demand and supply, which in turn determines the price. On the one hand, housing supply is driven by profit opportunities, materialized in investments (McCarthy & Peach, 2002, 2004). On the other hand, factors that impinge on the demand for housing over longer terms include growth in household's disposable income, shifts in demographics, permanent institutional framework as for example the legal tax framework promoting home ownership against other type of wealth accumulation, financing conditions -level of mortgage interest rate, fixed versus variable mortgage rates, conservative versus liberal prudential rules- (see ECB, 2003).

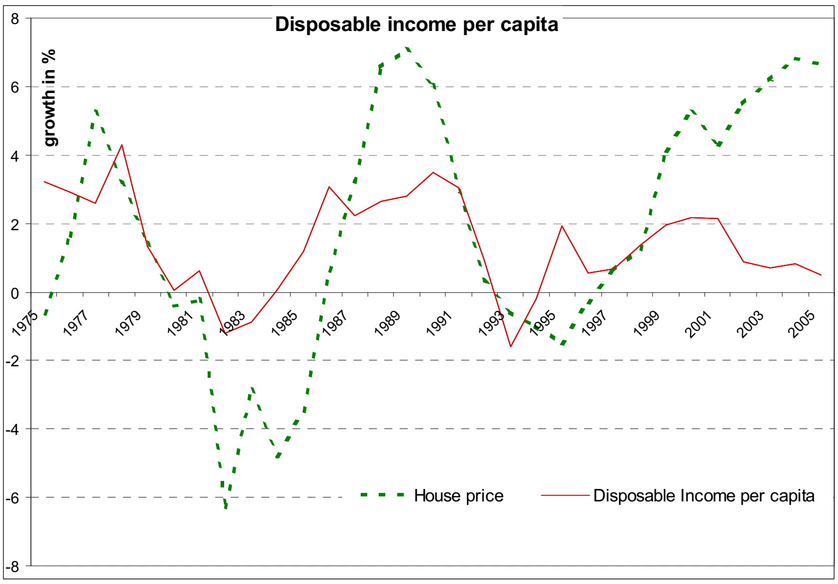
This paper aims at shedding light on determinants driving house price in the euro area and to identify a house price equilibrium. What belongs to a long-term and what to a short-term dynamics? Is the current house price above/below its fundamental value? Which long-term and short-term factors explain the movements of real estate prices? Short sample time span is the first challenge to overcome. Indeed, for house prices, the annual data available ranges from 1975 to 2005 (31 observations). On the one hand, panel econometrics allows a substantial gain in power. On the other hand, parameter homogeneity assumptions can lead to inconsistent estimates. The last issue is to disentangle long-term from short-term house price movements, since stickiness is a striking feature of the house price process.

The paper is organized as follows: Section 2 discusses some stylized facts observed in the euro area house market and mortgage market. Section 3 sets up a theoretical framework, which is used as a guide to select the relevant empirical model regarding the variables, the lag structure and the autoregressive form. Section 4 reviews the previous empirical housing literature and outlines the panel econometrics methodology used in this paper. Section 5 presents the empirical results, from panel unit root and cointegration tests to the estimation of the Panel Error Correction Model (PECM). The issues of homogeneity and endogeneity are addressed. In section 6 the estimated panel coefficients are used to simulate a euro area house price equilibrium and the short-term dynamics. Finally, factors explaining the euro area house price movements are highlighted and a return to a steady state is simulated. Section 7 concludes.

2 Stylized facts

The euro area real house price growth rate has risen steadily from year to year since 1997, reaching more than 6.5% in 2004 and 2005 (see Chart 1). From 1975 to 2005,[2] such a large growth rate was only attained once, in the peak year of the well-known 90's bubble which occurred in the majority of euro area countries (see Annex 3).[3] The average euro area real house price growth rate for the period 1997 to 2005 is more than twice as large as the growth rate of the whole sample (see bar Chart 2). This statement holds for all euro area countries except Germany. Indeed, the German real house price growth rate has been negative for the last 8 years while Germany accounts for more than one third of the euro area house price (see Annex 2, where aggregation methodology is discussed). Despite this fact, euro area house prices have experienced a strong increase. As can be remarkably seen in Chart 1, house price motions exhibit a long booming phase, a striking feature in this last cycle. House price movements in the last eight years correspond to a booming phase, which is nothing exceptional. However, never before 1975 had such a house price increase lasted so long, i.e. more than 8 years and that in so many countries. Countries which have experienced outstanding real house price increase in the last eight years are: Ireland, Spain, France and the Netherlands with respectively: 11.5, 8.7, 6.4 and 6.2 on average. The other euro area countries have also experienced a strong house price increase[4] albeit to a lesser extent.

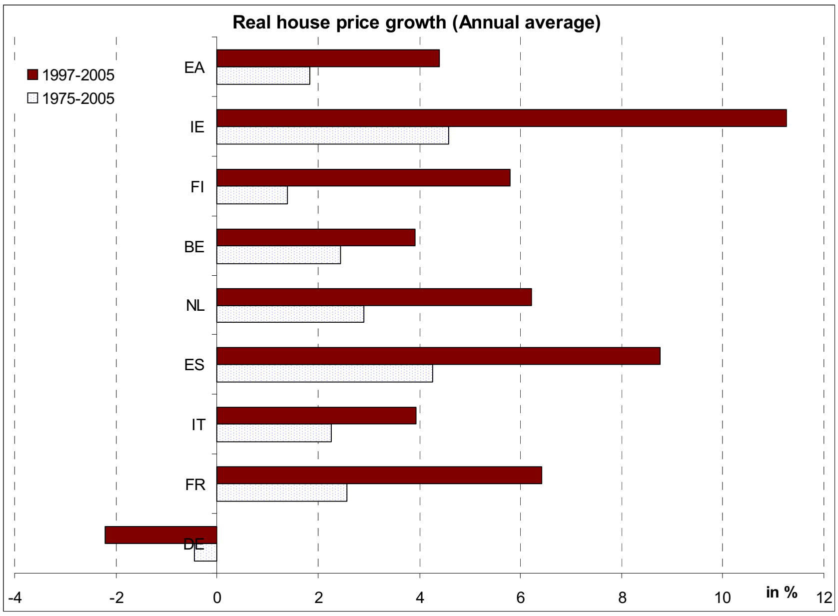
Chart 1



[2] Annex 1 gives inside on data sources and construction.
[3] The house price bubble at the beginning of the 90's was particularly sharp in Spain, Finland and Italy, and to a lesser extent in Ireland, France and Germany.
[4] Except Germany which is an outlier with regard to the rest of the euro area. The reunification provoked a booming house price, which in turn surged housing supply. Thereafter, housing demand declined and the staggered house supply did not follow as quickly. Not only weak disposable income growth but also excess housing supply may explain the subdued German house price.

According to the literature on housing, the ratio of house price over real disposable income shows mean reversion. If the house price deviates relative to the income, this misalignment tends to be corrected over time (Lamont & Stein, 1999; IMF, 2004; Lecat & Mesonnier, 2005). Thus, Chart 1 and Annex 4 depict the growth rate of real disposable income per capita (population aged from 15-64) together with house price in the euro area. One can notice at first glance that both cycles co-move, although house prices exhibit stronger volatility. Disposable income growth are one year in advance of booming house price. However the disposable income slowdown since 2001 has not depressed the housing market so far. Since income does not seem to explain everything, an alternative factor is investigated: mortgage loan development.

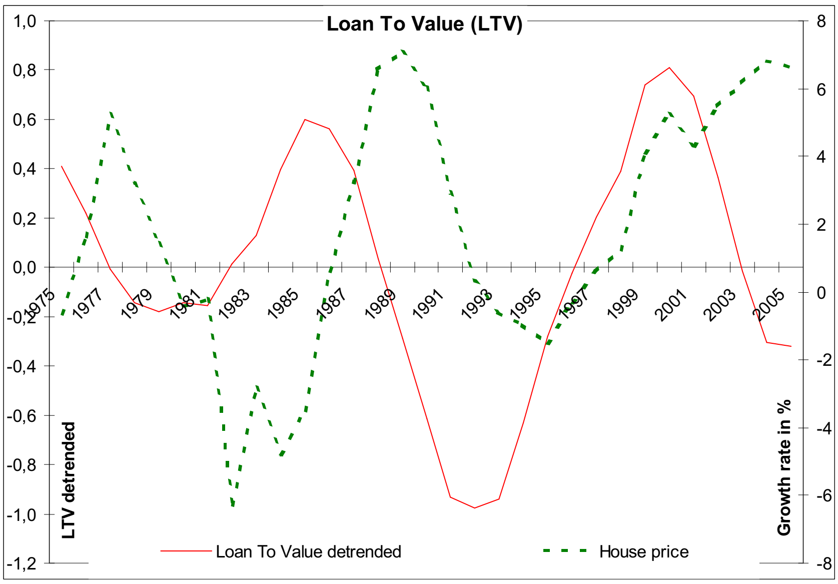
Chart 2



Mortgage loan development might explain house price boom. Since 1997, the euro area mortgage loan market has displayed an average annual growth rate of roughly 7%, while is average growth rate before 1997 was only about 4%. On a micro-level, financial institutions and other lenders examine before approving a mortgage. The Loan To Value (LTV) ratio is one lending risk assessment amid manifold others (Jackson & Kasserman, 1980). Beside the prudential ceiling fixed by law, the LTV determines how conservative mortgage lending is. Typically, high LTV ratios are associated with higher risk. Maclennan, Muellbauer & Stephens (1999) show that countries with a low LTV ratio and high transaction costs tend to experience lower house price volatility. One straightforward question worth asking is whether lax banking practice artificially fuels dramatic current house price increase. By the same token, on a macro-level total outstanding loans are divided by house price and the stock of dwelling to calculate the Current Loan To Value (CLTV).

The changes in the CLTV ratio over time might convey information on households' residential mortgage default risk exposure. Macroeconomic high risk exposure might be commensurate with large CLTV. The CLTV ratio has been detrended as the raw series exhibit a very strong time trend. Important structural reforms across euro area countries might explain this trend. Manifold countries embarked on extensive financial liberalization across the EU. Deregulation began in the early 80's and the pace varied markedly across countries. This development spurt credit growth across numerous countries, which could reflect an equilibrium adjustment from repressed to liberalized financial markets (Ortalo-Magné & Rady, 1999). Liberalization typically led to, first, more market-based mortgage markets, second, an increase in securization of mortgage loans, third, a higher LTV ratio and an expansion in mortgage debt. The detrended CLTV for the euro area captures well real house price movements roughly four years in advance. Chart 3 proves that the CLTV ratio was a reliable leading indicator to forecast house prices in the past. If this leading indicator remains stable in the future, euro area house prices should start decreasing in 2006. Annex 5 depicts country specific CLTV together with the real residential growth rate.

Chart 3



The sharp euro area house price growth rate has been caused by countries like Ireland, Spain, the Netherlands, and, to a lesser extent, France and Italy. It is interesting to investigate the question whether these countries exhibit larger variance over the entire sample. If in the past these same countries have shown strong volatility, the current phenomenon of large house price appreciation can be seen as predictable and expected to decrease in the future. As a rule, the answer is yes for all countries. Indeed, Chart 4 shows effectively that Spain, Ireland, the Netherlands and Finland are high volatility countries over the entire sample. Current large appreciation might be explained and expected to decrease for the same reasons by these countries exhibiting large variance. On the other hand, Belgium used to have a moderate volatility in the past while current volatility is much larger. But the weight of Belgium within the euro area is minor. Finally, the observed lower house price volatility from 1997 to 2005 relative to the entire sample for all countries is due to the pattern of the cycle. From 1997 onwards until today house prices have exclusively experienced a booming phase. Over the entire sample, however, there are several cycles characterized by a boom-bust pattern. As a result, it would be misleading to conclude that house price volatility is decreasing over time. On the contrary, according to Detken & Smets (2004) volatility of house prices increased over time due to financial deregulation.

Chart 4

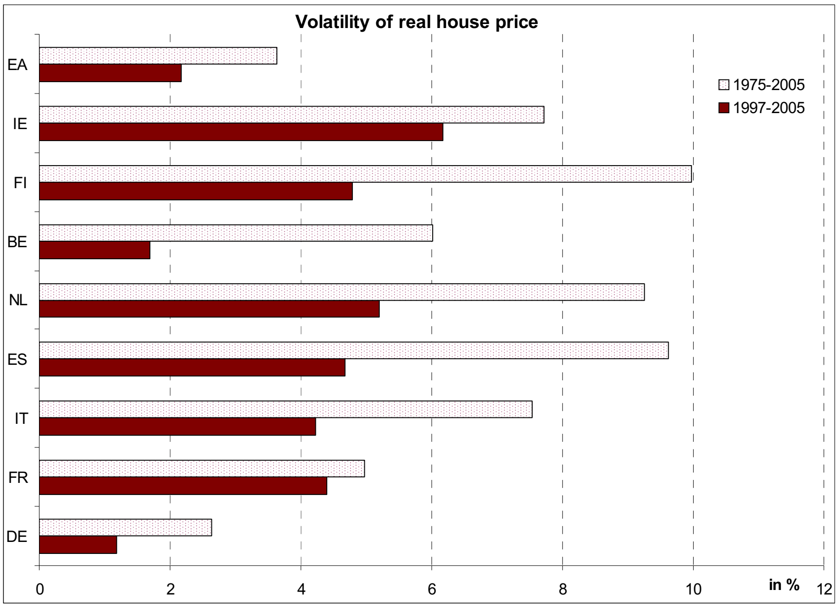
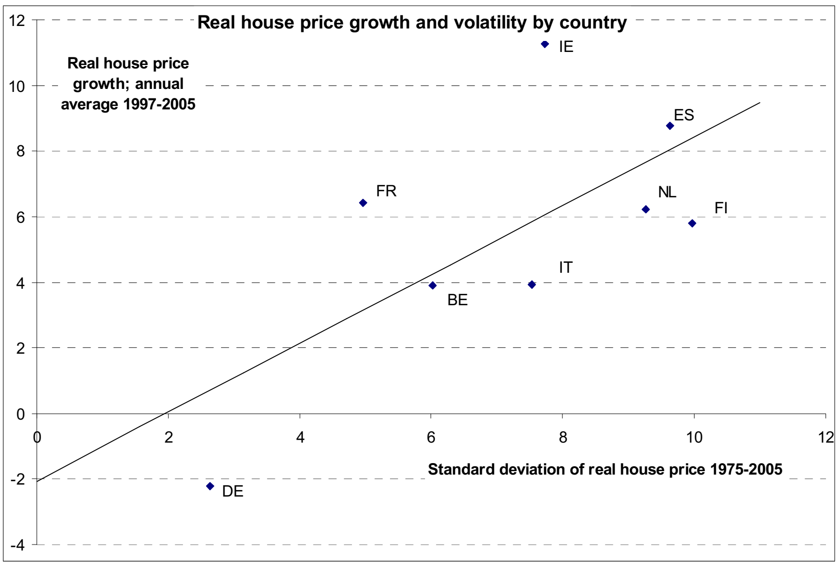
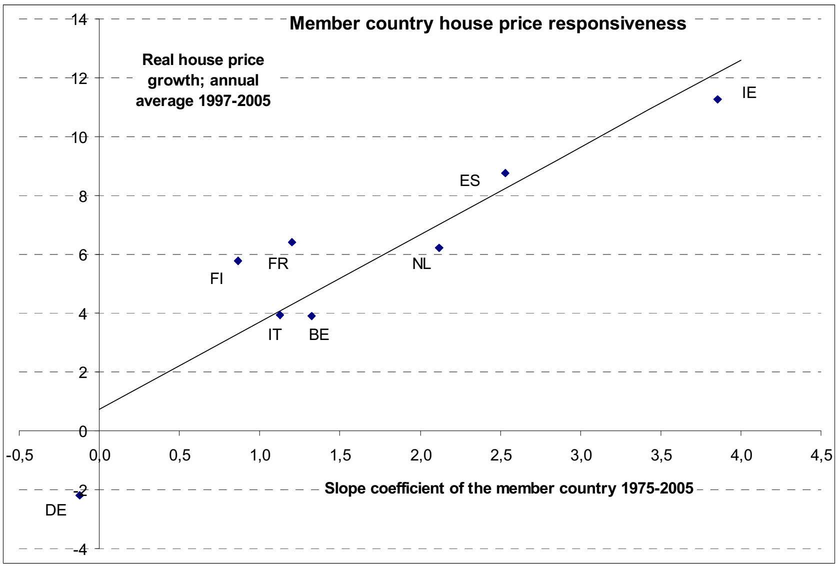


Chart 5



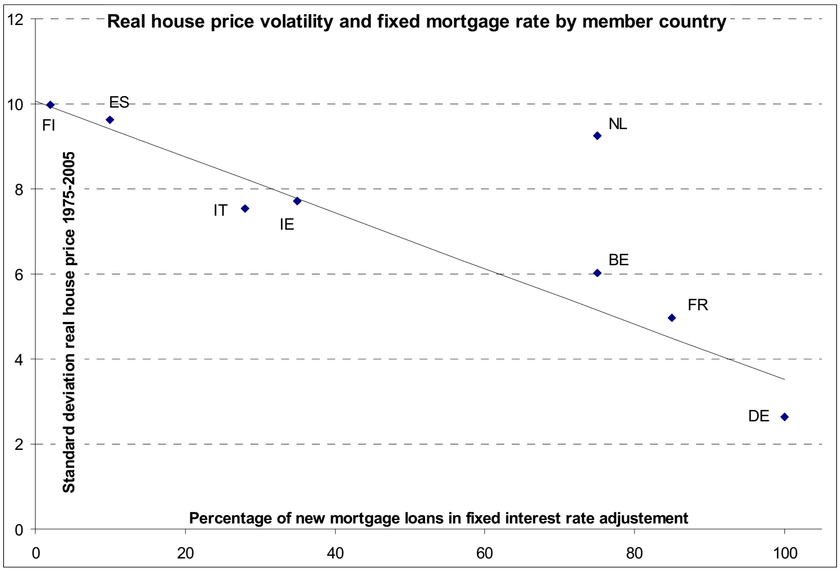
The relationship between the strong house price growth since 1997 and the overall volatility by country is deeper investigated. Two scatter diagrams show a relatively stable relationship. Chart 5 states that countries with stronger average growth rates since 1997 have also experienced standard deviations over the whole sample. By the same token, euro area house prices are regressed on country specific house prices from 1975 to 2005. The estimated slope coefficient has been associated with the average country specific growth rate from 1997 to 2005 in Chart 6. Once again a relatively stable relationship between real house price growth during the last eight years and house price responsiveness is established. Consequently, countries currently experiencing dramatic house price increase have already experienced large house price swings in the past. Thus, countries currently responsible for the strong euro area house price increase -"hot countries"- should also depress in the future at a larger scale than the "cold-countries". Finally, this proves also a systematic heterogeneity in variance among countries within the euro area. Despite the convergence of macro-aggregates due to the EMU, the functioning of the housing market depends essentially on country and local structural factors. The mortgage market system, local planing and urbanization scheme, taxes and land availability for instance remain country and even local specific.

Chart 6



Floating versus fixed mortgage rate practice is one of the major national feature in the European mortgage market. Mortgage market features affect strongly house price volatility as stressed in ECB (2003) and by Tsatsaronis & Zhu (2004). In countries where longer-term fixed rate mortgages with no prepayments have been more important, house price tend to be less sensitive to interests and other macro-aggregates. This leads to a less volatile house price. The scatter diagram (Chart 7) corroborates this statement. Indeed, a robust negative correlation between house price volatility and the percentage of outstanding mortgage loans with fixed interest rate contracts is established. The Netherlands is the only outlier as house price volatility is strong, despite a mortgage finance system predominantly based on fixed mortgage rate payments. There are other features on the house market like LTV and Mortgage Equity Withdrawal (MEW). Among countries with predominantly fixed mortgage interest rate adjustment, the Dutch mortgage market is the only one characterized by a high LTV and where MEW is current practice. This might explain the Dutch idiosyncrasy.

Chart 7



3 Theoretical framework

Consider an economy in which there are two goods, a non durable composite commodity, c (numerator) and a housing good, h, with relative price with respect to the non durable good, p. Following for instance Poterba (1984) and Brueckner (1994), I suppose that a representative household maximizes its discounted life time utility under budget constraint. $U(h, c)$ is the instantaneous utility function, the life time utility function is Vo:

$$Vo = \sum_{t=0}^{\infty} \beta^t E_t U(c_t, h_t), \tag{1}$$

and β is the time discount factor. The economy evolves in a stochastic environment, hence E_t the expectation operator. At each period $t = 1, 2...., T$, the representative household chooses how much of the composite commodity to consume, c_t, how many bonds that mature in the following period to buy, b_{t+1} and the level of housing consumption to carry into the next period, h_{t+1}. The household's real income is y_t. The period bond interest rate is i_t, while the mortgage interest rate is i_t^M, the amount of mortgage loan is m_t and π_t is the inflation rate of the non durable good. The stock of housing depreciates at the rate δ. The household chooses sequences of consumption, bond holdings, and housing consumption subject to the constraint:

$$b_{t+1}+c_t+p_th_t+\frac{1+i_t^M}{1+\pi_t}m_{t-1}=y_t+\frac{1+i_t}{1+\pi_t}b_t+p_t(1-\delta)h_{t-1}+m_t. \quad (2)$$

The L.H.S. of equation (2) pertains to the uses of the funds: the real value of bond carried over the next period, current real consumption, current purchases of real housing stock and the financial burden (interest payments) from the previous period mortgage loan. The R.H.S. of equation (2) defines the origin of the funds: real income endowment, the yield of the bonds, the value of the house carried over the previous period net of depreciation and the amount of mortgage loan subscribed. A borrowing constraint motivates a separate market for mortgage loans:

$$m_t=\kappa p_th_t, \quad (3)$$

with κ the LTV ratio imposed by the prudential rules which lies between 0 and 1. Annex 6 gives details of the intertemporal and intratemporal maximization. The straightforward solution of household's maximization problem yields:

$$\frac{U_{h_t}}{U_{c_t}}=p_t\left[1-\kappa\left(1-\frac{1+E_t(i_{t+1}^M)}{1+E_t(i_{t+1})}\right)\right]-E_t(p_{t+1})(1-\delta)\frac{1+E_t(\pi_{t+1})}{1+E_t(i_{t+1})}. \quad (4)$$

Equation (4) is the marginal rate of substitution (MRS) between consumption and housing and equals the user cost of housing. The latter is the slope of the budget line, which depicts the opportunity cost. The opportunity cost -or price- of an additional unit of housing is the amount of non durable goods that must be foregone to obtain it. $1-\kappa$ is the proportion of house value not financed by mortgage, i.e. the direct cost born by household to purchase the house. The second term in the first bracket:[5] represents the expected opportunity cost of financing part of the house by mortgage borrowing. The last and remaining term reflects the expected future value of the undepreciated portion of housing, discounted to the current period.

First, I calculate the MRS for the given instantaneous utility function: $U(h_t,c_t)=\ln h_t+\ln c_t$. Inserting the budget constraint (2), the borrowing constraint (3) and the MRS into equation (4) and solving it with respect to p_t gives:

$$\begin{aligned} & p_t\left[2-\frac{m_t}{p_th_t}\left(1-\frac{1+E_t(i_{t+1}^M)}{1+E_t(i_{t+1})}\right)-(1-\delta)\frac{h_{t-1}}{h_t}\right] \\ = \; & \frac{1}{h_t}\left[y_t+\frac{1+i_t}{1+\pi_t}b_t-\frac{1+i_t^M}{1+\pi_t}m_{t-1}+m_t-b_{t+1}\right] \\ & +E_t(p_{t+1})(1-\delta)\frac{1+E_t(\pi_{t+1})}{1+E_t(i_{t+1})}, \quad (5)\end{aligned}$$

after some arrangements and solving it again with respect to p_t yields:

[5] $\kappa\frac{1+E_t(i_{t+1}^M)}{1+E_t(i_{t+1})}$

$$
\begin{aligned}
& p_t\left(2-(1-\delta)\frac{h_{t-1}}{h_t}\right) \\
= \; & \frac{1}{h_t}\left[y_t+\frac{1+i_t}{1+\pi_t}b_t-\frac{1+i_t^M}{1+\pi_t}m_{t-1}+m_t\left(2-\frac{1+E_t(i_{t+1}^M)}{1+E_t(i_{t+1})}\right)-b_{t+1}\right] \\
& +E_t(p_{t+1})(1-\delta)\frac{1+E_t(\pi_{t+1})}{1+E_t(i_{t+1})}. \qquad (6)
\end{aligned}
$$

Equation (6) expresses the inverted demand of housing; price and quantity are characterized by an inverse relationship. Furthermore, real house price depends negatively on, first the current and expected real mortgage rate (current and expected mortgage payments), second the amount of bonds subscribed in period $t+1$, and third the spread between mortgage rate and bond rate. This latter actually reflects the borrowing constraint. Finally, ceteris paribus, real house price depends positively on disposable income (bond yield included), the amount of loan endowment and the expected discounted future house price, net of depreciation (net capital gain expectation).

Housing supply replete the dynamic general equilibrium model. In the short-term, housing supply[6] can be interpreted as an investment equation (see McCarthy & Peach, 2002):

$$I_t = \zeta E_t(p_{t+1}). \qquad (7)$$

The higher the expected house price, the larger the amount invested in housing by real estate investors. Equation (7) is a poor specified investment equation where construction costs and interest rate are omitted for the sake of clarity. On the other hand, the law of motion of the housing stock is:

$$h_{t+1} = h_t + I_t - \delta h_t. \qquad (8)$$

Substituting the investment equation (7) into the law of motion of housing stock (8), supply can be rewritten as a cobweb model:

$$h_{t+1} = h_t + \zeta E_t(p_{t+1}) - \delta h_t. \qquad (9)$$

The quantity supplied to the house market is determined by expected future house price. Supply in the current period is perfectly inelastic. Inertia in the supply of housing is featured in most of the literature dealing with housing supply. Empirical investigations have proven that the supply is typically constrained (Muellbauer & Murphy, 1997; Kenny, 2003). The demand, equation (6), responds to the usual factors (disposable income, user cost of housing etc.) and determines an equilibrium price, which feeds into next year's supply, see Annex 7. Thus, the supply reacts with delay (supply 2) relative to the demand which typically moves much faster (demand 1 to demand 3). As a result, there always exists the potential for house prices to overshoot their long-run equilibrium level following a sudden increase in housing demand (Kenny, 1999, 2003). This supply-demand interaction over time leads to the house price cycle.

[6] For a thorough theoretical and empirical investigation of housing supply, see Kenny (2003).

Substituting supply equation (9) into the nominator of L.H.S. of equation (6) (h_{t-1}) gives

$$p_t \left[2 - \left(1 - \frac{\zeta E_{t-1}(p_t)}{h_t} \right) \right].$$

Again, substituting supply equation (9) into the denominator this time of L.H.S. of equation (6) (h_t) gives:

$$p_t \left[2 - \left(1 - \frac{\zeta E_{t-1}(p_t)}{(1-\delta)h_{t-1} + \zeta E_{t-1}(p_t)} \right) \right]. \tag{10}$$

For the sake of clarity, the expression (10) and R.H.S. of equation (6) will be simplified. First, common knowledge between representative household and supplier is assumed. The house price expectations of household and investor are identical. Moreover, although the view of naïve forecast expectation has been challenged by Muellbauer & Murphy (1997), rational expectation hypothesis is not realistic either. Following Levin & Wright (1997) expectations of future changes in real housing prices are proxied by past changes in real housing price. It is assumed that expectations are based on current and past realization. This allows the introduction of inertia in the house price process which stems from the demand, a realistic assumption. By the same token, expected interest rates depend on past realizations. Consequently, the following expectations are introduced:

$$E_t(p_{t+1}) = \alpha p_t + (1-\alpha)p_{t-1},$$

$$E_t(i^M_{t+1}) = \gamma i^M_t + (1-\gamma)i^M_{t-1},$$

$$E_t(i_{t+1}) = \gamma i_t + (1-\gamma)i_{t-1}.$$

Second, wealth is introduced and reflects the total revenue of income and bond interest payment:

$$w_t = y_t + \frac{1+i_t}{1+\pi_t} b_t.$$

Finally, in view of the forthcoming estimation and panel cointegration results, the total amount of households: N_t and the aggregated stock of houses: H_t are introduced in the economy, thus: $h_t = \frac{H_t}{N_t}$.

Altogether, inserting all these elements in the expression (10) and R.H.S. of equation (6) yields, I approximate a log-linearized equation, of the following form:

$$\begin{aligned} \tilde{p}_t &= a_{11}\tilde{p}_{t-1} + a_{12}\tilde{p}_{t-2} - a_{20}\tilde{H}_t + a_{21}\tilde{H}_{t-1} - a_{30}\tilde{N}_t + a_{31}\tilde{N}_{t-1} \\ &\quad + a_{40}\tilde{w}_t - a_{50}i^M_t - a_{51}i^M_{t-1} - a_{60}i_t - a_{61}i_{t-1} + a_{70}\tilde{m}_t, \end{aligned} \tag{11}$$

and $a_{ii} > 0$ for all i.

Housing market house prices exhibit significant serial correlation. This autoregressive term (lagged dependent variable) is in line with the literature (IMF, 2004; Lecat & Mesonnier, 2005) and depicted in Annex 7. Indeed, the housing supply is inelastic and this inertia makes the house price process highly persistent (Muellbauer & Murphy, 1997; Kenny, 1998; IMF, 2004; McCarthy & Peach, 2002). Not only does the supply side of the housing market adjust gradually, due to the housing stock being fixed in the short-term, but so does the demand side. Households develop expectations by looking backward at historic prices. The relationship between real house price and stock is negative at time t, but positive at time t-1. The former describes the demand side, the latter the supply side. Finally, the largest lag order is 2 for house prices, consequently the following generalized dynamic process is proposed:

$$A_0\tilde{Z}_t = A_1\tilde{Z}_{t-1} + A_2\tilde{Z}_{t-2}, \tag{12}$$

with vector: $\tilde{Z}_t' = (\tilde{p}_t, \tilde{H}_t, \tilde{N}_t, \tilde{w}_t, i_t^M, i_t, \tilde{m}_t)$.

4 Econometric methodology

4.1 Proxies in literature on housing

Equilibrium house price, as in any other market is the match between demand and supply. However, most estimates of house price equation are best viewed as inverted demand (Lecat & Mesonnier, 2005; IMF, 2004 and Tsatsaronis & Zhu, 2004). Supply side factors are often absent. Consequently, they estimate a demand function by assuming an inelastic supply. At first sight, one may think that this may cause a problem of miss-specification. Indeed, if, for example, the observed house prices result from a supply shift along the demand curve, the estimates are biased (simultaneous equation bias, Hamilton, 1994). However, the risk of misspecification is not so important as they do not estimate the long-term relationship in level but the dynamics of house price growth rates which are mainly demand-driven.

Demand side factors are investigated by numerous proxies. For instance Tsatsaronis & Zhu (2004) use the GDP per capita as proxy to capture households' income, unemployment and wage, while some authors (e.g. Lecat & Messonier, 2005) use the disposable income per capita in real terms. Nevertheless, some other authors employ the permanent income as affordability variable, which in turn is proxied by consumption of non-durables and services and financial wealth (McCarthy & Peach, 2004, 2002; Bessone, Heitz & Boissinot, 2005). In Tsatsaronis & Zhu (2004) the link between GDP per capita and house prices is very tenuous while disposable income is largely significant in Lecat & Messonier (2005) and IMF (2004). This may be due to the different choice of proxy. In Tsatsaronis & Zhu (2004), CPI inflation has the strongest impact on the real house prices. This can be explained especially in high-inflation countries where hedging against inflation risk is current practice.

As regards financial conditions proxies (the capability to borrow), authors also differ, distinguishing between short/long-term and between nominal/real. Tsatsaronis & Zhu (2004) use the short-term nominal interest rate while all other variables are expressed in real terms in their model specification. Frictions in the credit market and inflation expectations underpin the use of nominal interest rates instead of real ones. To take into account the real affordability of the household, they incorporate the consumer price growth rate (CPI) and the real spread (difference between 10 years bonds and 3 month treasury bills deflated by the CPI). The importance of property investments as a hedge against inflation is investigated by including the CPI in the model. Lecat & Messonier (2005) employ the same financial condition proxies as Tsatsaronis & Zhu (2004) except that the short-term interest rate is expressed in real terms and the CPI is excluded. An alternative proxy for financial conditions instead of interest rates, is the user cost of housing (Bessone et al., 2005; McCarthy and Peach, 2004; Martinez & Àngel, 2003). This user cost of housing depicts the cost of holding a dwelling, including taxation, the expected valuation (capital gain) of the asset and its depreciation. The last financial condition variables investigated in the literature on housing, are real bank credit (mortgage loans, housing credits to households, or credit to the private sector) and real stock prices, which respectively aim at proxying mortgage rationing and the effort of households to rotate their portfolio in favour of housing (Lecat et al., 2005; Martinez & Àngel, 2003; Tsatsaronis & Zhu, 2004).

The less controversial result among the surveys, is the strong significance of financial condition variables (interest rate either, real-nominal or short or long-term, or even the spread, but also credit), while stock market prices are insignificant. Borio & McGuire's results (2004) can be reconciled with the non-significance of equity market return by supposing that both house prices and stock market prices are pro-cyclical. According to Tsatsaronis & Zhu (2004) not only do interest rate changes matter but so do national financial features like variable versus fixed mortgage interest rate, maximum loan-to-value and other prudential rules, or the level of deregulation, equity withdrawal, securized mortgage assets also have a significant impact on house prices. For instance, the link between credit growth and house prices is stronger in countries with more market-sensitive valuation methods (Tsatsaronis & Zhu, 2004). Lamont & Stein (1997) proved that credit constraint is a very important factor especially for indebted households. In the same stance, Lecat & Messonier (2005) show that financial conditions are essential factors explaining house price movements. They investigated the impact of structural changes. According to them, the deregulation of financial and credit markets mostly explain the house price bubble observed in the late 80's in France.

The third type of structural factors affecting the housing demand may be the gradual shift in demographics, the change of the number of households proxied by population aged from 15-65 years (IMF, 2004) or total population (Lecat & Mesonnier, 2005). According to the cited literature, these variables change very softly and have a low explanatory power in the short-term. In the long-run, however, demographic factors might have an influence (Mankiw & Weil, 1989) but it is difficult to assess since housing is a superior good.

Finally, about empirical results concerning price misalignment with respect to the fundamentals, the conclusions are different according to the countries. The IMF (2004) survey covering 18 industrial countries show that not only structural factors, like the fall in average short-term interest rates and the increase in the average growth rate of disposable income have contributed to the house price boom, but also the boom in credit. Guene (2004) also observes in the euro area a price misalignment with respect to fundamentals but it is much more moderate. This may be due to the falling real house price in Germany which account for more than a third in the euro area aggregate. Martinez & Àngel (2003) might observe in Spain a bubble as the strong significant interest rates can only explain partially the house price boom. In contrast, McCarthy & Peach (2004) conclude that there is no bubble in the USA ; house price increase is coupled with personal income growth and decline in nominal interest rates. In the same stance, Bessone et al. (2005) find no evidence of a bubble in France, especially currently when compared with the risk premium level reached in the beginning of the 90's. Lecat & Messonier (2005) financial deregulation proxy does not offer any explanation for the recent house price boom. According to the authors, the current house price boom can be explained by the interaction between low interest rates and a friendly legislative framework boosting access to mortgage credit.

4.2 The model specification

Recalling equation (11), the lack of some data obliges to assume that the gap between mortgage rate and bond interest rate is time-invariant, i.e. $i_t^M + \mu = i_t => E_t(i_{t+1}^M) + \mu = E_t(i_{t+1})$, and μ is a constant. Following this assumption, mortgage loans vanishes in equation (13). On the one hand, the risk of multicollinearity is averted. On the other hand, a credit constraint indicator is not taken into account, that is for the bad news. Last remark, interest rate increase has also a positive effect on households' wealth through bond interest payments, which increase consumer affordability and so positively impact house prices. I suppose this effect is benign, i.e. the negative effect through the increased mortgage burden largely outweighs the wealth effect. Including these elements in equation (13), the reduced form of the housing market equation with respect to the proxies gives an ARDL (2,2,2,2,2,2) process:

$$p_{i,t} = \psi_{i,11} p_{i,t-1} + \psi_{i,12} p_{i,t-2} + \sum_{j=2}^{6} \sum_{k=0}^{2} \psi_{i,jk} X_{i,j,t-k} + u_i + \epsilon_{i,t}, \qquad (13)$$

and $i = 1.....8$ are the 8 EMU countries investigated, u_i is the country fixed effect, whereas k is the lag operator indicator (time) ; finally $j = 2....6$[7] is respectively, log of stock of dwelling, log of real income per capita (population aged from 15 to 64), nominal short-term interest rate, population aged from 15-64, and detrended log of mortgage loan[8] which can be written as transpose of the vector X:

$$(X_{i,2,t}; X_{i,3,t}; X_{i,4,t}; X_{i,5,t}; X_{i,6,t}) = (dw_{i,t}; dy_{i,t}, in_{i,t}, po_{i,t}, lm_{i,t}).$$

Starting from the general ARDL model, I derive at time t the long-run reduced house price function (steady state):

$$p_{i,t} = \frac{1}{1 - \psi_{i,11} - \psi_{i,12}} \left[\sum_{j=2}^{6} \sum_{k=0}^{2} \psi_{i,jk} X_{i,j,t} + u_i \right] + \eta_t. \qquad (14)$$

The PMG estimation procedure allows to estimate a common long-run coefficient. I have to test whether the variables are I(1) and cointegrate, making η an I(0) process. So, the error correction equation is:[9]

$$\begin{aligned} \Delta p_{i,t} &= (\psi_{i,11} - 1)\Delta p_{i,t-1} - (1 - \psi_{i,11} - \psi_{i,12})\eta_{t-2} + \sum_{j=2}^{6} \psi_{i,j0} \Delta X_{i,j,t} \\ &\quad + \sum_{j=2}^{6} \sum_{k=0}^{1} \psi_{i,jk} \Delta X_{i,j,t-1} + \epsilon_{i,t}. \qquad (15) \end{aligned}$$

[7] $j = 2....5$ when mortgage loan is omitted.
[8] Annex 1 gives a detailed review of data sources and construction.
[9] Annex 8 gives a detailed a thorough calculation of equation (16).

Δdw is the growth rate of the stock of dwelling, Δp is the growth rate of the house price,[10] Δdy is the growth rate of household's real disposable income, Δpo growth rate of population, Δlm growth rate of mortgage loans, and Δin is the first difference of the nominal interest rate.

For a long relationship to exist, $\psi_{i,11} + \psi_{i,12}$ must be different from one. Short-run coefficients and the disturbances must be independent to have consistent estimates. In contrast, as shown by Pesaran et al. (1997) the long-run coefficients of the $X_{i,j}$ can be dependent, as long as $X_{i,j}$ have finite-order autoregressive representation. Consequently, in the cointegration relation, coefficients in front of endogenous variables are consistent, but short-term coefficients are not. The PMG also allows σ_i to differ across countries besides a fixed effect u_i. The Mean Group (MG) provides consistent estimates of the mean of the long-run coefficients, but inefficient if slope homogeneity holds (Pesaran et al., 1997). Under long-run slope homogeneity, the pooled (PMG) estimator is consistent and efficient. Therefore, the effect of the heterogeneity on the means of the coefficient can be determined by a Hausman type test applied to the difference between MG and PMG estimates. However it is important to notice that as T is small, making inference about the speed of adjustment is difficult.

4.3 Choice of estimator

The choice of the econometric methodology is based on the following considerations. First, the short time dimension of the available data on a country level hinders robust estimates with classical time series econometrics. Indeed, the annual data available ranges from 1975 to 2005 (31 observations). Heterogeneous estimators are normally unstable (individual country estimates vary within wide ranges) and unreliable, though they have the desirable property of allowing for differences among countries. Panel econometrics allow a substantial gain in power. In addition, panel estimators are proven to deal better with the problem of measurement bias (see Baltagi et al., 1995). In the same stance, Baltagi & Griffin (1997) show that pooled estimators have desirable properties and typically outperform their heterogeneous counterparts. For example, they find that pooled models tend to produce more plausible estimates even for panels with relatively long time series and that they offer overall superior forecast performances.

As a rule, two methods are used to estimate long-run and short-term dynamic in panel econometrics. On the one hand, the first supposes to estimate N separate regression (for each country) and to calculate the coefficient means. This estimator, e.g. Mean Group (MG), is consistent but mostly inefficient. On the other hand, the traditional pooled estimators, such as FE, RE, IV and GMM, which assume that the slope coefficients and error variance are identical, are performed. The asymptotic properties in case of large T and small N with traditional panel econometric procedures have proven to produce inconsistent estimates in dynamic panel data unless the slope coefficients are in fact identical. This assumption of homogeneity among euro area countries is far-fetched as observed in section 2. First, Pooled Mean Group (PMG), which assumes homogeneity of long-run coefficients but allows short-term elasticities to vary across countries (groups or cross-sections), combine the benefits of both classes of estimators. Second, as already mentioned in the previous section, house price is a persistent process. The PMG allows autoregressive terms, and

[10] House price is proxied by residential property price: Δrpp.

so captures one striking feature of the house price process. Third, any empirical attempt at modeling the housing market must clearly distinguish the long- from the short-run dynamic since I want to estimate a house price equilibrium. Finally, allowing heterogeneity in short-run parameters averts the problem of spurious and overestimated relationship, as explained by Haque, Pesaran & Sharma (2000).

More precisely, Pesaran, Shin & Smith (1997) propose an intermediate estimator, the PMG estimator. This is essentially a dynamic error correction model that allows the short-run parameters to vary across countries (groups), while restricting long-run elasticities to be identical across countries. The problem of heterogeneity among countries highlighted in section 2 assails the use of classical panel econometrics. Instead, the PMG estimator allows to estimate the common long-run coefficient without making less plausible assumptions of identical dynamics in each country. Imposing long-term homogeneous coefficients across euro area countries may be seen as tantamount to estimating the long-term relationships in the euro area. ECB policy decisions are based on euro area aggregates. The panel parameters estimated are used on a euro area level, muting the problem caused by the homogeneity assumption on long-term parameters. Moreover, assuming long-term homogeneity on a euro area level can be defended as countries have become more integrated over the past two decades. The launch of the euro particularly boosted the integration of the financial market, i.e. the synchronization of interest rates of short and longer maturity coined a common business cycle.

On the other hand, the mortgage market remains strongly characterized by national features, and this market interacts with the housing market. Although long-term house price movements across countries may be synchronized since the forces driving house prices (such as output and interest rates) tend to move together across euro area countries, housing is quintessentially a nontradable asset. House price dynamics depends on local elements, e.g. land price and availability, urbanization policy, mortgage financing tradition, supply channel etc. Indeed, the stylized facts in section 2 highlighted strong idiosyncrasies across countries. The PMG estimator allows not only country-specific short-term coefficients to differ but also to estimate country-specific long-term coefficients (at least for a sub-set). This possibility is very welcome with respect to the matter of the empirical estimation. According to the empirical results and diagnostic tests, I will decide whether to impose full homogeneity in the long-run or only partially. Thus, the PMG estimator is a suited estimator regarding the purpose of the empirical study.

Based on these statements, this paper will employ Pesaran, Shin & Smith (1997) estimator in order to gauge the periods when disequilibrium have arisen and the nature of the disequilibrium (under-supply versus under-demand). The actual house price is compared to the long-run price equilibrium. Actual house price is theoretically underpinned by the general equilibrium model in section 3. The long-term house price equilibrium can be easily derived from the same general equilibrium model. Equilibrium price is tantamount to the steady state house price and is calculated by assuming $\tilde{Z}_t = \tilde{Z}_{t-1} = \tilde{Z}_{t-2}$. The misalignment of actual house price with respect to the long-run house price equilibrium cannot be assimilated to a bubble as defined by Stiglitz (1990).[11] On the contrary, the

[11] In Stiglitz definition, the non fundamental part of a price increase is a bubble. A bubble in turn is based on expectations: the level of prices has been raised beyond what is consistent with the underlying fundamentals of the asset pricing evaluation and buyers of the asset do so with the expectation of future price increase.

cycle is a salient feature of house price due to the functioning of the house market.

4.4 Endogeneity

Equation (16) includes three endogenous variables: lm, dw and p. First, the volume of mortgage loan is endogenous to the house price via the lending collateral (see Ott, 2006b). Banks are only willing to lend if the borrower owns a collateral. As this collateral is the house itself, an increase of house prices will induce an increase of mortgage loans. Thus, causality is hard to pin down, as rising mortgage debt may be the result of high prices, not the cause, while any co-movement could reflect a common response to a third factor such as interest rates and expected incomes. Second, the stock of dwelling is simultaneously determined by the demand and supply. On the one hand a positive demand shock puts house prices under inflationary pressure, on the other hand the increased house prices will trigger a positive reaction (albeit sluggish) of the supply mitigating the pressure. Third, in opposite to housing wealth, house prices are not included in the calculation of the disposable income,[12] consequently the disposable income is considered exogenous. The endogeneity of the interest rate is even less plausible, but possible through the simultaneous equation of the demand and supply of mortgage loans. However, monetary policy interest rate strongly determines the mortgage loan interest rate, the short-term and even the long-term interest rate. And I suppose that the monetary policy does not react[13] to house price variations.

In case of endogenous variables, the PMG estimator remains consistent for long-run coefficients but not for short-run coefficients. As a result, two short-term lag structures will be investigated. The first lag structure is chosen to omit short-run effects of stock of dwelling and mortgage loan; let us call it the restricted ARDL(2,0,x,x,x,x,0). Nevertheless this leads to another problem: the omitted variable bias. The other alternative is to choose a lag structure based on the information criteria by allowing short-term effect of mortgage loan and housing stock variation; I call it the unrestricted ARDL. To conclude, there is clearly a trade-off between omitted variable bias and inconsistency due to endogeneity.

5 Empirical results

5.1 Panel unit root tests

The major caveat of classical time series unit root tests (e.g. ADF or KPSS tests) applied individually to each country (group or section) is the lack of power. Indeed, the relatively short time span (T=31) gives too few observations. However the time span is long enough to be concerned by the stationary proprieties of the series. As a consequence, to gain power, panel unit root tests are used. The first generation of panel unit root tests do not take into account possible cross-sectional correlations. The first test was developed by *Levin, Lin & Chu* (1993). Beside omitting the problem of cross sectional correlation, this test only allows for heterogeneity across sections (countries) by a fixed effect. The

[12] Renting revenues are included in disposable income. However, housing rents are not correlated with house price via arbitrage (Ott, 2006a, 2006b). Thus, it is not far-fetched to suppose that disposable income is exogeneous.

[13] Although the FED as well as the ECB have shown concern about house prices, it is however realistic to suppose that house price movements are not included in the reaction function of the Central Bank. Monetary policy interest rates are mainly driven by output gap and CPI inflation movements.

problem of heterogeneity is better taken into account by *Im, Pesaran & Shin* (1997) and *Maddala & Wu* (1999) tests. These tests suppose under H_1 not only heterogeneous autoregressive coefficients among sections, but also divergent cases among sections in view of stationarity. Im, Pesaran & Shin propose an average ADF test over the sections, and under H_0 all sections have a unit root without fixed effect.

A new generation of panel unit root tests[14] was developed, taking into account the problem of cross-sectional correlation: *Bai & Ng* (2001), *Moon & Perron* (2003), *Choi* (2002) and *Pesaran* (2003). Monetary union and the convergence process imply a very strong cross-sectional correlation among the series. This is particularly true for the interest rates. All four tests perform a unit root test only on the idiosyncratic component. The Bai & Ng test supposes to know the number of common factors in a total factor model. On the other hand, Moon & Perron, but also Choi, eliminate the common components of the series, and so perform a unit root test on the transformed series. These last two tests are certainly the most relevant ones with regard to their asymptotic properties. Finally, Pesaran's test (augmented Dickey-Fuller) does not transform the data. Instead the test is performed on the raw data.

First generation panel unit root tests, (1) *Levin, Lin & Chu*, (2) *Breitung*, (3) *Im, Pesaran & Shin*, (4) *ADF Fisher* (Fisher Chi-square, Choi Z-stat), (5) *Phillips Perron* test (Fisher Chi-square, Choi Z-stat), but also second generation: (1) *Bai & Ng*, (2) *Moon & Perron*, (3) *Choi* (4) *Pesaran*'s test have been performed. All tests were performed with a maximum lag order of 4. The number of lags were chosen automatically section by section based on the SIC (Schwartz Information Criteria). The null hypothesis for all tests is unit root. All variables are in log level, except the interest rate.

As can be seen in Annex 9, according to the second generation of panel unit root tests, all variables in level are found to have a unit root. However, the log of residential property price is found to be trend-stationary according to all three old generation tests (see Annex 10). The log of dwelling is also found to be trend stationary according to the Levin, Lin & Chu and Breitung's tests. On the other hand, Choi and Moon & Perron tests conclude to a unit root process for both series. I rather trust the new generation of panel unit roots, as there might be strong cross-sectional correlations. For these two series, however, as this contradiction casts some doubts, I also performed a country specific ADF tests (see Annex 11). Once again, the lag order chosen is based on SIC. According to the ADF test with or without trend, unit root processes cannot be rejected at 5 %. In first difference, the unit root is clearly rejected for all these series. Finally, the ratio stock of dwelling over population, as well as real interest rates proved to be I(0). For these reasons, the population was parted from stock of dwelling in section 3, and the nominal instead of the real interest rate was investigated.

5.2 Panel cointegration tests

The use of cointegration techniques to test for the presence of long-run relationships among integrated variables has enjoyed growing popularity in the empirical literature. Once again, the inherently low power of these tests when applied to sections leads me to use panel

[14]The new generation of unit root tests were performed thanks to the matlab codes developed by Christophe Hurlin.

cointegration tests.[15] Pedroni (1999) proposes 7 statistics to test under the null hypothesis no-cointegration in dynamic panels with multiple regressors (heterogenous slopes among cross-sections). About the 7 statistics, as time dimension equals T=31 and the section dimension equals N=8, only the *panel-t* and the *group-t* statistics offer good asymptotic properties (see Pedroni, 2004). Consequently, the investigation on long-run cointegration among series will be based on these two statistics only. It is also more relevant to use parametric statistics, since I have only 248 observations. Under the Ho hypothesis of no-cointegration, the statistics have to be compared with the critical values of the standard normal distribution N(0,1).

The results in the Table of Annex 12 fail to prove that all six variables in equation (15) cointegrate. However, Pedroni's tests reject the null of no-cointegration when the mortgage loan is omitted from the equation (15). Thus, I assume that residential property price, stock of dwelling, disposable income, interest rate and population cointegrate. To summarize, according to Pedroni's cointegration test, these series cointegrate, i.e. a long-term relationship is assumed. When the real mortgage loan is added, the fact that the six series cointegrate is less obvious according to Pedroni's test. Consequently, to address this issue, I estimate two different specifications by omitting or not mortgage loan. It is worth mentioning however that the results of Pedroni's test are only indicative for two reasons. First, Pedroni's tests do not deal the problem of cross-country correlation (Banerjee, 1999). Second, under Pedroni (1999, 2004) null hypotheses, heterogeneous slope is assumed while I only assume for some specifications heterogeneous slopes for mortgage loan. Indeed, the long-term relationship in the PMG is considered common among all countries. Being aware that the null hypotheses under the Pedroni's panel cointegration test does not match exactly the PMG assumptions, the residuals of the cointegration relationship is also tested. Pesaran et al. (1997) suggest to test whether the residuals are I(0) with the *Im, Pesaran & Shin* (1997)[16] test[17], and so to conclude whether the series cointegrate. This has been done in section 5.3.3.

5.3 Pooled Mean Group estimates

The PMG assumes three hypotheses. First, the disturbances in the ARDL model are independently distributed across the section and time, with zero means, and finite fourth-order moment; error variances σ_i can differ across countries. Besides, the independence of the disturbances and the regressors is needed for the consistent estimation of the short-run coefficient. As shown by Pesaran et al. (1997) it is relatively straight forward to allow dependence of the regressors on the error term with the long-run coefficients, as long as the regressors have finite-order autoregressive representation. Second, the ARDL process must be stationary. Third, the long-run coefficients of all regressors are the same across countries -with the possible extension to constrain only a subset.

Following Pesaran et al. (1997),[18] I estimate the dynamic heterogeneous panel equation (16) by using the maximum likelihood estimator. The estimates are computed with the Newton-Raphson algorithm, which uses both the first and the second derivatives of

[15] The cointegration tests were performed thanks to the Rats program provided by Pedroni (1999).
[16] The test itself was developed in 1997, however the publication year is 2003, see under Reference.
[17] A test which, under Ho, supposes an homogeneous slopes and country specific autocorrelation.
[18] The Gauss program was developed by Shin (1997) and is available on Pesaran's web site: www.econ.cam.ac.uk/faculty/pesaran/.

the likelihood function. I first estimate with standard PMG, i.e. with short-run dynamic heterogeneity but restrict all or a subset of the long-run coefficients to be the same across groups (countries). The variables are: *real house price*, *stock of dwelling*, *real disposable income per capita*, *nominal short-term interest rate*, *population aged from 15-64 and detrended outstanding mortgage loans.*[19]

Annex 13 reports the result among different specification concerning restricted/unrestricted and with homogeneity/heterogeneity mortgage loan slope. First, the difference in the income coefficient estimates between the homogeneous mortgage loan slope and the specification omitting mortgage loan is substantial. However, among models with imposed lag structure, the difference in coefficients between the model without mortgage loan and the one with heterogeneous slope is quite tiny since below 15%. In contrast, interest rate coefficient differences ranges from 30 to 50%. This large difference can be explained by the interaction between interest rate and mortgage loan. The interest rate coefficient of the specification where the mortgage loan is omitted is much larger because it captures, not only the interest rate effect but also the credit rationing due to the problem of asymmetric information. This proves that households are typically dependent on financial institutions. Even though the mortgage loan is not proved to cointegrate by Pedroni's test,[20] I refrain from excluding it on the ground of asymmetric information theory. Indeed, the omission of mortgage loan as suggested in a neoclassical view might lead to an omitted variable bias. As a result, the mortgage loan is included in future specifications. A better proxy of credit rationing would have been the spread between government bonds and mortgage interest. Unfortunately, due to missing data, this alternative cannot be investigated.

5.3.1 Lag structure - endogeneity

The short-term dynamic will be specified according to an automatic lag selection or an imposed (restricted) one. First, the automatic lag selection specification based on the Akaike (AIC), Schwartz (SBC) or the Hannan and Quinn criteria (H&Q) is one of the most current option. Pesaran et al. (1997) propose a lag selection strategy in PMG estimations. Annex 14 reports the results from panel regression with unrestricted lag section criteria AIC and H&Q[21] with homogeneous or heterogeneous long-term mortgage loan slope. As can be established from Annex 14, the coefficient estimates between the different lag section criteria are very benign. However they once again differ when imposing or not long-term homogeneity on the mortgage loan coefficient. Second, I suggest to impose a given lag structure to eschew endogeneity problems (restricted ARDL). The strong persistence of house price growth is one striking feature highlighted in the literature and proved in this survey. Table 2 reports the short-term house price auto-regressive coefficients of the preferred models, all systematically significant at 95%, except in Germany. Consequently, the ARDL in level must be characterized by a lag order of 2 in its first rank. The lag order of the regressors is however more open to debate. In case of endogeneity, short-term coefficients are inconsistent. One solution is to suppose that the growth rate of the endogenous variables does not influence house price growth. Thus, I suppose that the stock of dwelling and real mortgage loans do not enter the short-term equation but only the long-term. The restricted ARDL specification is then of the form ARDL(2,0,x,x,x,0).

[19] All variables are expressed in logarithm, except the interest rate.

[20] As already explained, Pedroni's test is only indicative any way.

[21] The coefficients estimated based on the Schwartz criteria were very similar, and so omitted.

The PMG technique already implies high numbers of estimation parameters especially in heterogeneous mortgage loan estimates. Thus, I suggest to choose ARDL (2,0,1,1,1,0) instead of ARDL (2,0,2,2,2,0) due to the limited degrees of freedom. Moreover, estimates from the former yields better results in terms of stability than the latter. In addition, the long-term coefficient estimates between restricted and the unrestricted ARDL are benign. After the thorough investigation and the try of a number of alternative specifications, I select the four models reported in Table 1 under the two columns headed "homogeneous" and "heterogeneous mortgage loan" respectively. It reports the long-term PMG coefficient estimates and the error correction term by country. The results are quite satisfactory, both from the viewpoint of the explanatory power of the regressions, and from the viewpoint of the sign and level of significance of the coefficients. In particular, all common long-term coefficient estimates are statistically significant at conventional levels in any specification, restricted, as well as unrestricted, and signed in line with the theory. In the columns headed *lm* in Table 1, the heterogenous mortgage loan coefficients are all right-signed except Belgium. However, the coefficients are not all significant, in the restricted 5 countries over 8 and in the unrestricted half of the countries. The importance of each factor will be investigated in the next section.

In Table 1, differences between the restricted and unrestricted model are very minor. The differences in stock of dwelling and population do not account. Indeed, the coefficient ratio stock of dwelling over population is roughly the same between restricted and unrestricted model. Annex 19 depicts for the euro area the fitted values of the restricted and unrestricted model with a common mortgage slope, and both display the same price history in level. The same holds with heterogeneous slopes in mortgage in Chart group 9. These results confirm, first, the stability and robustness of long-term coefficients irrespective not only of the lag restricted versus unrestricted structure, but also irrespective of mortgage loan slope homogeneity versus heterogeneity. Second, they also confirm the consistency of long-term parameter estimates across the models (Table 1), which are not affected by endogeneity problems. The problem however remains in the short-term specification. I am aware that excluding endogenous variables in the short-term specification may lead to another problem: the omitted variable bias. There is clearly a trade off between inconsistency due to endogeneity and the omitted variable bias. For this reason, both type of models, a restricted and unrestricted will be estimated. Even though the long-term picture between both specification is alike, the short-term dynamic is different, as proved later.

Table 1: PMG estimates restricted - unrestricted ARDL

Elasticities	Homogeneous mort. loan		Heterogeneous mort. loan			
long-term	ARDL(2,0,1,1,1,0)	H&Q	ARDL(2,0,1,1,1,0)		H&Q	
st. dwelling dw	-4.55 (-3.99)	-1.42 (-2.50)	-2.54 (-6.30)		-1.73 (-3.87)	
real income dy	3.03 (4.78)	1.18 (3.12)	2.06 (7.77)		1.90 (6.96)	
int. short. in	-6.91 (-5.34)	-2.97 (-5.42)	-2.68 (-5.14)		-2.60 (-5.10)	
population po	3.22 (3.16)	3.01 (5.40)	2.68 (4.25)		1.83 (4.24)	
mort. loan lm	0.06 (0.45)	0.30 (3.51)				
ECT coeff.	η	η	η	lm	η	lm
DE	-0.03 (-1.53)	-0.00 (-0.01)	-0.01 (-0.57)	0.36 (0.07)	-0.01 $(-0.20.)$	-13.7 (-0.20)
FR	-0.09 (-3.49)	-0.16 (-3.45)	-0.33 (-6.00)	1.36 (6.55)	-0.34 (-6.19)	1.59 (7.54)
IT	-0.10 (-1.72)	-0.31 (-3.96)	-0.17 (-2.22)	0.50 (1.47)	-0.34 (-4.75)	0.37 (2.47)
ES	-0.07 (-1.21)	-0.24 (-3.70)	-0.10 (-1.33)	0.17 (0.22)	-0.13 (-1.74)	-0.36 (-0.46)
NL	-0.14 (-2.97)	-0.11 (-2.16)	-0.24 (-3.00)	0.69 (3.02)	-0.22 (-3.34)	0.92 (4.17)
BE	-0.15 (-5.77)	-0.12 (-3.15)	-0.12 (-4.29)	-0.54 (-2.37)	-0.17 (-4.87)	-0.06 (-0.47)
FI	-0.24 (-3.99)	-0.61 (-6.32)	-0.62 (-6.42)	0.44 (3.19)	-0.60 (-5.65)	0.03 (0.16)
IE	-0.14 (-3.61)	-0.19 (-4.53)	-0.29 (-4.87)	0.62 (4.50)	-0.27 (-5.99)	0.68 (5.03)

In the second half section of Table 1, I also report the ECT (Error Correction Term) coefficients for each country under the column headed η. The long-run relationship is statistically significant in almost every country and across all 4 models, except in Germany and Spain for the homogeneous models. The hypothesis of no long-run relationship (Ho: η=0) is rejected in 7 out of 8 cross-sections in the less restrictive model (leftest column). The coefficients are all negative, implying that current house prices tend to return back to equilibrium following a shock. It is comforting that the long-run relationship does exist. More problematic is the large variance among countries and especially across models. The error-correction coefficient is a measure of how quickly each of the country should return to its long-run equilibrium following a shock. These speeds of adjustment vary quite considerably across models and countries. While countries can be very different, the large difference across countries proves an instability in the short-term coefficients. Italy and France have a speed of adjustment of approximately 11 years in the most restrictive model (rightest column) but only 3 years in the less restrictive model (leftest column)! In the same stance, for Finland (respectively Ireland) it varies from 4 years (respectively 7 years) to one and half year (respectively three and half) in the less restrictive model.

The variation of the speeds of adjustment may in part reflect the volatility in the sample under consideration as well as some degree of small sample bias. Interestingly, the less restrictive models have the highest speed of adjustment, while the most restrictive ones have the lowest.

Table 2 reports first, the short-term autoregressive house price coefficients of the models of Table 1 ; second, the mean group estimates under the column headed MG. As the econometric theory suggests, imposing homogeneity causes an upward bias in the coefficient of the lagged dependent variable. For almost all countries, the PMG estimates allow to come to more realistic persistence coefficient than for country specific estimates, this is especially true for Germany and Italy. These results confirm that the PMG estimator perform better than the more consistent MG estimator.

Table 2: Coefficient autoregressive term: Δp_{t-1}

	PMG hom		PMG het		MG	
Country	rest	unres	rest	unres	rest	unres
DE	0.43		0.42		-0.04	
	(3.08)		(3.00)		(−0.20)	
FR	0.92	0.80	0.56	0.36	0.43	0.31
	(7.46)	(6.86)	(4.04)	(2.89)	(2.41)	(2.80)
IT	0.29	0.12	0.23	0.03	-0.27	-0.36
	(1.79)	(0.73)	(1.43)	(0.16)	(−2.02)	(−2.62)
ES	0.59	0.79	0.59	0.81	0.78	0.78
	(3.74)	(7.67)	(3.70)	(6.60)	(5.20)	(7.17)
NL	0.67	0.37	0.78	0.45	0.40	0.37
	(6.09)	(2.96)	(7.12)	(3.89)	(2.11)	(2.87)
BE	0.60	0.99	0.85	0.94	0.63	0.47
	(8.23)	(8.46)	(14.37)	(9.86)	(5.18)	(2.00)
FI	0.66	0.69	0.74	0.66	0.75	0.59
	(4.59)	(5.20)	(6.46)	(4.57)	(4.42)	(3.68)
IE	0.34	0.53	0.32	0.38	0.35	0.34
	(2.50)	(4.62)	(2.71)	(3.56)	(2.38)	(2.31)

5.3.2 Long-term slope homogeneity and error variance

The error variance (or SE: standard error of the regression) differs strongly among countries as shown in Table 3. Equality of error variance across countries as assumed in dynamic panel estimators are not an appropriate assumption, leading to inconsistent coefficient estimates. Regarding this problem, PMG and MG perform much better. For obvious reasons as PMG is more restrictive, the SE of the PMG are systematically larger than the country specific sigma (MG) irrespective of restrictive, unrestricted, heterogeneous, homogeneous. Across the PMG models, the unrestricted heterogeneous model has the lowest SE on average (precisely: 0.040), whereas the restricted homogeneous model has the largest (precisely 0.048). Finally, the restricted heterogeneous model has almost the same as the unrestricted homogeneous one (0.043). These results corroborate the theory.

Table 3: Error variance across models by country						
	SIGMA restricted ARDL			SIGMA unrestricted ARDL		
Country	PMG hom	PMG het	MG	PMG hom	PMG het	MG
DE	0.020	0.021	0.011	0.020	0.019	0.006
FR	0.026	0.018	0.014	0.028	0.020	0.012
IT	0.072	0.070	0.034	0.065	0.060	0.032
ES	0.071	0.071	0.050	0.062	0.071	0.047
NL	0.057	0.056	0.042	0.048	0.043	0.029
BE	0.019	0.021	0.017	0.022	0.018	0.015
FI	0.072	0.056	0.054	0.052	0.056	0.046
IE	0.045	0.040	0.034	0.045	0.038	0.034

PMG imposes homogeneity of the long-run slope, this hypothesis can be tested using a likelihood ratio test, since PMG is a restricted version of the set of individual country equation. The log-likelihood ratio statistic (LR) is distributed as a χ^2 variate with kN degrees of freedom, where k is the dimension of the parameters and N is the number of countries (groups or sections). Although it is common practice to use pooled estimators without testing the implied restrictions, in cross-country studies, the likelihood ratio tests normally reject equality of error variances and slope coefficients at conventional significance levels. This is clearly the case in our models as reported in Table 4, even in the heterogeneous mortgage loan slope case. One possible explanation is that the group-specific estimates may be biased because of omitted variables or measurement errors that are correlated with the regressors. If the bias is non-systematic and averages to zero over groups, pooled estimation would still be appropriate despite the homogeneity assumption being rejected.

Table 4: LR statistic for equal long-term parameters				
		deg. freed.	LR stat.	prob-lim
restricted ARDL(2,0,1,1,1,0)	PMG hom	35	195.75	0.00
	PMG het	28	157.20	0.00
unrestricted ARDL H&Q	PMG hom	35	249.54	0.00
	PMG het	28	211.22	0.00

Another type of test can help testing parameter homogeneity: the Hausman (1978) test. Consistent estimates of the mean of the long-run coefficients can easily be obtained from the MG estimator. These, however, will be inefficient if slope homogeneity holds. Under slope homogeneity, the pooled estimator is consistent and efficient. Therefore, the effect of heterogeneity on the means of the parameters can be determined by a Hausman-type test between the MG and PMG estimates. As can been seen in Table 5 and 6, the null hypothesis[22] of long-term slope homogeneity is rejected at any common level, even in the unrestricted mortgage loan specification. Thus, it is proven that strong heterogeneity among country exists. This is a further reason to allow heterogeneous slopes at least in mortgage loans. It is however important to stress that, due to the low time span, the Hausman test might lack statistical power.

[22] Under the null of the Hausman test, there is no difference between the MG and PMG estimates.

Table 5: Long-run coefficients PMG and MG & Hausman test					
restricted ARDL(2,0,1,1,1,0)					
	Coefficients			Hausman test	
	PMG hom	PMG het	MG	h-test	p-lim
st. dwelling *dw*	-4.55 (-3.99)	-2.54 (-6.30)	2.73 (0.75)	2.12	0.15
real income *dy*	3.03 (4.78)	2.06 (7.77)	1.60 (2.67)	0.73	0.39
int. short *in*	-6.90 (-5.34)	-2.70 (-4.37)	-1.00 (-1.06)	5.46	0.02
population *po*	3.22 (3.16)	2.68 (7.03)	-7.03 (-1.02)	1.97	0.16
mort. loan *lm*	0.06 (0.45)	0.45 (2.38)	0.47 (2.08)		
	Joint Hausman Test:			14.86	0.00

Table 6: Long-run coefficients PMG and MG & Hausman test					
unrestricted ARDL H&Q					
	Coefficients			Hausman test	
	PMG hom	PMG het	MG	h-test	p-lim
st. dwelling *dw*	-1.42 (-2.5)	-1.73 (-3.87)	4.71 (1.05)	2.08	0.15
real income *dy*	1.18 (3.12)	1.88 (6.96)	1.02 (1.00)	0.76	0.38
int. rate *in*	-3.0 (-5.42)	-2.60 (-5.16)	-0.60 (-0.76)	12.25	0.00
population *po*	3.01 (5.40)	1.83 (4.24)	-9.88 (-1.26)	2.23	0.13
mort. loan *lm*	0.31 (3.51)	0.46[23] (1.78)	0.48 (1.77)		
	Joint Hausman Test:			15.50	0.00

In conclusion to this section, I propose to restrict the analysis to the restricted and unrestricted models with heterogeneous mortgage slopes for three reasons. First, as highlighted in this section, homogeneous slope assumption may cause inconsistent estimates. The homogeneity assumption is too strong for the detrended mortgage loan series. Second, the ECT coefficient is significant and right signed for Spain. Finally and mostly, short-term dynamic estimates are less sensible in the homogeneous case. Consequently, I will restrict the analysis to the two heterogeneous models hereinafter.

5.3.3 Residuals

Importantly, residuals of the two models considered -restricted and unrestricted with heterogeneous mortgage loan slope- must be stationary. Annex 15 and 16 display the residuals which seem to show mean reversion. To confirm the intuition, the IPS (Im, Pesaran &

[23] The German mortgage loan coefficient has been omitted.

Shin, 1997) unit roots test in heterogeneous panels was performed.[24] This test allows for individual effects, time trends, and common time effects. Based on the mean of the individual Dickey-Fuller *t-statistics* of each unit in the panel, the IPS test assumes that all series are non-stationary under the null hypothesis. Lags of the dependent variable may be introduced to allow for serial correlation in the errors. The exact critical values of the *t-bar* statistics are given in Table 7 below. Under the null hypothesis of non-stationarity, the p-value rejects at any common level unit-root for any sensible lag. To conclude, both models track actual house prices fairly well in most countries, but still diagnostic tests must be performed.

Table 7: Im, Pesaran & Shin unit root test

Residuals	lag	t-bar	W-bar	p-value
restricted	0	-3.18	-8.72	0.00
	2	-3.13	-8.19	0.00
unrestricted	0	-2.50	-5.21	0.00
	2	-6.02	-21.22	0.00

Table 8 and 9 reports the diagnostic tests on the error correction models, including estimates of goodness of fit. These tests are designed to empirically examine whether the underlying statistical assumptions of the model hold. First, corrected R-squared figures vary by country, but overall they suggest that the explanatory variables explain more than 60 % (restricted) and almost 66% (unrestricted) model the fluctuations in the countries in average. In 5 to 8 countries considered, the models explain over 60% of the change in real residential property price growth rate, and in all but 2 countries (Germany and Italy) the corrected R-squared is higher than almost 50%. The overall explanatory power of the models is satisfactory. Second, most country regressions in the panel are robust to standard diagnoses. The following exceptions must be stressed. At the 5% significance level, both models' error terms show problems of serial correlation for Italy. Moreover, functional form misspecification is a problem in Germany (restricted model) but also in the Netherlands and Ireland (unrestricted model). However, whether violation of functional form for these 2 countries will significantly alter our 8-country panel estimates is highly doubtful. The assumption of normally distributed errors is also violated in the case of Italy in a restricted model. However, in large samples, strict normality is not required as long as errors have the same variances. The test of error variances is reported in the column headed "Ch-HE" and indicates that none of the countries are significantly affected in the restricted model. In the unrestricted, however, the Netherlands show abnormal variance, but this heteroscedasticity may not be troublesome as all residuals are normally distributed.

[24] The IPS test was performed on STATA thanks to the codes developed by Christopher Baum and Fabian Bornhorst.

Table 8: Diagnostic tests restricted ARDL(2,0,1,1,1,0)						
Country	$\bar{R}^2$	Ch-SC[25]	Ch-FF[26]	Ch-NO[27]	Ch-HE[28]	LL[29]
DE	0.38	0.18	7.57	0.72	2.25	77.81
FR	0.87	1.33	0.03	0.08	1.79	81.59
IT	0.17	61.2	0.34	19.87	0.02	42.95
ES	0.47	0.05	0.43	1.40	0.57	42.48
NL	0.62	3.43	0.36	1.19	1.48	49.35
BE	0.87	0.60	14.6	0.81	1.28	77.61
FI	0.69	0.04	0.19	1.45	0.63	49.50
IE	0.74	0.01	3.40	1.16	3.31	59.30

Table 9: Diagnostic tests unrestricted ARDL H&Q						
Country	$\bar{R}^2$	Ch-SC	Ch-FF	Ch-NO	Ch-HE	LL
DE	0.46	5.67	0.64	0.36	3.22	81.71
FR	0.85	2.48	0.55	0.17	2.28	79.58
IT	0.38	9.04	1.12	0.54	0.70	47.14
ES	0.46	3.39	1.67	0.84	1.25	42.32
NL	0.77	1.41	6.12	0.44	9.12	60.37
BE	0.90	3.29	3.13	0.85	3.22	84.65
FI	0.68	0.95	0.09	0.96	0.44	49.23
IE	0.76	0.77	4.31	1.38	2.76	59.05

6 Determinants of the euro area house price

6.1 Parameter aggregation

Deriving country specific conclusions based on panel parameter estimates might be risky. Instead, and it is the purpose of the paper, I suggest to infer insights on a euro area level, which in turn avert homogeneity problems. Basically, two aggregation methods as regards the PMG estimates might be used. The first supposes to derive the fitted values on a country level, and then to aggregate the fitted values to find the fitted euro area. The second, instead, suggests to derive euro area parameters and to calculate the fitted euro area house price with euro area series. The former might be the less controversial. The latter, is however more adapted to simulate euro area shocks or convergence to steady and analyze the consequence on the euro area house prices. For this reason, I choose the second aggregation method.

The long-term common coefficients of the error correction model can be taken in their raw form. However, short-run parameters and error correction coefficients are country-specific and so need to be aggregated into euro area coefficients. Also, the heterogeneous long-run mortgage loan coefficient must be aggregated. I propose to follow the aggregation rule used for the euro area series.[30] Consequently, the mortgage loan weighting is applied to the long-term heterogeneous mortgage loan coefficients for both models. The short-term

[25] Chi-square test of residual serial correlation
[26] Chi-square test of functional form misspecification
[27] Chi-square test of normality of residuals
[28] Chi-square test of heteroscedasticity
[29] Maximised Log-likelihood
[30] The explanation as regards the aggregation of national series to euro area level is given in Annex 2.

parameters estimates and the error correction coefficients were aggregated with different weightings. The corresponding weighting was applied with respect to the series, that is, residential property price weighting to the error correction coefficients and respectively to the lagged house price growth coefficient. The HICP weighting was used for the interest rate. The three other weightings (population, stock of dwelling, income) were calculated for the purpose of the parameter aggregation by means of the data set. Consequently, the second Table in Annex 2 gives the averages over the entire sample, as they are indeed-time varying, albeit at a very low range.

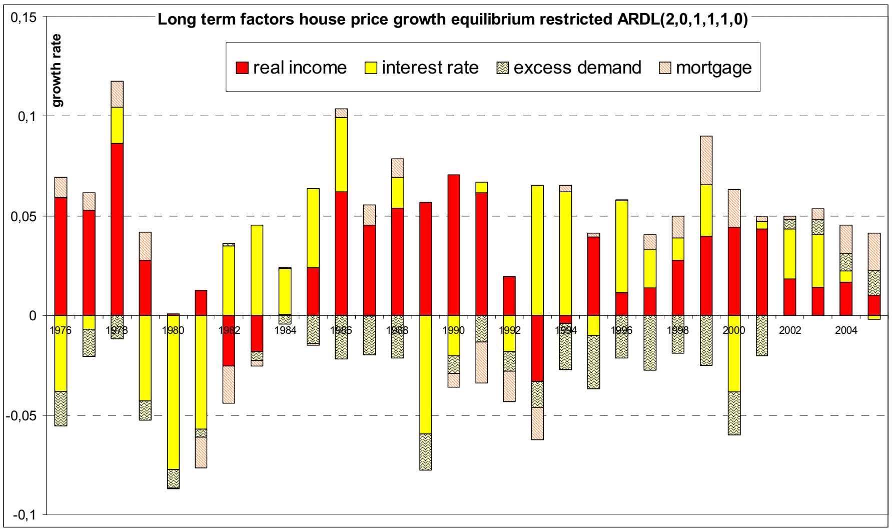
This aggregation yields sensible results as clearly stated not only in Annex 19 (homogeneous models) but also Chart group 9 and 10 (heterogeneous models). All four price levels deliver the same euro area house price history. Importantly, artificial euro area residuals have been constructed. The artificial residuals in Annex 17 prove that the unrestricted model tracks better current house price in the end of the sample period than the restricted model. Overall, both models track actual house price fairly well. I call it artificial as inference and diagnostic tests are not based on these residuals, but on the panel residuals shown by country in Annex 15 and 16. Indeed, the euro area models only exist through artificial aggregation. The artificial residuals in Annex 17 give insight on how well the two models perform with regard to the euro area house price forecast.

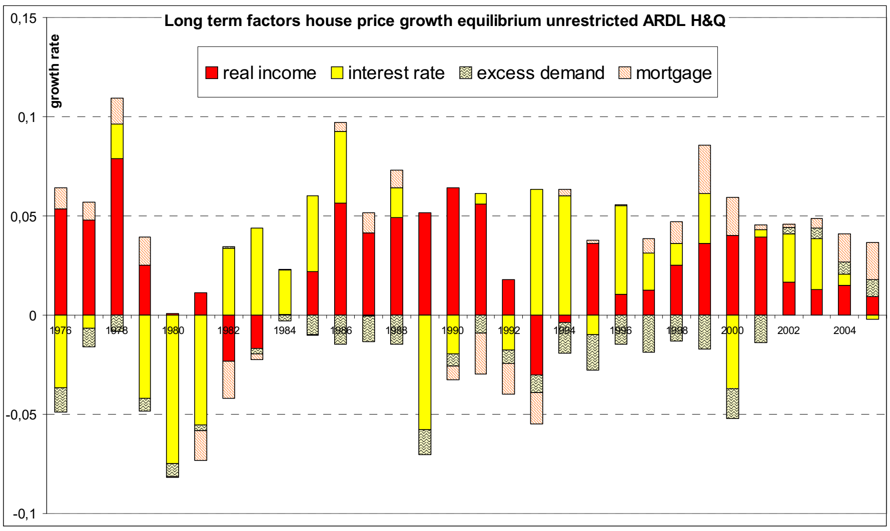
6.2 Long-term factors

According to the estimated coefficients shown in Table 1, the euro area real house price equilibrium over time was calculated (fitted value) for each specification. Annex 19 (homogeneous slope) and Chart graph 9 and 10 first graph (heterogeneous slope) depict the euro area long-term equilibrium price relative to the actual real euro area house price, the series are expressed in log index. Interestingly, fitted house prices in level (price equilibrium) have the same historical pattern across the four models, confirming the robustness of long-run coefficients. Misalignments can be interpreted as the difference between the actual (or current) and predicted euro area house price equilibrium. As can be observed, the actual house price overshoots the equilibrium price during three periods. The first begins with the second oil price shock in 1979 and finishes in the mid 80's (1985 exactly). The second starts in the late 80's and ends in 1997. Since 2000, the current house price is above the house price equilibrium and this misalignment has not shown reversion yet. The fitted euro area house price equilibrium captures well the house bubble of the 90's highlighted by the literature on housing. These results also prove that the current house price is over-valued with respect to long-term equilibrium. To examine the factors behind the model's equilibrium price, the growth rate of the equilibrium price is decomposed into the contribution factors, as can be seen in Chart group 8 for the restricted and unrestricted model, respectively.

The equilibrium price decreased sharply during the period 1979-1985. This dramatic equilibrium price decrease is not only due to the recession which occurred following the second oil price shock but also to the tightening of the monetary policy at the beginning of the 80's (which in turn exacerbated the recession) to purge the endemic consumer price inflation. Indeed, the Bundesbank led a harsh monetary policy to contain inflationary pressures, followed by the French authorities after the socialist experience in 1983 -the so called "politique du Franc fort". The deflationary effects of the monetary policy on the house price equilibrium can be seen in terms of price (interest rate) and quantity (mortgage loan[31]). The fact that the equilibrium price was below the actual house price during this period is not due to expectation behaviors on the house market price characterizing bubbles, but rather by the sudden decrease of the equilibrium price. Indeed, the interest rate and the disposable income explain essentially house price movements during this period. The actual house price followed the equilibrium price in a staggered way because of the inertia which is a typical feature of the house market.

Chart group 8: factors contributing to house price equilibrium growth





From the mid 80's to the mid 90's, the actual house price caught up the equilibrium price for three years and thereafter overshot it. The monetary policy succeeded in damp-

[31] Mortgage loan is a counterpart of money aggregate M3.

ening consumer price inflation quickly in the beginning of the 80's.[32] Consequently, the monetary authorities focused again more on fostering economic activity. The expansionary monetary policy starting in the mid 80s preceded and helped the economic recovery gain pace. Indeed, the two monetary policy stance indicators in our euro area model, i.e. interest rate and mortgage loan prove an expansionary monetary policy starting already in 1982. The former coupled with the latter positively impinged on the equilibrium price. The strong households' disposable income growth -commensurate with the business cycle- drove mainly equilibrium house price increase. Nevertheless, after 1988 the actual house price increased even more. Two factors explain the increasing gap between equilibrium house price and actual house after 1988. First, the Bundesbank until 1992 kept raising interest rates due to inflationary pressures exacerbated thereafter by the German reunification. Second, the structural reforms on the financial market -deregulation on the financial and credit market- allowed banks to overlend (see Annex 18, the growth rate of mortgage loan). The former effect impinged negatively on the equilibrium house price, while the latter fuelled the actual house price. The deregulation in the financial market provoked a bubble which burst in the first half of the 90's with the slowdown of the economic activity. In the end of the period under consideration, it is important to note that monetary policy stance indicators prove a tightening despite the slowdown of the euro area economy.[33] Some countries like France maintained the currency peg within the EMS (European Monetary System) against the tide in 1993 and 1995, at odds with the optimal "leaning against the wind" rule and thus even harming more economic activity. This also explains the weak growth of the equilibrium house price.

From 1996 to 2000, actual house prices tracked equilibrium house prices; thereafter, the latter has grown at a slower pace than the former causing an increasing disequilibrium gap with no reversion yet. From 1997 onwards, the convergence process towards the EMU and eventually the launch of the euro have allowed a substantial fall in the nominal interest rate due to a credibility gain for numerous member countries. Moreover the vigorous recovery and long-lasting growth of the economy in a low inflationary environment -associated with an accommodative monetary policy- improved twice the affordability power of households. First, the costs born to finance mortgage loans assuaged and, second, disposable income strengthened households' purchasing power. Manifold households took opportunity to materialize their dream provoking a current house price increase in line with the house price equilibrium. This environment characterized by strong fundamentals lead to a second round effect. As usual, banks thereafter relaxed their standard based on expected house price increase and income. Since pledging collateral is one way of alleviating the consequences of asymmetric information, housing prices may in turn also influence credit availability. The self-perpetuating process of increasing real estate increase and credit upsurge might explain the soaring house price increase overshooting house price equilibrium. The misalignment of house price equilibrium with respect to actual house price has been exacerbated by the recession in 2001. While the world economy, including the euro area, was already teetering on the brink of a recession, the terrorist attack on the 11th of September pushed it over the edge. The two leading factors driving house price equilibrium are interests and disposable incomes. The slowdown of the former impinged on the equilibrium house price moderately as it was compensated by a loosening of the

[32] Thereafter, the oil price drop in 1986 helped policy makers to keep the lid on inflation until 1988.

[33] The German economy was an outlier due to the reunification. This country-specific shock put the EMS under pressure.

ECB -leaning against the wind- policy. Altogether house price equilibrium has grown at a lower pace, exacerbating the gap between house price equilibrium and actual price.

The excess demand was derived by summing the effects of population and stock of dwelling on house price growth equilibrium. First, despite adding the housing depreciation effect, excess demand impinged negatively on house price over the sample, except in the last four years. As can be observed in Annex 18, stock of dwelling and population exhibit both a downward trend. Nevertheless, the growth rate of population is well below the stock of dwelling. Stock of dwelling do not take into account quality improvement in housing. Perhaps a new series stock of dwelling corrected by quality improvement and housing depreciation would exactly offset the growth of the number of households in the long-turn, at least this is what theory would suggest. Due to missing data on quality, this hypothesis cannot be tested. Second, in a PECM, there is no possibility to identify several cointegration relationships (cointegration rank) within a single model. One alternative would have been to estimate a demand and a supply separately, but this option is flawed by poor supply side data. Instead, a reduced model (very close to a demand equation) was estimated with the drawback of not being able to identify what belongs to demand versus supply. Thus, conclusions based on excess demand should be taken with caution. According to Chart group 8, however, supply did not react quickly enough at the end of the period under consideration, and thus provoking a positive excess demand which had a positive impact on the house price equilibrium.

6.3 Short-term factors

As discussed earlier, heterogeneous mortgage loan slopes[34] have been chosen because the short-term parameters are more sensible than in the homogeneous pairwise models. Chart group 9 depicts the results of the restricted model while Chart group 10 depicts the unrestricted ones. The first graph shows the current house price in level beside the estimated euro area house price equilibrium. The chart in the middle shows the short-term dynamics of the current house price beside the fitted values of the error correction model. Finally, the bottom graph indicates the factors driving the house price dynamics according to the model estimates.

The restricted model captures well the current house price dynamic until 2001. Afterwards, the model predicts a substantial drop in the growth rate bottoming at 2%, while actual house price kept growing eventually exceeding 6% per year the last two years. This proves that the model fails in predicting accurately house price at the end of the sample. At least one important factor is missing. The unrestricted model performs better in-sample forecasts over the entire sample. Despite some huge residuals, the unrestricted model explaining mostly the history of the euro are house price dynamics. Annex 17 illustrates the artificial residuals of both models.

Both models indicate that persistence and disposable income drive mainly current house price dynamics. This salient feature of house price dynamics highlighted in the literature is also in line with the theory developed in section 3. First, house price stickiness is underpinned by staggered supply not only due to the investment function and law of

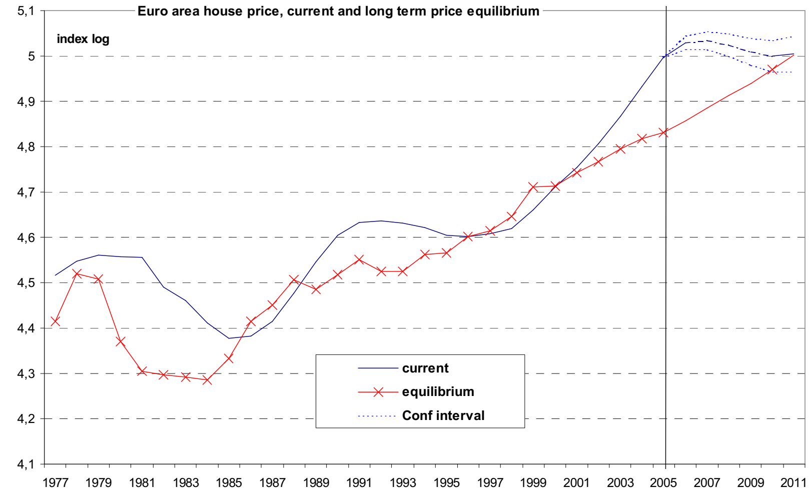
[34] Models where the long-run coefficients of mortgage loan are not required to be the same across countries.

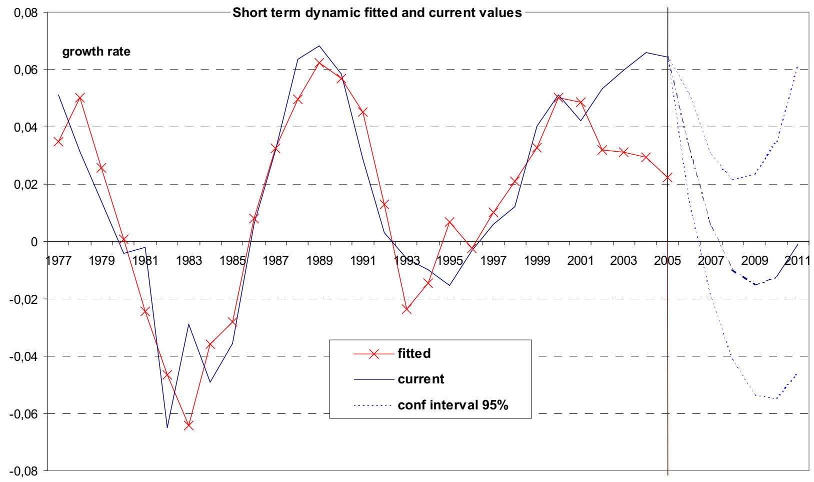
motion of housing stock, but also to house price expectations based on past prices. Second, current income and expected income enable households to afford real estate purchase and to meet the bank's standard to agree to a mortgage loan. These two points are consistent with the main theoretical literature and earlier empirical findings. Surprisingly, the interest rate effect on house price dynamics is quite nil, while it counts in the long-term house price equilibrium. The same result was found in Ott, 2005b, albeit to a different form: first difference interest rate was not significant but real interest rate in level was. In a PECM estimation procedure, it is not possible to specify in both equations: long- and short-term the same variable twice in level. Interestingly, in the long-term specification, interest rate is strongly significant. As a result, in Ott 2006b, the interest rate in level might capture a long-term effect.

The lackluster performance in forecasting the last four years proves that the restricted model fails to pick up at least one important factor. This lies in the specification of the restricted model itself, as it omits short-term variation of stock of dwelling and mortgage loan dynamics. Indeed, in the unrestricted model variation of stock of dwelling and especially mortgage loan dynamic explains almost half of house price dynamics after 2001. The still growing house price -despite the slowdown of the economy after 2001- might be due to the supply responding with delay, but also to the role of banks on the mortgage market. The inertia of housing supply has already been explained in the previous paragraph. However, mortgage loan development story must be deepened. A growing house price is tantamount to higher collateral values. This enables households to attract more mortgage credit since the problem of asymmetric information becomes less critical to banks. The former feeds the latter and vice versa leading to a self-perpetuating process (Ott, 2006b). To conclude, these two effects together explain mostly the house price dynamic after 2001. Since the restricted model does not capture these two mechanisms in the short-term specification, the predicted disequilibrium between current and price equilibrium of the restricted model stops building up and instead dies out at 16.4% per year, according to the euro area error correction term.

Overall, in the unrestricted model, it is worth mentioning that mortgage loan only influences sporadically house price dynamics. It only has a significant impact in the end of the period under consideration. Reviewing some past episodes, this raises some questions. Thus, the sharp increase of real house price in the mid-80's was sustained by fundamentals like strong disposable income growth. Thereafter, house price kept growing beyond the fundamentals ending up in a bubble. I would have expected a surge in housing credit coupled with the ongoing house price increase in the end of the 80's and beginning of the 90's. As can be seen in Chart group 10, mortgage loans as factor contribution do not explain anything for this period. Reviewing the country data, Germany, Spain, Finland and Belgium were concerned by an upsurge in housing credit. Annex 18 states clearly that a boom-bust housing credit occurred from the mid-80's to the beginning of the 90's. However, thereafter, the upsurge in credit boom is much more impressive, reaching an unprecedented 10% peak in 1999. The literature documents well the Nordic countries and the UK experience (Ortalo-Magné & Rady, 1999) for massive shifts due to financial liberalization. However, Finland does not account much in euro area weighting and the UK is not even a member state. The financial liberalization occurred in euro area countries successively and not at the same time according to the country policy pace. On a euro area level, this smooths the impact of financial liberalization while on a country scale, the effect is much more abrupt.

Chart group 9: Imposed lag structure (restricted) ARDL(2,0,1,1,1,0) heterogeneous mortgage loan slope





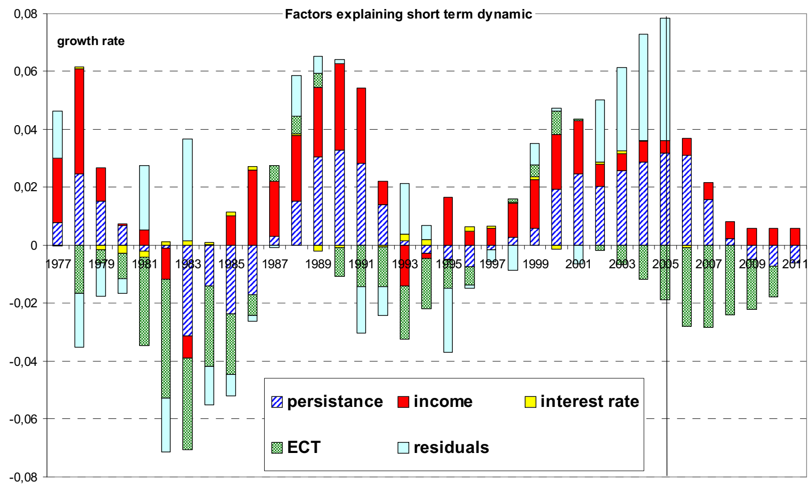
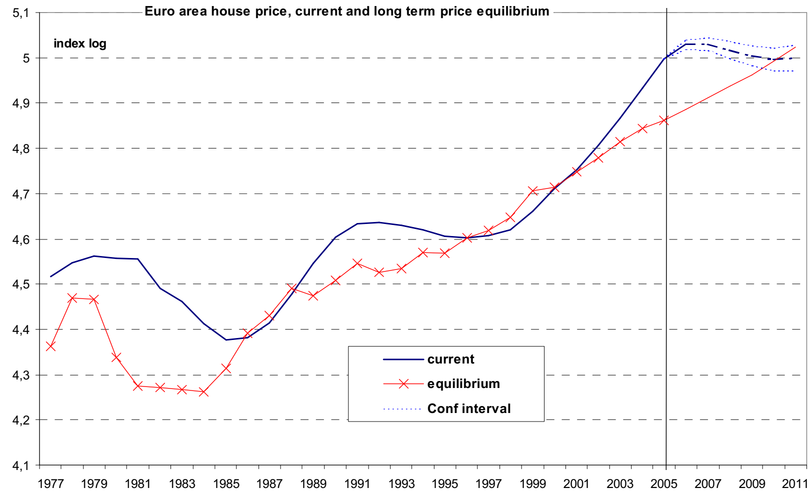
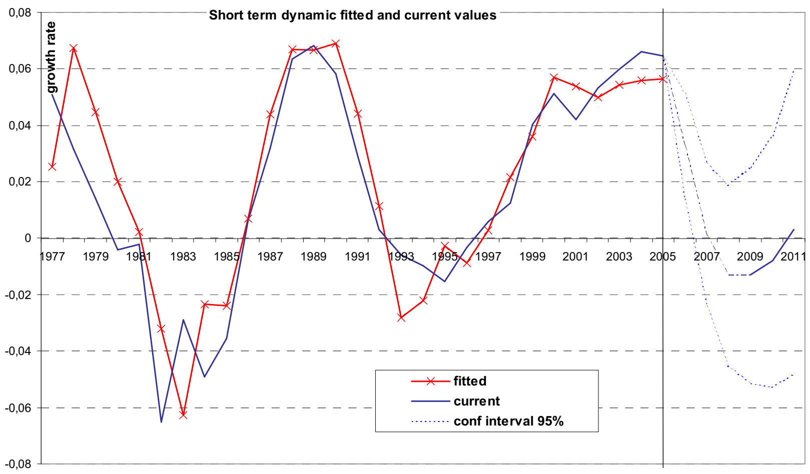
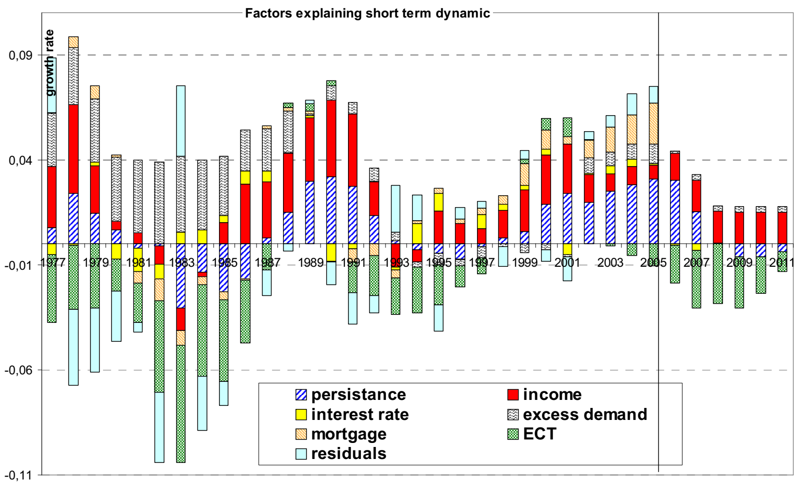


Chart group 10: H&Q lag structure (unrestricted) ARDL heterogeneous mortgage loan slope







The purpose now is not to forecast euro area house prices for the next few years but rather to simulate an adjustment process back to equilibrium. The investigation is the following, supposing that the tide starts to turn in 2006, how will euro area house prices go back to its equilibrium level. I made following assumptions as regards the steady state values of the explanatory variables. I took the mean growth rate over the entire sample of: disposable income per capita, stock of dwelling and population. Interest rate equilibrium and mortgage loan growth rate are set to 2% and 0% respectively. The accuracy of the forecast within the 95% confidence interval lies in the arbitrary assumption that the turning point is actually 2006. The disequilibrium may keep building up for a couple of years. However a trigger event can impinge on the house price negatively, and a lower house price will again bring to the fore the problem of asymmetric information, forcing banks to focus on the expected repayment capacity of their client in a subdued house price. A squeeze of mortgage supply follows and this can start a vicious circle in line with the financial accelerator (Bernanke & Gertler, 1995). This trigger event may be an increase of the interest rate, as it worsens household indebtedness and repayment capability on the outstanding mortgage loans. Today the euro area economy is gathering pace and to avert any inflation pressure, the ECB is raising its refinancing rates. It is far-fetched to suppose an abrupt real estate price fall. Contrary to stock prices which tumble down overnight, house prices are sticky. However, interest rate increase might trigger a reversal to a more subdued house market and to a soft landing of house price. Thus, supposing that the turning point happens in 2006, might not be an unrealistic assumption.

Between both models, the picture of the adjustment process is broadly similar except for the adjustment speed. Indeed, the error correction term is -0.164 and -0.20 for the restricted and unrestricted model, respectively. As a result, it takes 6 years in the restricted model but only 5 years in the unrestricted model to go back to equilibrium. The sharp of the forecasted house price growth may not be unusual with regard to past experiences. This does not mean that it will happen again, however. The euro area house price landing might be softer and smoother than predicted. The sharp drop in the beginning of the 80's occurred in a high inflationary environment associated with harsh monetary policy which in turn decided to put a lid on inflation -regime switch of high to low inflation. The substantial house price fall in the mid 90's also happened in a different context. In France for instance, the macro-economic environment was characterized by low inflation, economic activity slowdown and high interest rates. The non-optimal monetary policy was the price to pay to maintain the currency peg with the Deutsche mark. The current macro-environment is different to that of the 80's and 90's. A single currency with an independent Central Bank might eschew high inflationary pressure and/or non-optimal monetary policy with regard to the business cycle. Thus, the peak year can be postponed a couple of years, and the present ongoing cycle will be even larger. Despite the existence of a cycle in house prices, a sinusoidal regularity is far-fetched due to idiosyncratic macro-events. Once again, the purpose is not to forecast accurately future house price movements, and the results should be taken with caution. Nevertheless, the models are informative and allow to simulate the adjustment dynamics from current price to price equilibrium.

7 Conclusion

This study investigates the empirical relationship between real euro area house price and a set of macroeconomic variables. A general equilibrium model -where a representative household maximizes its utility and firm its profit- underpins the choice of macro variables. The choice of the estimator is based on four aspects. First, the theoretical part indicates that house prices might be an autoregressive process, thereafter corroborated empirically. Second, the time span is short and does not allow robust estimates in a classical time series framework. Third, one purpose of the paper is to disentangle long-term from short-term effects in order to derive a house price equilibrium. Fourth and last challenge, the house market depends on local specific factors and the mortgage market across euro area countries bears the stamp of strong national features; as a result, heterogeneity is of concern. A sensible choice of estimator is the PMG, which posits a dynamic PECM that allows short-run and a sub-set of long-run parameters to vary across countries, while restricting long-run coefficients to be identical across the sections. The specification tests performed on the data corroborates the choice of the PMG estimator since it performs better than MG or restricted estimators.

The models provide good results as regards the sign, significance of coefficients and the explanatory power of the regressions. The residuals do not show significant abnormal pattern as proved by the diagnostic tests. The empirical results suggest a strong long-term empirical relationship between house price and not only fundamentals such as disposable income, interest rate, stock of dwelling and population but also mortgage loan. The estimates concerning the short-term dynamic however do not fulfill the expectations. To find sensible results, long-term heterogeneous mortgage loan slopes are introduced, which improves significantly the short-term estimates. The short-term quantitative estimates as regards the importance of each factor on house price dynamics are similar to previous findings in Ott (2006b), even for interest rate. Indeed, the first difference of interest rate was not significant either but in level (Ott, 2006b). Finally, I use the estimated models to generate euro area fitted values instead of deriving country specific conclusion. This assuages the criticism as regards homogeneity assumption of long-term coefficients. From 2002 to 2005, the fitted values underestimate actual house price growth, exactly as in Ott (2006b) even in the most specified second model. To conclude, I compare the fitted values with the actual real house prices to derive three types of conclusions. First, are the actual real house prices above the equilibrium price level? Second, which factors drive not only long-term house price equilibrium but also actual euro area house price dynamics? Third, if there is a disequilibrium, how would house prices convergence back to their equilibrium level?

The model estimates of euro area house price equilibrium depict three positive misalignment with respect to actual house prices. The first starting during the second oil price shock until the mid 80's. The second was beginning in the late 80's and ending in the mid 90's. The third and last house price overshooting begins in 2001 and is still ongoing. The gap between actual and house price equilibrium has widened since 2001 and has not shown reversion yet. According to the results, house price equilibrium is essentially driven by disposable incomes and interest rates. Surprisingly, in the short-term house price dynamics interest rates do not account for much, but income and the autoregressive term are both the most important factors. The last house price cycle begins in 1995/1996 and was mainly driven by households' disposable income coupled with declining interest rates due to the EMU process. Since 2001, the economic slowdown should have dampened house price growth, but expectations of further price increase and staggered supply fueled further house price increase. Low short-term interest rates and expectations of future price increase allowed households to capture housing credits with apparent strong collateral. Thus, demand is still overshooting supply and the disequilibrium has not started to revert yet. Supposing the tide starts to turn in 2006, current house prices would smoothly catch up equilibrium price in 5 to 6 years according to the models. In the simulation of current house prices adjustment to equilibrium level, I suppose that all explanatory variables equal simultaneously their steady value in 2006 and onwards. By consequence, the adjustment to equilibrium might be even softer and smoother than what is depicted in the simulation.

The gap between house price equilibrium and current price cannot be assimilated to a bubble as defined by Stiglitz (1990). Indeed, the misalignment of current prices to long-term equilibrium price is a natural feature of the functioning of the house market. On the contrary, the unexplained part (residuals) and, generously one half of mortgage loan development and persistence may be due to a self-fulfilling and/or speculative behavior in house prices. This very generous calculation in favour of a bubble represents roughly 3% in the second model of house price growth in 2005. This bubble estimate is well below "the biggest bubble in history" documented by *The Economist* (2005) and Baker (2002). It is realistic to suppose that the tide will start to turn in 2006 as supply starts reacting and interest rates increase. However, contrary to them, the estimates would rather suggest a soft and smooth landing, very typical of sticky and persistent house prices. *The Economist* (2005) instead conjectures that house prices will tumble down and harm heavily real economic activity through the wealth effect by comparing western house prices with Japanese house prices in the last 25 years. The present study does not fit into this scenario. The burst of the Japanese bubble in the beginning of the 90's had disastrous outcomes essentially for two reasons. First, two bubbles occurred together with cross-linkages, one in the stock market, the other in the house market. In addition both bubbles had risen to very high levels. Second, banks risk exposure was excessively high. As a result, when the bubble burst, indebted households were not able to serve their mortgage payments, which in turn worsened banks balance sheets. The crisis propagated into the fragile banking sector provoking massive bank failures. The disruption of the credit supply channel caused a credit squeeze (credit crunch). The banking crisis propagated on the entire financial system and economy (systemic failure). In contrast, as the banking sector remains strong in Europe, i.e. banks balance sheets do not worsen in both sides together (asset and liability), a deflation scenario is far-fetched.

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ANNEX 1: Data

Annual data from 1975 to 2005 are used covering the longest available common period restricted to 8 EMU countries: Germany (DE), France (FR), Italy (IT), Spain (ES), the Netherlands (NL), Belgium (BE), Finland (FI) and Ireland (IE). As Residential Property Price is not available for the period under consideration, Luxembourg, Portugal, Greece and Austria were excluded. As a result, the sample consists of 31 observations in the time dimension and 8 cross-sections. The panel series are: *residential property price*, *consumer price index*, *interest rate short-term*, *long-term, stock of dwelling, household disposable income, population aged from 15-64, outstanding mortgage loan volume, credit to households, housing depreciation rate, housing rents* and *stock index price.* Real series were constructed by deflating the nominal series by the corresponding domestic CPI indices, except household real disposable income, which is GDP deflated.

The ECB provided the residential property price, which was calculated from the national central banks and private agencies like the BulwienGesa AG in Germany and the European Mortgage Federation, for instance. The database of Claudio Borio from the Bank of International Settlement helped completing the ECB database. The collection is a weighted average of series for new dwellings and existing dwellings. Note that data before 1995 include only West-Germany. Concerning the year 2005, I completed the dataset on residential property price thanks to Livia Figà-Talamanca of the European Mortgage Federation (2006).

The CPI is the yearly average of the monthly HICP (Harmonized Index Consumer Price) from 1980 to 2005. ECB database uses Eurostat data and national CPI with a fixed euro conversion rate. The database was filled by the cost of living index for all households, all items, provided by the BIS. The source of the Irish CPI however is the national central bank of Ireland as the BIS cost of living index is not available.

For all countries including Germany, the ECB Desis database was used for the nominal short- and long-term interest rate which is the 5 year government bond yield and the 3 month interbank offered rate, respectively. Once again, the data set was filled by the European commission DG-ECFIN AMECO database for data prior to 1990 except for Germany, where I used the International Financial Statistics of the IMF for the long-term interest rate and the OECD Main Economic Indicator for the short-term interest rate.

The sectorial Housing CPI was chosen as proxy for rents, except for Finland prior to 1995, where a rent index provided by the Finish National Statistic Office (Veli Kettunen) was used. The ECB database on rents was also filled for Spain, from 1976 to 1984, for Ireland from 1975 to 2004. These data were provided by respectively the Instituto Niacional de Estadística (Web site) and the Irish Central Bank (McQuinn Kieran). As 1975 was missing for Germany, Spain and the Netherlands, I projected the missing value by linear extrapolation over approximately the last 10 years (depending on the pattern of the series).

The housing depreciation rate (δ_t) was calculated according to following formula: $\delta_t = \frac{GFCF_t-(NCS_t-NCS_{t-1})}{NCS_{t-1}}$
GFCF and NCS stand for Gross Fixed Capital Formation and Net Capital Stock in housing sector, respectively. National sources but also the European Mortgage Federation database were used.

Three different demographic indicators were investigated: the number of households, the population aged from 15 to 65, and the total population. Data scarcity on the number of households obliged me to deal only with the other two variables. The source of the data is Eurostat (European Labour Force Survey) but completed by the OECD. The German database required some arrangements. The reunification causes a structural break, i.e. the OECD database jumps roughly from 60 millions to 80 millions around 1990. From 1990 to 2005, the new database provided by Eurostat was taken. Prior to 1990, the West-German population growth rate was applied to the new Eurostat database.

The consumption of non durables and services and financial wealth was not available for many countries and GDP is too broad an aggregate to proxy household affordability and purchasing power. As a result, households' real disposable income provided by the OECD, the current issue was used. To settle the German reunification data break, I took the raw data from 1991 to 2005 and then calculated until 1975 by assuming the West-German growth rate. Two sources were used: from 1975 to 1989, OECD database, and prior to 1990, ECB internal database (Forecasting section) except for Spain, Belgium and Ireland where only nominal data were available. The OECD database does not provide data for Ireland before 1977. Consequently, the database was filled by deflating the nominal disposable income (source: Central Bank of Ireland) with the GDP deflator from the IFS database (IMF).

Two proxies for housing credit were chosen: loans for house purchasing over 1 and up to 5 years maturity and total loans to households. The former is the mortgage loan and is the most accurate variable which theoretically impact the house price, while the latter encompasses credits including non housing purchases like consumption credits. Unfortunately, the ECB by using data from National Central Banks provides mortgage loan data only from 1995 to 2005. Consequently, I calculated the series backward by using the growth rate of housing loans which stems from the BIS. The source of the second credit series: loans to households, is also published by the BIS. Unfortunately these series do not cover the entire sample either. Consequently, the total loans to households was calculated, backward and sometimes forward when necessary by the credit to private sector growth rate also provided by the BIS. Counterpart of the credit to private sector includes households but also individual enterprises. Italy, the Netherlands, Belgium and Finland are concerned by this arrangement. The series for Italy in 1989, Spain in 2002 but especially Belgium in 1994 (more than 140% credit mortgage increase) used to show measurement errors. Consequently they were corrected by assuming the growth rate of the next closest and broader credit series. In the empirical study of this paper, only mortgage loan series were used.

The sectorial Housing CPI (source: ECB) was chosen as proxy for housing rents, except for Finland prior to 1995, where a housing rent index provided by the Finish National Statistic Office (Veli Kettunen) was used. The series housing rent were filled for Spain, from 1976 to 1984, for Ireland from 1975 to 2005. These data were provided by respectively the Instituto Niacional de Estadística (Web site) and the Irish Central Bank (McQuinn Kieran). As 1975 was missing for Germany, Spain and the Netherlands, I projected the missing value by linear extrapolation over approximately the last 10 years (depending on the pattern of the series).

Stock price indices stem from both, International Financial Statistics (IMF) and the

Main Economic Indicator (OECD), which are almost identical. Both sources were used as, for example, the OECD index has a longer sample span for Germany but smaller for Italy, Spain, Finland and the Netherlands relative to the IFS stock price index. The longest stock price index available for Belgium is provided by the BIS which starts in 1980 while IFS stock index is not available and the Main economic Indicators only starts in 1986. Frans Buelens (University of Antwerp) and Stijn Nieuverburgh (University of New York) provided the missing data (source: National Bank of Belgium).

ANNEX 2: Euro area aggregation

Currently 12 EU countries have joined the EMU, the member states are: Belgium (BE), Germany (DE), Greece, Spain (ES), France (FR), Ireland (IE), Italy (IT), Luxembourg, the Netherlands (NL), Austria, Portugal and Finland (FI). However, in this empirical study, the euro area was restricted to 8 countries due essentially to the lack of data for the remaining countries. The weightings were recalculated for the eight countries (see Table A2.1), following the ECB methodology (see ECB, 2005b) as regards the Residential Property Price (RPP) and the Harmonized Consumer Price Index (HICP).[35] National series of interest rates and consumer price index, respectively residential property price index were aggregated to euro area series by applying HICP weighting, respectively RPP weighting. First, the HICP for the euro area is published by Eurostat. However, as the study only uses the national data set of 8 countries, for congruence reasons an artificial euro area CPI was constructed according to the European consumer basket for the entire sample. Second, contrary to the CPI, the national RPPs are not harmonized. Despite the possible error margins, price trends and movements are correctly reflected (see BIS, 2005). The GDP weighted index applied to aggregate the national RPPs (Table A2.1) is an acceptable solution given the available data. Overall, the reliability of the euro area RPP is strong. Finally, the euro area depreciation rate was calculated with respect to the formula given in Annex 1. For this purpose national Gross Fixed Capital Formation and Net Capital Stock in housing sector were added up to euro area series.

Table A2.1: **Weighting euro area series (%)**

Country	% in HICP	% in RPP	% in LM
DE	32.46	31.61	46.65
FR	22.26	23.13	24.12
IT	20.85	19.32	5.41
ES	11.84	11.06	9.33
NL	5.86	6.75	8.59
BE	3.58	4.00	3.32
FI	1.74	2.13	1.59
IE	1.41	2.00	1.00

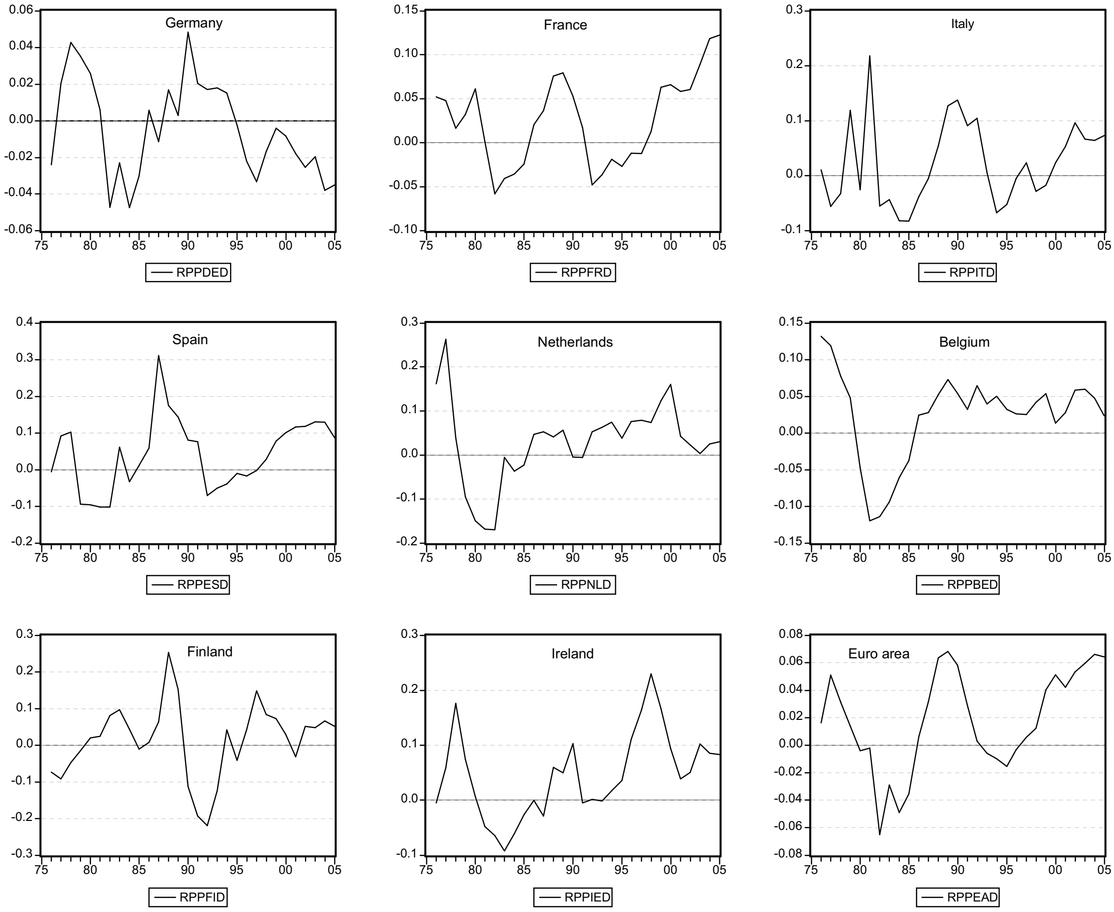
[35] see "Compendium of HICP reference documents (2/2001/B/5)" under http://forum.europa.eu.int

First, national series were aggregated to euro area series in three different ways depending on the series. The stock of dwelling, the population and the real loans were added by countries. Two different euro area real disposable income were calculated by aggregating the national series. The former was divided by total population, the latter by population aged from 15-64. In contrast, the other variables are indices, consequently a weighting was applied (see Table A2.1 above) as already explained. The euro area HICP and the nominal RPP were constructed. The real euro area RPP is the ratio nominal index over HICP. The HICP weighting was applied to the interest rate. The euro area series can been seen in Annex 18. Second, since population, stock of dwelling, disposable income and mortgage loan have no weighting, I calculated a weighting with respect to the data set in order to be able to generate euro area parameters. In the empirical investigation disposable income per capita aged from 15-64 years old yields better results, thus Table A2.2 only reports this proxy. These weightings are actually time-varying, albeit at a very low scale. Table A2.2 and the last column of Table A2.1 only reports the average over the sample. As a result, country specific parameters were aggregated to euro area parameters by using the weightings given in Table A2.1 and A2.2.

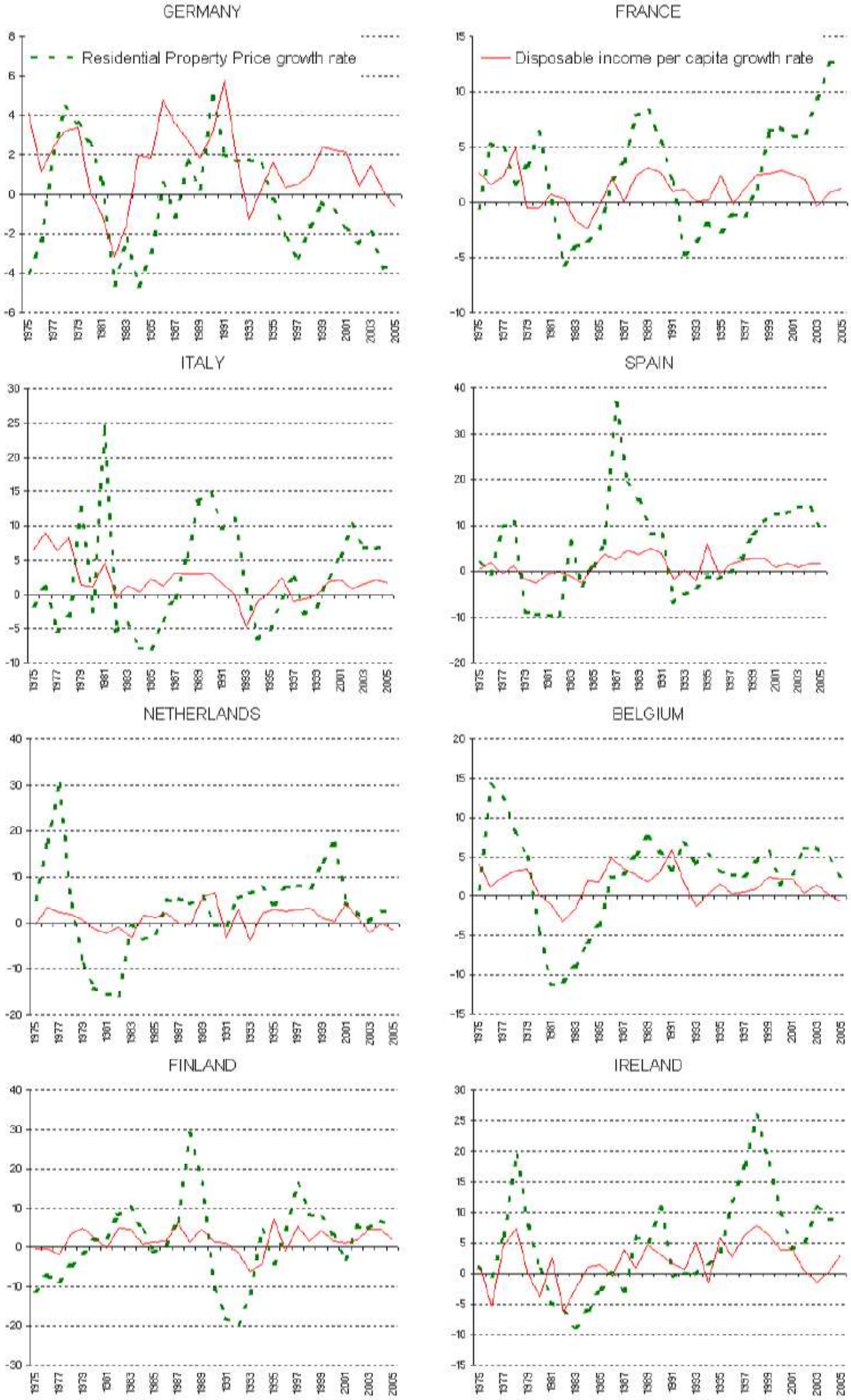
Table A2.2: **Weighting parameter estimates (%)**

Country	% in PO	% in DW	% in DY
DE	30.30	25.52	16.19
FR	20.40	23.31	15.27
IT	21.90	20.93	12.45
ES	14.57	15.21	8.20
NL	5.77	4.87	10.94
BE	3.82	3.35	14.87
FI	1.93	1.90	10.88
IE	1.30	0.91	11.20

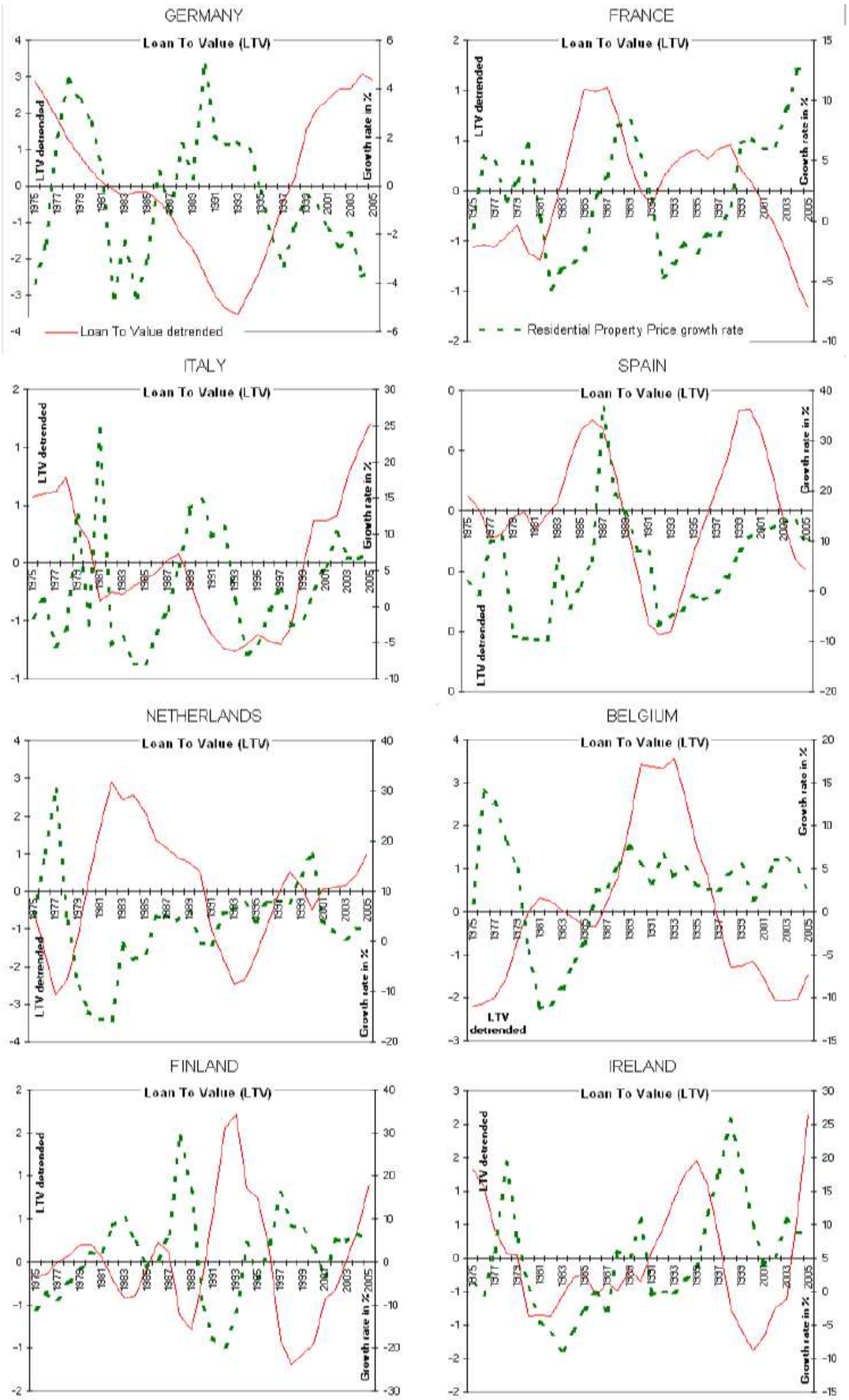
ANNEX 3: Real residential property price growth rate by country



Annex 4: Real disposable income and real residential property price growth rate (in %)



Annex 5: CLTV detrended and residential property price growth rate



ANNEX 6: Utility maximization representative household

The representative household maximizes its life utility:

$$Vo = \sum_{t=0}^{\infty} \beta^t U(c_t, h_t),$$

under the intertemporal budget constraint given by:

$$b_{t+1} + c_t + p_t h_t + \frac{1+i_t^M}{1+\pi_t} m_{t-1} = y_t + \frac{1+i_t}{1+\pi_t} b_t + p_t(1-\delta)h_{t-1} + m_t$$

and the borrowing constraint,

$$m_t = \kappa p_t h_t.$$

I integer the borrowing constraint into the budget constraint. This gives the Lagrangian:

$$\begin{aligned}\mathcal{L}(c_t, h_t, b_{t+1}; \lambda_t) &= \beta^t U(c_t, h_t) \\ &\quad -\lambda_t \begin{pmatrix} b_{t+1} + c_t + p_t h_t + \frac{1+i_t^M}{1+\pi_t} \kappa p_{t-1} h_{t-1} - y_t \\ -\frac{1+i_t}{1+\pi_t} b_t - p_t(1-\delta)h_{t-1} - \kappa p_t h_t \end{pmatrix} \\ &\quad -\lambda_{t+1} \begin{pmatrix} b_{t+2} + c_{t+1} + p_{t+1} h_{t+1} + \frac{1+i_{t+1}^M}{1+\pi_{t+1}} \kappa p_t h_t - y_{t+1} \\ -\frac{1+i_{t+1}}{1+\pi_{t+1}} b_{t+1} - p_{t+1}(1-\delta)h_t - \kappa p_{t+1} h_{t+1} \end{pmatrix}.\end{aligned}$$

I maximize the Lagrangian with respect to c_t, h_t, b_{t+1} and λ_t, this gives the following derivatives:

1) with respect to c_t:

$$\lambda_t = \beta^t U_{c_t} \tag{A6.1}$$

2) with respect to h_t:

$$\beta^t U_{h_t} = \lambda_t p_t (1-\kappa) + \lambda_{t+1} \left(\frac{1+Et(i_{t+1}^M)}{1+Et(\pi_{t+1})} \kappa p_t - (1-\delta) E_t(p_{t+1}) \right) \tag{A6.2}$$

3) with respect to b_{t+1}:

$$\frac{\lambda_t}{\lambda_{t+1}} = \frac{1+E_t(i_{t+1})}{1+E_t(\pi_{t+1})}. \tag{A6.3}$$

Substituting A6.3) into A6.2) eliminates λ_{t+1} and thereafter substitute (A6.1) into this new equation yields:

$$U_{h_t} - U_{c_t} p_t (1-\kappa) - U_{c_t} \frac{1+E_t(\pi_{t+1})}{1+E_t(i_{t+1})} \left(\frac{1+Et(i_{t+1}^M)}{1+Et(\pi_{t+1})} \kappa p_t - (1-\delta) E_t(p_{t+1}) \right) = 0,$$

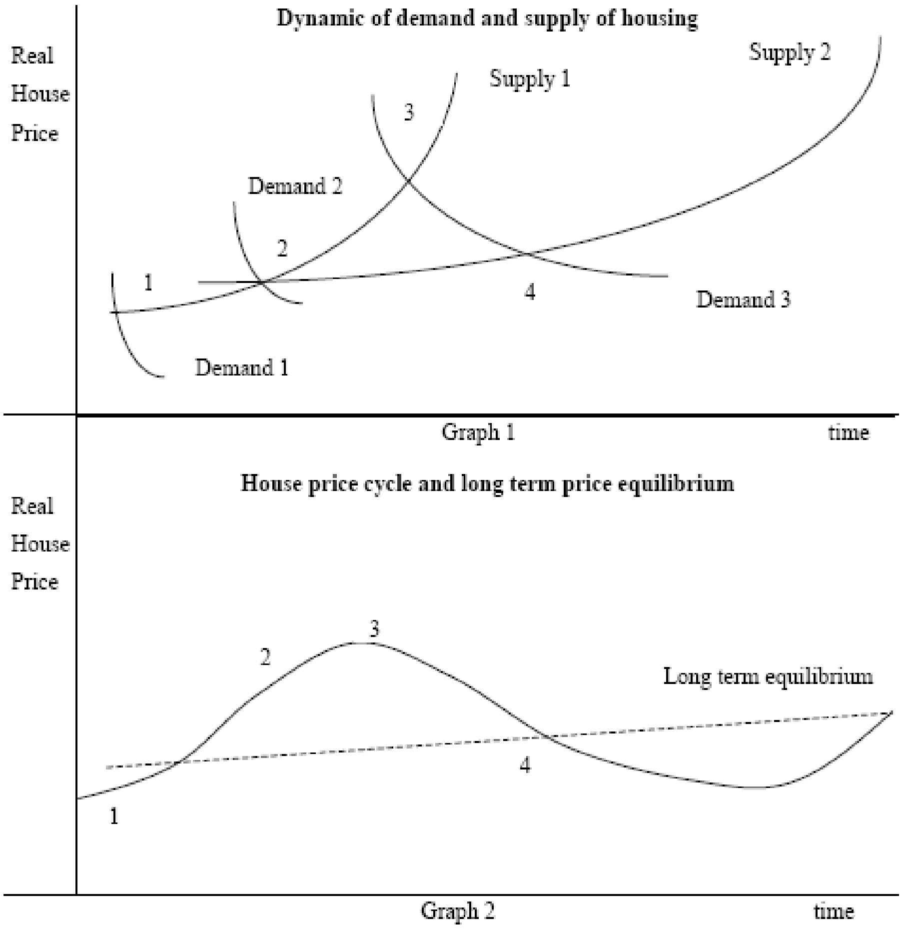
which gives the MRS, equation (4).

To fulfill the dynamic optimization problem, the representative household must meet the following two last conditions, i.e. 4) and 5):

4) Transversality condition: $\lim_{t\to\infty} \lambda_t b_{t+1} = 0$, for the sake of clarification of equation (6), I suppose $b_{t+1} = 0$,

5) intertemporal budget constraint.

ANNEX 7: House price dynamics and long-term pattern



ANNEX 8: Algebra details ARDL (2,2,2,2,2,2) error correction model

Recalling the ARDL process of equation (14):

$$p_{i,t} = \psi_{i,11}p_{i,t-1} + \psi_{i,12}p_{i,t-2} + \sum_{j=2}^{6}\sum_{k=0}^{2}\psi_{i,jk}X_{i,j,t-k} + u_i + \epsilon_{i,t}, \tag{14}$$

I rewrite equation (14) by inserting steady state values (upper bar) for each variable and $\bar{\epsilon}_i = 0$. This gives:

$$\bar{p}_i = \psi_{i,11}\bar{p}_i + \psi_{i,12}\bar{p}_i + \sum_{j=2}^{6}\sum_{k=0}^{2}\psi_{i,jk}\bar{X}_{i,j} + u_i,$$

and so:

$$\bar{p}_i = \frac{1}{1-\psi_{i,11}-\psi_{i,12}}\left[\sum_{j=2}^{6}\sum_{k=0}^{2}\psi_{i,jk}\bar{X}_{i,j} + u_i\right]. \tag{A.1}$$

At time t, I suppose the long-term relationship (steady state equilibrium). By adding a time subscript to equation (A1), I find equation (15):

$$p_{i,t} = \frac{1}{1-\psi_{i,11}-\psi_{i,12}}\left[\sum_{j=2}^{6}\sum_{k=0}^{2}\psi_{i,jk}X_{i,j,t} + u_i\right] + \eta_t. \tag{15}$$

and η_t stands for the short-term deviation with respect to the long-run equilibrium house price value.

Starting again from the ARDL process of equation (14), and subtracting both sides of the equation by $p_{i,t-1}$ yields:

$$\Delta p_{i,t} = (\psi_{i,11}-1)p_{i,t-1} + \psi_{i,12}p_{i,t-2} + \sum_{j=2}^{6}\sum_{k=0}^{2}\psi_{i,jk}X_{i,j,t-k} + u_i + \epsilon_{i,t}.$$

After the differentiation of $p_{i,t}$, the other variables like $p_{i,t-1}$ and all $X_{i,j,t}$, $X_{i,j,t-1}$ (for $j = 2, 3.., 6$) are differentiated as well by the same way. This gives:

$$\begin{aligned}\Delta p_{i,t} \;=\; & (\psi_{i,11}-1)\Delta p_{i,t-1} + (\psi_{i,11}+\psi_{i,12}-1)p_{i,t-2} + \sum_{j=2}^{6}\psi_{i,j0}\Delta X_{i,j,t} + \\ & \sum_{j=2}^{6}\sum_{k=0}^{1}\psi_{i,jk}\Delta X_{i,j,t-1} + \sum_{j=2}^{6}\sum_{k=0}^{2}\psi_{i,jk}X_{i,j,t-2} + u_i + \epsilon_{i,t}. \end{aligned} \tag{A2}$$

After some arrangements (A2) becomes:

$$\Delta p_{i,t} = (\psi_{i,11}-1)\Delta p_{i,t-1} + \sum_{j=2}^{6}\psi_{i,j0}\Delta X_{i,j,t} + \sum_{j=2}^{6}\sum_{k=0}^{1}\psi_{i,jk}\Delta X_{i,j,t-1} + \epsilon_{i,t} + (\psi_{i,11}+\psi_{i,12}-1)\left(p_{i,t-2} - \frac{1}{1-\psi_{i,11}-\psi_{i,12}}\left[\sum_{j=2}^{6}\sum_{k=0}^{2}\psi_{i,jk}X_{i,j,t-2}+u_i\right]\right).$$

Substituting this last equation into equation (15) rewritten at time t-2, gives equation (16).

ANNEX 9: Moon & Perron (2003), Choi (2002), panel unit root tests

Var	Test	Deterministic terms	Statistics Z(Choi), tb (M&P)	p-limit
rpp	Choi	c,t	1.90	0.97
		c	-0.12	0.45
	M&P	c,t	-0.45	0.32
		c	-2.25	0.01
dw	Choi	c,t	-0.91	0.18
		c	4.29	1.00
	M&P	c,t	0.02	0.51
		c	-3.34	0.42
dy	Choi	c,t	1.10	0.86
		c	2.97	1.00
	M&P	c,t	-0.14	0.44
		c	-3.63	0.14
po	Choi	c,t	-2.51	0.00
		c	6.12	1.00
	M&P	c,t	-0.20	0.42
		c	-3.94	0.41
in	Choi	c	0.81	0.79
	M&P	c	3.65	0.13
lm	Choi	c,t	1.53	0.92
		c	5.28	1.00
	M&P	c,t	0.15	0.41
		c	-2.18	0.02

ANNEX 10: Levin, Lin & Chu (1992), Im, Pesaran & Shin (1997), panel unit root tests

Var	Test	Deterministic terms	Statistics, t*(LLC), W(IPS)	p-limit
rpp	LLC	c,t	-1.68	0.05
		c	1.10	0.87
	IPS	c,t	-3.21	0.00
		c	-0.83	0.80
dw	LLC	c,t	-2.07	0.02
		c	0.45	0.70
	IPS	c,t	2.02	0.98
		c	1.79	0.96
dy	LLC	c,t	-0.79	0.21
		c	-0.64	0.26
	IPS	c,t	-0.15	0.44
		c	2.37	0.99
po	LLC	c,t	1.11	0.87
		c	0.63	0.74
	IPS	c,t	-0.96	0.17
		c	6.10	1.00
in	LLC	c	1.30	0.90
	IPS	c	2.64	1.00
lm	LLC	c,t	0.92	0.75
		c	3.13	1.00
	IPS	c,t	0.24	0.31
		c	6.81	1.00

ANNEX 11: Time series ADF Tests

Var	Count	Lags	Deterministic terms	Statistics ADF	5% critical value
rpp	DE	1	c,t	-2.72	-3.58
		1	c	-2.25	-2.97
	FR	1	c,t	-3.62	-3.58
		1	c	0.03	-2.97
	IT	4	c,t	-5.98	-3.60
		1	c	-1.47	-2.97
	ES	0	c,t	-7.01	-3.57
		1	c	-0.52	-2.97
	NL	1	c,t	-2.33	-3.58
		1	c	-1.26	-2.97
	BE	2	c,t	-2.12	-3.59
		2	c	-0.32	-2.98
	FI	2	c,t	-3.18	-3.59
		1	c	-2.80	-2.97
	IE	2	c,t	-2.92	-3.59
		1	c	-0.28	-2.97

Var	Count	Lags	Deterministic terms	Statistics ADF	5% critical value
dw	DE	1	c,t	-2.53	-3.58
		3	c	-1.63	-2.98
	FR	1	c,t	-2.83	-3.58
		1	c	2.08	-2.97
	IT	1	c,t	-1.04	-3.58
		1	c	-2.55	-2.97
	ES	1	c,t	-2.15	-3.58
		1	c	1.38	-2.97
	NL	1	c,t	-1.44	-3.58
		1	c	-3.44	-2.97
	BE	1	c,t	-1.45	-3.58
		1	c	-1.03	-2.97
	FI	4	c,t	-0.13	-3.60
		4	c	-1.96	-2.99
	IE	1	c,t	-1.77	-3.58
		1	c	3.10	-2.97

ANNEX 12: Pedroni's cointegration test (the statistics refer to a standard normal distribution)

rpp	*dw*	*dy*	*in*	*po*	*lm*	(1)	(2)
x	x					-3.13	-3.77
x		x				-1.46	-1.63
x			x			-1.74	-1.51
x				x		-3.18	-3.83
x					x	-3.06	-3.73
x						1.82	2.28
x	x	x				-0.03	-1.14
x	x		x			-0.66	-0.59
x	x	x	x			-0.67	-0.50
x	x	x	x	x		-1.31	-2.19
x	x	x	x	x	x	-1.19	-1.17

(1) Parametric panel ADF-statistic
(2) Parametric group ADF-statistic

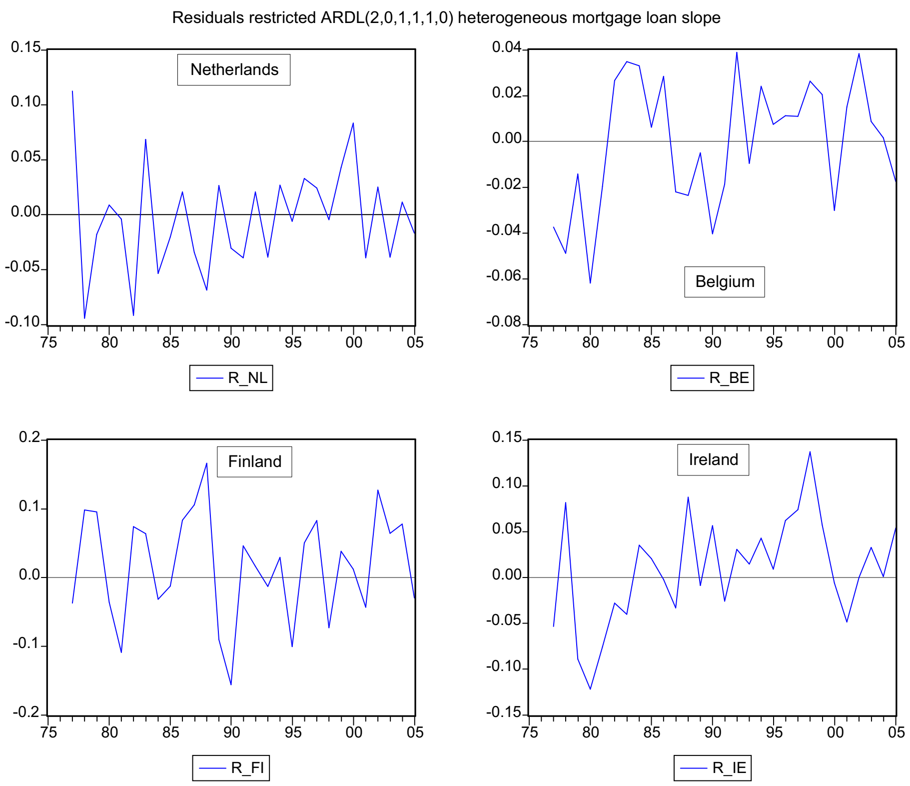
ANNEX 13: PMG estimates - with/without mortgage loan

Pooled Mean Group estimates long-term coefficients					
Elasticities long-term	Omission mort. loan		Hom. mort. loan	Het. mort. loan	
	H&Q	ARDL(2,2,2,2,2)	ARDL(2,0,2,2,2,0)	ARDL(2,0,2,2,2,0)	
st. dwelling *dw*	-2.64 (−3.74)	-2.70 (−3.84)	-2.25 (−5.72)	-2.83 (−7.34)	
real income *dy*	2.37 (6.22)	2.27 (−5.54)	1.59 (6.31)	2.27 (−9.07)	
int. rate *in*	-3.50 (−5.76)	-4.87 (−5.90)	-2.80 (−5.30)	-2.70 (−4.35)	
population *po*	1.60 (2.29)	2.05 (2.74)	2.86 (7.00)	2.77 (7.10)	
mort. loan $1m$			0.66 (8.27)		
ECT coeff.	η	η	η	η	$1m$
DE	-0.02 (−0.53)	-0.08 (−1.01)	-0.00 (0.18)	-0.00 (−0.05)	3.49 (0.05)
FR	-0.12 (−3.45)	-0.18 (0.88)	-0.33 (−6.07)	-0.42 (−7.38)	1.39 (8.19)
IT	-0.28 (−4.39)	-0.23 (−2.89)	-0.25 (−3.02)	-0.31 (−4.07)	0.50 (3.04)
ES	-0.07 (−1.03)	-0.17 (−2.64)	-0.17 (−2.36)	-0.15 (−1.91)	-0.04 (−0.07)
NL	-0.14 (−3.23)	-0.29 (−3.75)	-0.24 (−3.17)	-0.30 (−3.32)	0.68 (−0.07)
BE	-0.21 (−8.03)	-0.18 (−5.71)	0.01 (−0.40)	-0.12 (−3.18)	-0.54 (3.83)
FI	-0.53 (−5.76)	-0.48 (−4.90)	-0.61 (−5.32)	-0.60 (−5.57)	0.41 (2.74)
IE	-0.18 (−4.50)	-0.19 (−3.10)	-0.28 (−4.30)	0.23 (−3.52)	0.75 (3.42)

ANNEX 14: PMG estimates - homogeneous/ heterogeneous mortgage slopes

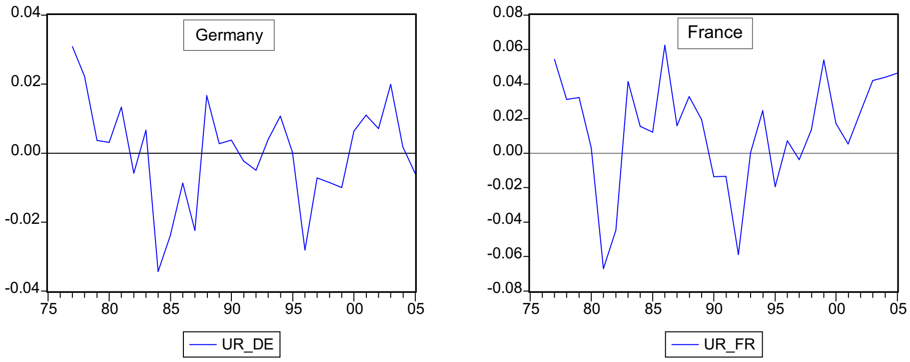
Pooled Mean Group estimates long-term coefficients						
Elasticities long-term	Hom. mort. loan		Het. mort. loan			
	AIC	H&Q	AIC		H&Q	
st. dwelling dw	-1.42 (-2.69)	-1.42 (-2.50)	-1.72 (-3.88)		-1.73 (-3.87)	
real income dy	1.20 (3.39)	1.18 (3.12)	1.88 (6.99)		1.88 (6.96)	
int. rate in	-2.86 (-5.36)	-2.97 (-5.42)	-2.57 (-5.14)		-2.60 (-5.10)	
population po	2.71 (5.39)	3.01 (5.40)	1.82 (4.25)		1.83 (4.24)	
mort. loan $1m$	0.37 (4.32)	0.30 (3.51)				
EC coeff.	η	η	η	$1m$	η	$1m$
DE	-0.01 (-0.63)	0.02 (0.74)	-0.01 (-0.20)	-13.7 (-0.20)	-0.00 $(-0.20.)$	-13.7 (-0.20)
FR	-0.18 (-3.75)	-0.16 (-3.45)	-0.34 (-6.20)	1.59 (7.55)	-0.34 (-6.19)	1.59 (7.54)
IT	-0.32 (-3.96)	-0.31 (-3.96)	-0.34 (-4.76)	0.38 (2.49)	-0.34 (-4.75)	0.37 (2.47)
ES	-0.21 (-3.13)	-0.24 (-3.70)	-0.14 (-1.98)	-0.24 (-0.36)	-0.13 (-1.74)	-0.36 (-0.46)
NL	-0.12 (-2.24)	-0.11 (-2.16)	-0.22 (3.35)	0.92 (4.19)	-0.22 (-3.34)	0.92 (4.17)
BE	-0.11 (-2.72)	-0.12 (-3.15)	-0.17 (-4.87)	-0.06 (-0.48)	-0.17 (-4.87)	-0.06 (-0.47)
FI	-0.63 (-6.37)	-0.61 (-6.32)	-0.66 (-5.66)	0.02 (0.14)	-0.60 (-5.65)	0.03 (0.16)
IE	-0.22 (-4.99)	-0.19 (-4.56)	-0.27 (-6.00)	0.68 (5.05)	-0.27 (-5.99)	0.68 (5.03)

ANNEX 15: Residuals restricted lag order ARDL(2,0,1,1,1,0) by country

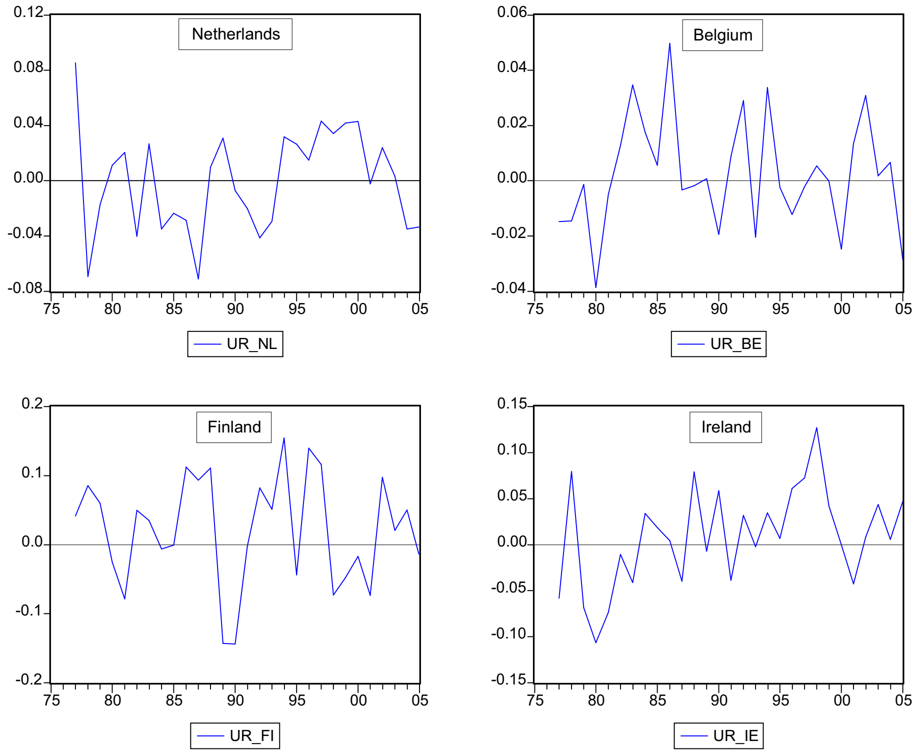


ANNEX 16: Residuals unrestricted lag order ARDL H&Q by country

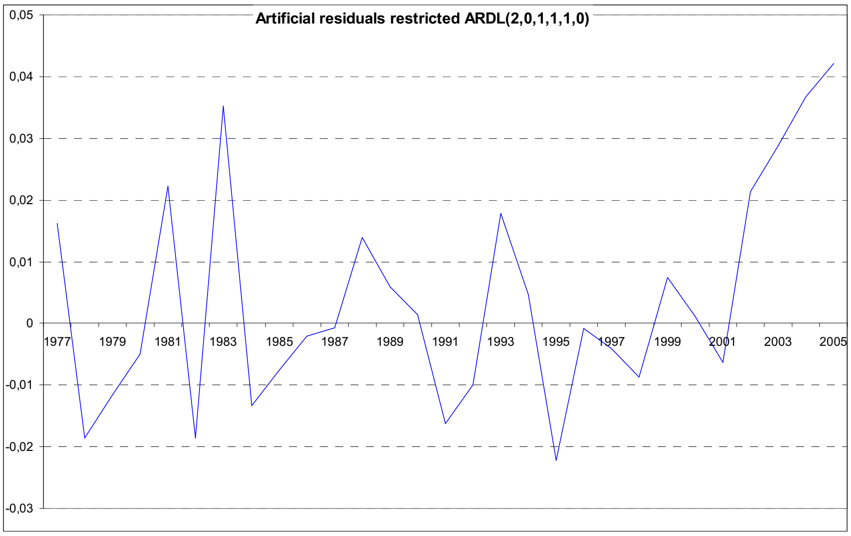
Residuals unrestricted ARDL H&Q heterogeneous mortgage loan slope

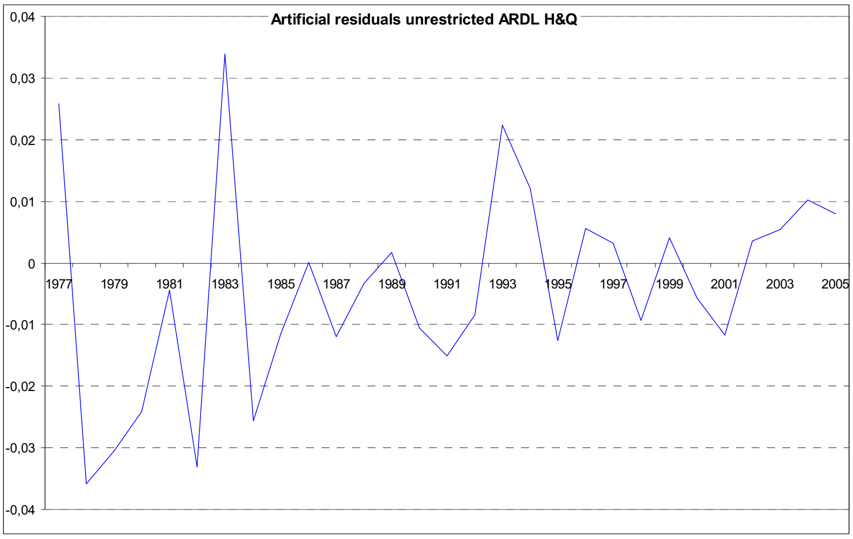


Residuals unrestricted ARDL H&Q heterogeneous mortgage loan slope

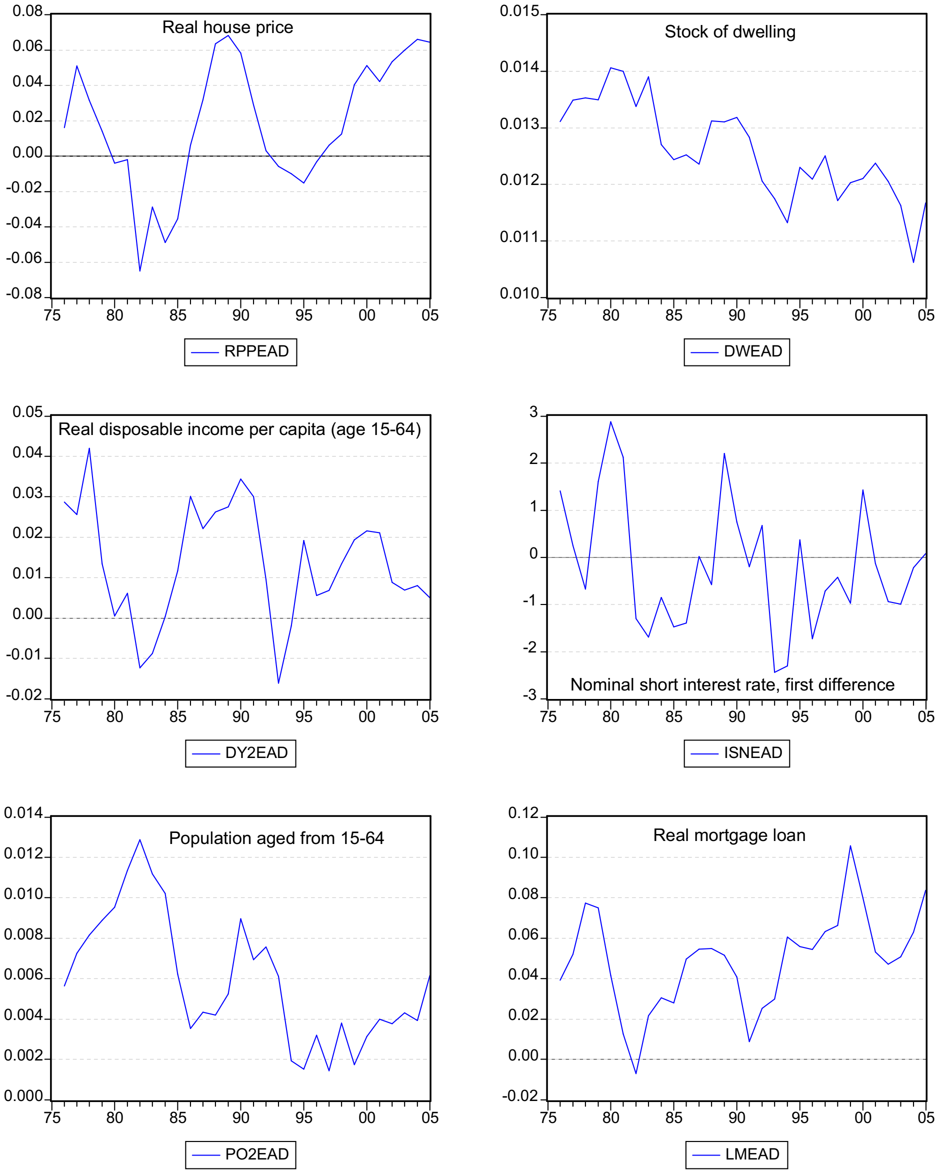


ANNEX 17: Residuals - constructed euro area models - restricted/unrestricted heterogeneous mortgage loan slopes



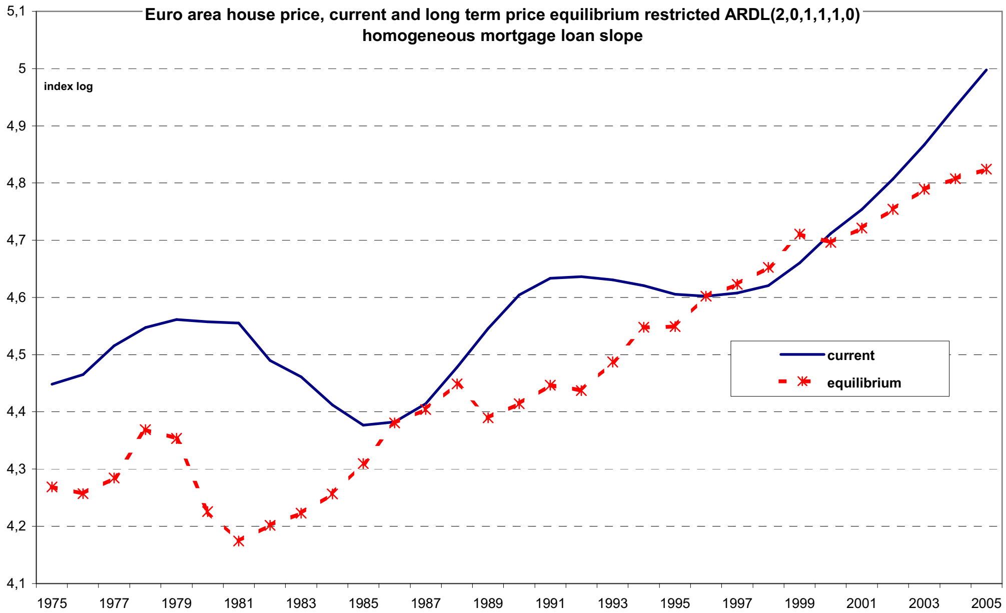


ANNEX 18: Euro area time series, growth rates except interest rate

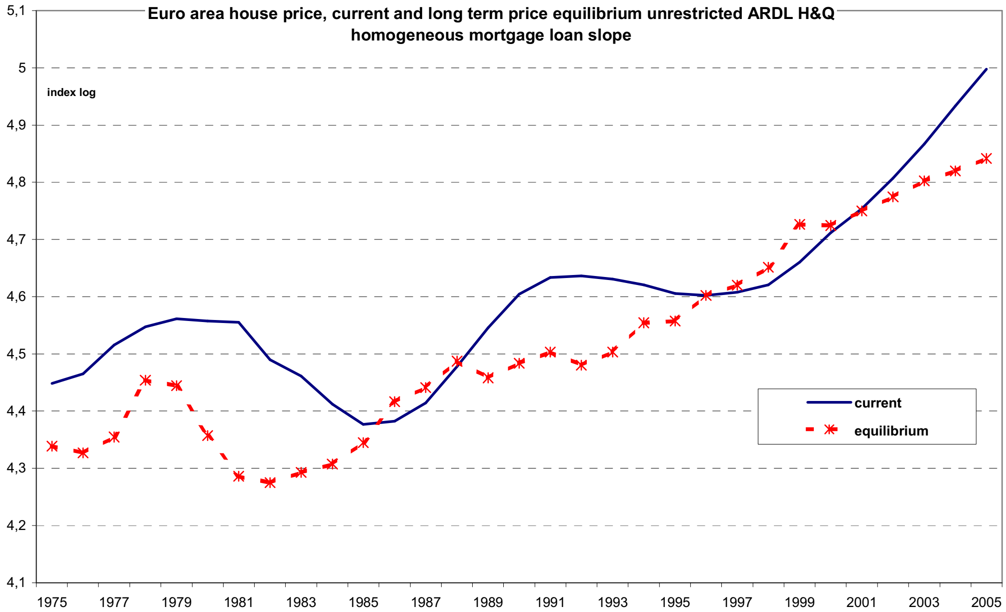


ANNEX 19: Euro area house price equilibrium homogeneous mortgage loan

1) imposed lag structure - restricted ARDL



2) H&Q lag structure - unrestricted ARDL



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[1] "Coopérant du Service National en Entreprise": Civil Service.