HOUSE PRICES: BUBBLES, EXUBERANCE OR SOMETHING ELSE? EVIDENCE FROM EURO AREA COUNTRIES

BANCO DE PORTUGAL
EUROSYSTEM

Working Papers 2015

Rita Fradique Lourenço | Paulo M. M. Rodrigues

17

17

HOUSE PRICES: BUBBLES, EXUBERANCE OR SOMETHING ELSE? EVIDENCE FROM EURO AREA COUNTRIES

Working Papers 2015

Rita Fradique Lourenço | Paulo M. M. Rodrigues

November 2015

Please address correspondence to
Banco de Portugal, Economics and Research Department
Av. Almirante Reis 71, 1150-012 Lisboa, Portugal
T +351 213 130 000 | estudos@bportugal.pt

BANCO DE PORTUGAL
EUROSYSTEM

Lisbon, 2015 • www.bportugal.pt

WORKING PAPERS | Lisbon 2015 • Banco de Portugal Av. Almirante Reis, 71 | 1150-012 Lisboa • www.bportugal.pt •
Edition Economics and Research Department • ISBN 978-989-678-391-4 (online) • ISSN 2182-0422 (online)

House prices: bubbles, exuberance or something else? Evidence from euro area countries

Rita Fradique Lourenço
Banco de Portugal

Paulo M. M. Rodrigues
Banco de Portugal
NOVA School of Business and Economics

November 2015

Abstract
The real estate market plays a crucial role in a country's economy. Since residential property is the most important component of households' wealth, real estate markets price trends can affect households' consumption and investment decisions via wealth effects. As real estate is often used as collateral for loans, changes in real estate prices affect households' debt and their ability to repay loans, and consequently also impact on the banking sector. As housing covers a basic human need, analyzing fluctuations in residential property prices is also important from a social perspective. Furthermore, since the construction industry is a main employer, investment in construction has a major influence on economic activity. Thus, developments in the real estate market have far-reaching implications on the economy as a whole as well as on financial stability. In this paper we use different methodologies with the objective of providing evidence regarding potential bubble/exuberant behaviour of economic agents in several European countries and the US, over the last four decades.

JEL: C12, C22

Acknowledgements: We thank participants of the Exchange seminar at Banco de Portugal, the Workshop for Time Series Econometrics at the Goethe University Frankfurt, and the WGF Workshop on House Prices at the ECB for useful comments and suggestions. We also thank Joerg Breitung for making his MATLAB codes for bubble dating available to us.

E-mail: rmlourenco@bportugal.pt; pmrodrigues@bportugal.pt

1. Introduction

The housing market is of considerable importance as it may have major impacts on economic activity through, for instance, changes on housing wealth on consumption and the credit channel. Homes are the major assets in households' portfolios (Englund *et al.*, 2002) and consequently, changes in housing-wealth may lead to changes in homeowners' consumption (Case, Quigley and Shiller, 2005).

In effect, it has been shown that changes in housing wealth can be more important in their effect on the economy than changes in wealth caused by stock price movements (Helbling and Terrones, 2003 and Rapach and Strauss, 2006). To further highlight the importance of this variable we note that Kemme (2012) presents evidence showing that tracking just real house prices would have been enough to predict the global financial crisis in 2007. In effect, economic history suggests that some of the most severe systemic financial crises have been associated with boom-bust cycles in real estate markets (see e.g., Bordo and Jeanne 2002, Reinhart and Rogoff 2012, Crowe et al. 2013).

Over recent years, attention in Europe has been centred in solving the problem of the indebted nations of Southern Europe and on the recovery from the recent financial crisis, however, it seems that concerns are emerging that a new problem may be developing as a consequence of increasing property prices in Northern and Western Europe, in particular as this is raising the fears of a repeat of the real estate bubbles which were at the origin of the global financial crisis.

Bubbles refer to situations when asset prices exceed their fundamental value because of investors' expectations of future gains. According to Stiglitz (1990) "if the reason that the price is high today is only because investors believe that the selling price will be high tomorrow - when "fundamental" factors do not seem to justify such a price - then a bubble exists". For instance, Detken and Smets (2004) define asset price booms as a period during which the aggregate real asset price index is continuously more than 10% above its trend.

Asset price bubbles, regardless of the type, have common features. In a first stage, ample credit expansion is accompanied by sustained increases in asset prices, such as stocks and real estate, which inflate the bubble; and in a second stage, the bubble bursts and prices collapse as short-sales abound. This occurs often over a short period of time (a few days or months), however sometimes also over longer periods (particularly in real estate markets). Sufficiently large bubbles may lead to the default of many agents who had borrowed to buy assets at historically high prices, and may ultimately also originate banking crisis (Allen and Gale, 2000).

Reports of bubbles date back to the XVII century. Prominent examples include the Dutch Tulipmania in the XVII century, the Mississippi and South Sea bubbles in the XVIII century and the Wall Street Crash of 1929 (Garber, 1990). Later in the XX century, there was the rise in the late 1980's and fall in early 1990's of real estate and stock prices, respectively in Japan and in house prices in Nordic countries (Allen and Gale, 2000). Emerging economies have been very prone to financial and currency crises of this kind in the 1980's and 1990's, with examples in Latin American countries, e.g. the Mexican Tequilla crisis, and the South East Asian crisis (see e.g. Kindleberger and Aliber, 2005 for an interesting historical overview of financial crises). More recently, the world has experienced an unprecedented financial and economic crisis as a result of the US subprime market collapse of 2007 which quickly spread worldwide. Shiller (2008) argues that the housing bubble that created the subprime crisis grew as big as it did because people did not understand or knew how to deal with speculative bubbles: the core of the problem was an epidemic of irrational public enthusiasm for housing investments. Duca et al. (2010) focusing on the US housing and credit boom argue that financial innovations increased the liquidity of housing wealth through changes in the collateral role of housing and promoted a borrow-funded consumption boom, which in turn, affected lending behaviour and loan quality.

The literature on bubbles is extensive (see, among others, Shiller, 1981, 2005, Flood and Hodrick, 1990, and Gürkaynak, 2008 for overviews). Since bubbles cause extremely large positive price changes as they grow (especially during the last stages of their growth process), and even larger negative price changes when they burst, the distribution of price changes will have negative skewness and large kurtosis if bubbles exist. Large kurtosis was reported, among others, by Friedman and Vandersteel (1982) and Okina (1985) for foreign exchange rates, by Dusak (1973) for commodity futures prices, by Fama (1976) for stock prices and by Blanchard and Watson (1982) for gold prices.

Although there is a large literature on bubbles, empirical research on house (real estate) price bubbles is much less common than on stock prices. Examples of such studies include Garino and Sarno (2004) who have found evidence for the existence of bubbles in UK house prices over the period 1983-2002; Nneiji *et al.* (2011) who used a Markov regime switching model on price-to-rent ratio series for the US from 1960 to 2009 and detected evidence of an intrinsic bubble during the pre-1998 period; and Agnello and Schuknecht (2009) who used a random effects panel probit model for 18 European countries over 1980-2007 and found that most of the recent housing booms have been persistent and of considerable magnitude.

The objective of this paper is to analyse whether real estate prices in several European countries have deviated from their fundamental values (assuming that agents are homogeneous, rational and the market is informationally efficient). In particular, the interest centres on understanding whether market prices may equal their fundamental values plus a bubble term. Hence, the aim of this paper is to contribute to this literature by providing evidence of whether potential bubble/exuberant behaviour of economic agents in several countries occurred over the period 1970 - 2014, by resorting to different methodologies. We contribute to the literature on several fronts. First, we apply conventional measures to have a descriptive analysis of the dynamics of several variables typically used in the characterisation of housing markets; second, we resort to a quantile regression approach to detect periods in which house prices were not in line with their macroeconomic determinants, i.e., a robust analysis of deviations from fundamentals; and third, we empirically examine the conjecture of housing bubbles through a recently developed econometric procedure introduced by Philips et al. (2015).

The remainder of the paper is organized as follows. Section 2 briefly reviews the concepts of bubbles typically considered in the literature, section 3 describes house price dynamics and the results of the empirically analysis, and section 4 concludes.

2. Asset Price Bubbles

To briefly introduce the notion of bubbles, we follow Cuthbertson (1996) [see also Poterba (1984, 1991) and Topel and Rosen (1988)] and simplify the exposition by considering that agents are risk neutral and have rational expectations; and that investors require a constant (real) rate of return, r, on the asset, i.e., $E_t R_t = r$. Hence, following Campbell et al. (1997) the standard present value model of asset prices can be written as,

$$P_t = \delta E_t (P_{t+1} + D_{t+1}) \tag{1}$$

where P_t is the real asset price at time t, D_{t+1} is the real dividend paid to the owner of the asset between t and $t+1$, $\delta := 1/(1+r)$ is the discount factor and E_t is the conditional expectations operator for information at time t. The Euler equation in (1) can be solved under rational expectations by repeated forward substitution to yield,

$$P_t = \sum_{i=1}^{\infty} \delta^i E_t D_{t+i} =: P_t^f \tag{2}$$

under the assumption that the transversality condition holds, i.e., that $\lim_{n \to \infty} (\delta^n E_t D_{t+n}) = 0$.

The importance of the transversality condition is that it ensures an unique solution (price) given by (2), which corresponds to the fundamental value of the asset, P_t^f. The idea behind the rational bubble model is that there is another expression for the real asset price that satisfies the Euler equation in (1), namely,

$$P_t = \sum_{i=1}^{\infty} \delta^i E_t D_{t+i} + B_t = P_t^f + B_t \tag{3}$$

where B_t represents a rational bubble. Equation (3) indicates that the market price, P_t, deviates from its fundamental value, P_t^f, by B_t, the value corresponding to the rational bubble.

However, in order for (3) to satisfy (1) some restrictions need to be imposed on the dynamic behaviour of B_t. These restrictions can be determined by assuming that (3) is a valid solution of (1). For illustrative purposes consider, as suggested in Cuthbertson (1996, pp. 157-158), equation (3) at time $t+1$ and take its expectations at time t, *i.e.*,

$$\begin{aligned} E_t P_{t+1} &= E_t \left[\delta E_{t+1} D_{t+2} + \delta^2 E_{t+1} D_{t+3} + ... + B_{t+1}) \right] \\ &= \delta E_t D_{t+2} + \delta^2 E_t D_{t+3} + ... + E_t B_{t+1} \end{aligned} \tag{4}$$

where the second equality follows from the law of iterated expectations, i.e., $E_t\left(E_{t+1}D_{t+j}\right) = \left(E_t D_{t+j}\right)$.

Thus, considering (1) and (4) it follows that

$$\begin{aligned} P_t &= \delta(E_t D_{t+1} + E_t P_{t+1}) \\ &= \delta E_t D_{t+1} + (\delta^2 E_t D_{t+2} + \delta^3 E_t D_{t+3} + ... + \delta E_t B_{t+1}). \qquad (5) \end{aligned}$$

Consequently, given the result in (2) and (5) we can write that,

$$P_t = P_t^f + \delta E_t B_{t+1} \qquad (6)$$

and therefore, for (3) to be a valid solution it is necessary that $\delta E_t B_{t+1} = B_t$ or equivalently that $E_t B_{t+1} = B_t/\delta = (1+r)B_t$. Thus, apart from a discount factor (δ), B_t must behave has a martingale (in other words, the best forecast of all future values of the bubble depend only on its current value). Note however that although the bubble solution satisfies the Euler equation, it violates the transversality condition (when $B_t \neq 0$) and because B_t is arbitrary, the solution (price) in (3) is not unique.

We note from this exposition that the bubble in this set up is not a mispricing effect but a component of the asset price, and that arbitrage opportunities are ruled out. Under the assumption that dividends grow slower than r, the market fundamental part of the asset price converges and the bubble part in contrast is nonstationary. This type of bubble has been considered in detail in, e.g., Shiller (1981), Le Roy and Porter (1981), West (1987) and Blanchard and Watson (1982).

The rational bubble model just described can be extended to allow for strictly positive bubbles which colapse almost surely in finite time (see, among others, Blanchard, 1979, Evans, 1991, Diba and Grossman, 1988, Taylor and Peel, 1998, and Hall et al. 1999), i.e., define this type of bubble as,

$$B_{t+1} = \begin{cases} (1+r)B_t u_{t+1} & if \quad B_t \leq \alpha \\ \left\{\delta + \pi^{-1}(1+r)\theta_{t+1}\left[B_t - (1+r)^{-1}\delta\right]\right\} u_{t+1} & if \quad B_t > \alpha \end{cases}$$

where u_t is an exogenous i.i.d. positive random variable with $E_t(u_{t+1}) = 1$, θ_{t+1} is an exogenous i.i.d. Bernoulli process (independent of u_{t+1}) with $P[\theta_{t+1} = 1] = \pi$ and $P[\theta_{t+1} = 0] = 1 - \pi$, $0 \leq \pi \leq 1$, $\alpha > 0$ and $0 < \delta < (1+r)\alpha$. Note that this last condition on δ is necessary to guarantee that the bubble is always positive. The parameter π is thus the probability of continuation of the bubble; see e.g. Yoon (2012).

The above two rational bubble models are informative about the time series properties of the bubble once it is under way. In these models, the bubble component is considered 'exogenous' to the fundamentals of expected returns, but it must grow exogenously at an expected rate of $(1+r)$ per period to be arbitrage free. One implication of rational bubbles is that they cannot be negative.

Froot and Obstfeld (1991) suggest a different formulation of bubble, one in which the bubble is tied to the level of dividends, known as intrinsic bubble. To tie the bubble to the fundamentals, dividends should be explicitly modelled. In particular, Froot and Obstfeld assume that log dividends, denoted by d_t, follow a random walk with drift, *viz.*,

$$d_t = \mu + d_{t-1} + \xi_t \tag{7}$$

where $\xi_t \sim N(0, \sigma^2)$ and μ is the dividends growth rate. The functional form of the intrinsic bubble specified by Froot and Obstfeld (1991) is $B(D_t) = cD_t^{\lambda}$, where c is an arbitrary constant and λ is the positive root of $\lambda^2 \frac{\sigma^2}{2} + \lambda\mu - r = 0$.

However, Sola and Driffill (1994) note that the time invariance of Froot and Obstfeld's random walk characterization of the log dividends in (7) may be restrictive and propose a regime switching model of dividends such as,

$$d_t = d_{t-1} + \mu_0(1 - s_t) + \mu_1 s_t + [\sigma_0(1 - s_t) + \sigma_1 s_t]\,\varepsilon_t \tag{8}$$

where s_t is a state variable that follows a Markov process with constant transition probabilities. In this case, the growth rates of dividends, Δd_t, are distributed as $N(\mu_0, \sigma_0^2)$ in the $s_t = 0$ state, and as $N(\mu_1, \sigma_1^2)$ in the $s_t = 1$ state. Sola and Driffill note that the formulation of the dividend process in (8) fits the data better, and then test the model with regime switching fundamentals. For further results on regime dependent models see, *inter alia*, Hall et al. (1999), Funke et al. (1994), van Norden and Vigfusson (1998) and Psaradakis et al. (2001).

Remark 2.1: *Note also that prices may drift away from intrinsic values because social forces create temporary fashions, fads, in asset markets, as for instance in the markets for cars, food, houses and entertainment. Following Camerer*

(1989) we can define a fad, F_t, as a deviation between prices and the intrinsic value which slowly reverts to its mean of zero (Shiller and Perron, 1985; Summers, 1986; and Lo and Mackinlay, 1988) as in

$$P_t = P_t^f + F_t \tag{9}$$

with P_t^f as considered in (2) and $F_{t+1} = \varphi F_t + e_t$ where φ is a parameter measuring the speed of convergence or decay of the fad and e_t is a zero mean independent error term. If $\varphi = 0$ any fads disappear immediately. If $\varphi = 1 + r$ the fad corresponds to a rational growing bubble. However, fads are not rational because (9) does not satisfy the equilibrium condition if φ is less than one (since the expected return on the faddish part of the price will be less than r and investors should sell assets, making the fad disappear). However, if φ is close to one, the fad may be so slow to decay that investors cannot easily profit by betting on it to disappear.

Hence, given the different nature of bubbles, in what follows we use different approaches to shed light on the dynamic properties of house prices in Europe over the last four decades.

3. House Price Dynamics

From the previous discussion we note that bubbles arise when the expectations of future asset prices have an abnormally important influence on the valuation of assets, potentially stimulating demand and thus leading to deviations of prices from their fundamentals.

To investigate the possible existence of exuberance periods (possible bubbles) in real house prices in Europe over the last decades we use different methodological approaches, which will be described next in Sections 3.1 - 3.6, in order to obtain a more complete understanding of the house price dynamics in Europe.

3.1. Data

Our data set comprises quarterly time series from 1970:Q1 to 2014:Q4 for eleven euro area countries (Germany, France, Italy, Spain, the Netherlands, Greece, Ireland, Portugal, Austria, Belgium and Finland), the UK and the US, the latter is considered for comparative purposes. Data on house prices, disposable income, GDP, labour force, private consumption deflator, price-to-income ratio and price-to-rent ratio were collected from the OECD, while short-term interest rates were taken from the European Central Bank. A detailed description of all data sources and availability, as well as country specificities are provided in Tables D.1 and D.2 in Appendix D.

House price indices correspond generally to seasonally unadjusted series constructed from national data from a variety of public and/or private sources (for example, national statistical services, mortgage lenders and real estate agents). National house price series may differ in terms of dwelling types and geographical coverage (most are country-wide and refer to existing apartments). Several series are based on hedonic approaches to price measurement, characterized by valuing the houses in terms of their attributes (average square metre price, size of the dwellings involved in transactions and their location). The price-to-rent ratio corresponds to the nominal house price divided by the consumer price index rent price. The price-to-income ratio is the ratio of nominal house price to per capita disposable income. Short-term interest rates correspond to 3-month national interbank money market yield rates. All series in real terms are computed using the private consumption deflater.

3.2. Descriptive Results

Before analysing the results obtained under the different approaches considered in this paper, it is important to briefly provide a descriptive analysis of the evolution of real house prices in the euro area countries, the UK and the US over the past three decades. From Figure 1 and Table 1, we identify three broad groups of countries on the basis of their real price appreciation in the decade prior to the onset of the financial crisis in 2007. Evidence shows that between 1997 and 2006 in a first group of countries (Group I), house prices grew strongly (above or around 7 per cent). This group includes, for instance, Ireland, the UK, Spain, France and Greece, where the growth of house prices was more than double the average growth recorded between 1987 and 1996. A second group of countries (Group II) with smaller but still significant real house price growth (4-6 per cent) comprises Italy, Finland, Belgium, the Netherlands and the US. Finally, a third group of countries (Group III) where real house prices were mostly flat or even declined include Germany, Austria and Portugal. In this context, it is worthwhile mentioning that fast rising house prices in many economies over a long period of time occurred against the background of a high growth of household disposable income and corresponded in many cases to a significant growth of indebtedness of households over the last decades; see Figure 2.[1]

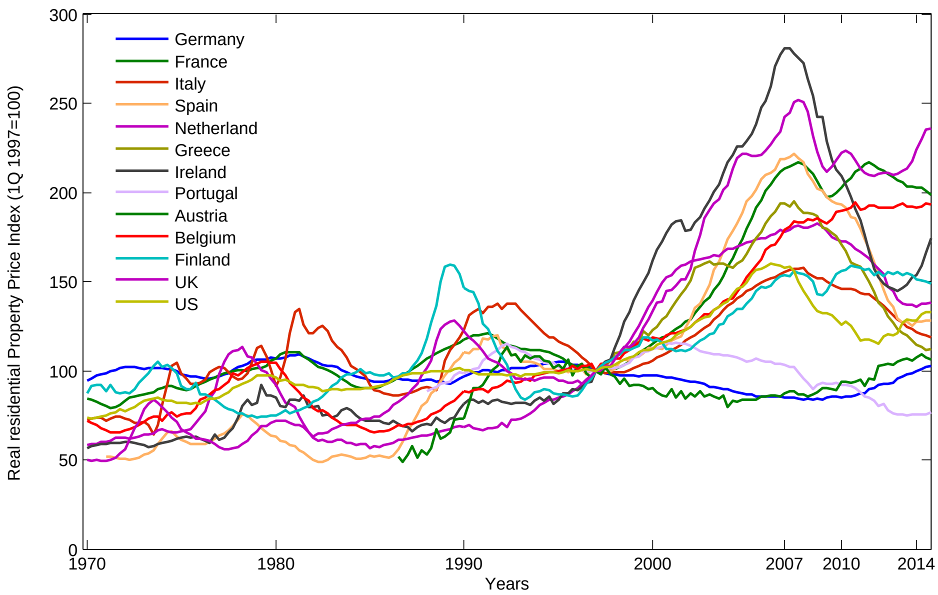


FIGURE 1: Log of Real House Prices.
Source: OCDE

The years of 2007 and 2008 signal the start of a downward correction in real estate prices in the large majority of countries independently of whether they had gone up or down in the previous decades. This reflects how the US subprime collapse in 2007 quickly spread worldwide and how housing markets developments can have a major impact on the economy. Besides the US, the

1. This is specially the case in Ireland and Spain which in 2014 still presented very high ratios of mortgage loans to disposable income (140% in Ireland and 85% in Spain in 2014 against 30% and 40%, respectively in 1997). In Portugal, although there was no significant increase in house prices over this period, there was however a considerable increase in household indebtedness rising from 30% in 1997 to 90% in 2014.

largest declines in house prices were as might be expected in countries which experienced highest growths in the past, particularly Ireland, the UK and Spain. But there were also strong declines in Portugal and Finland. Judging by house prices evolution more recently it appears that housing markets have been already improving in several Western and Northern European countries, speeding up particularly in Ireland and the UK. In the latter, this may be associated with more liquid and mature housing markets or higher income elasticity of house prices compared to other industrialized countries (Hunt, 2005).

Table 1: Real House Prices Dynamics

	Average 1987-1996	Average 1997-2006	Average 2007-2014	2008	2014	Acum. 1987-1996	Acum. 1997-2006	Acum. 2007-2014
	Percent					2010=100		
Austria	6.2	-1.6	2.5	1.9	0.6	82	-11	24
Belgium	4.0	5.7	1.0	1.3	0.5	48	68	10
Finland	-0.3	4.3	-0.4	-7.7	-2.7	-3	60	-2
France	0.4	7.8	-0.9	-4.9	-2.4	4	106	-6
Germany	0.6	-1.6	2.4	-0.2	3.9	6	-15	20
Greece	-	6.8	-6.6	-2.6	-3.9	-	94	-42
Ireland	3.2	10.7	-5.8	-12.0	14.6	37	196	-37
Italy	1.7	4.4	-3.3	-3.4	-3.7	18	50	-23
Netherlands	4.6	6.0	-3.1	0.8	0.9	57	84	-23
Portugal	1.3	0.4	-3.7	-6.9	1.4	13	4	-26
Spain	4.2	8.1	-6.5	-7.8	2.2	50	117	-41
UK	1.2	8.9	-0.3	-11.6	8.6	12	140	1
US	0.2	4.8	-2.1	-11.3	3.9	2	59	-17

Source: OECD.

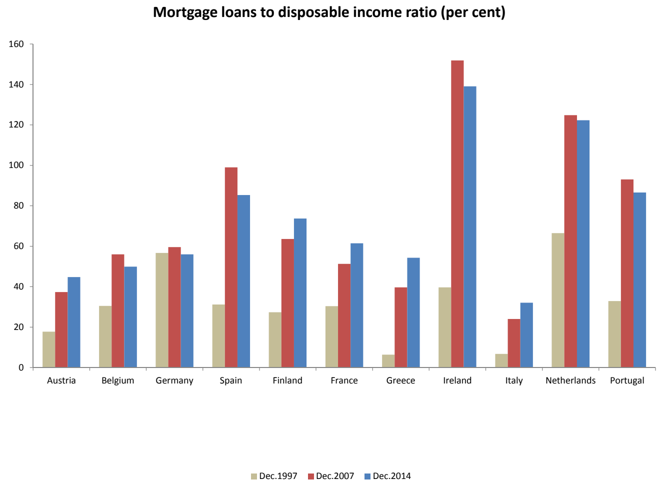


FIGURE 2: Mortgage loans to disposable income ratio (per cent).

3.3. The Price-to-Rent and Price-to-Income Ratios

To better understand the descriptive results just presented, it will be useful to complement the analysis with more formal measures. Summary measures frequently used to assess housing market conditions are the price-to-income and the price-to-rent ratios. Asset pricing theory predicts a clear relation between house prices, rents, and discount rates, where the price-to-rent ratio captures the long-run relation between the cost of owning a house and the return on renting it out (Poterba, 1984). It is the equivalent in real estate markets of the price-to-earnings ratio (PER), the most common measure of the cost of an asset. Intuitively, when house prices are too high relatively to rents, potential buyers find it more advantageous to rent, thus reducing the demand for houses which should in turn exert downward pressure on house prices and bring house prices back into line with rents. The reasoning is of course the opposite when the price-to-rent ratio is low, then in this case it will be better to buy a house than to rent it. If by any chance the price-to-rent ratio remains high for a prolonged period of time, it can be argued that prices are being supported by unrealistic expectations of future price gains rather than by the true (fundamental) rental price. Hence, a continuous upward price-to-rent ratio may suggest the existence of bubbles. Note however that care needs to be taken in the interpretation of this metric as it is more adequate in liquid rental and housing markets where arbitrage opportunities can be fully exploited, and this is not the case in several European countries.

Another metric conventionally used when assessing house price dynamics is the price-to-income ratio. The price-to-income ratio looks at the total cost of a home relative to median annual incomes, and measures whether or not housing is within reach of the average buyer. It captures the idea that house prices in the long-term are constrained by the affordability of housing for households, including the ability to service the debt incurred for the house purchase from the stream of income. If this ratio rises above its long-term average, it could be an indication that prices were overvalued and in this case, prospective buyers would find purchasing a home difficult, which in turn should reduce demand and lead to downward pressure on house prices.

It should be noted that the price-to-rent and price-to-income ratios may, however, fail to reflect accurately the state of housing costs and indicate that house markets may appear exuberant when house prices are in fact reasonably priced. According to Himmelberg *et al.* (2005) the price of a house is not the same as the annual cost of owning, so rising house prices does not necessarily indicate that ownership is becoming more expensive or that housing is overvalued. Also, it is possible that considerable variability in the price-to-rent ratios across markets exists given differences in expected appreciation rates of houses and taxes. Finally, they further draw attention to the fact that the sensitivity of house prices to fundamentals is higher at times when real long term interest rates are already low, and therefore accelerating house price growth may not intrinsically signal a bubble.

The evolution of the price-to-rent and price-to-income ratios for the countries under analysis are presented in Table 2, where the long-term averages are given in columns 1 and 4, respectively. The latest values observed in columns 2 and 5 and the relationship between these and the long term averages in columns 1 and 4, are provided in columns 3 and 6, respectively. For illustrative purposes, Figures 4 and 5 depict the cyclical deviations of both measures against their long-term trends.

The last column of Table 2 shows that in most countries house prices are in line with their long-term averages. This conclusion does not apply to France, Belgium, the UK and Finland (in the latter just for the price-to-rent ratio), where house prices are clearly above their long-term averages (between

20 and 50 percent) and Portugal where prices are below the long-term average. Moreover, in the period before the crisis, the deviations from the long-term averages reached more than 50 per cent in Spain and over 60 per cent in Ireland (in the latter country it was almost 100 per cent for the price-to-rent ratio). Finally, it is noteworthy that the downward adjustment observed following the crisis has come to an end in Spain and Ireland (see Figures 3 and 4).

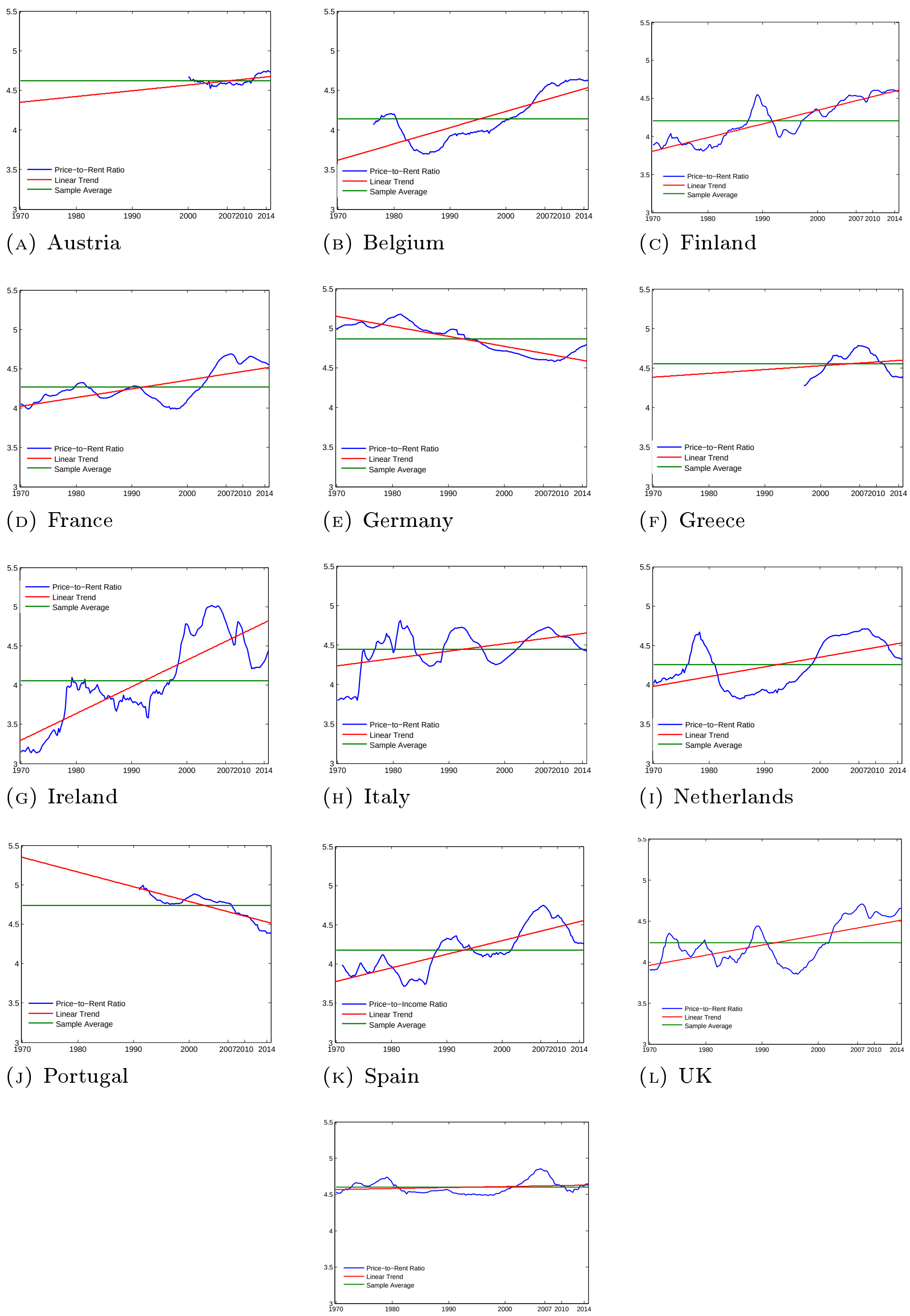
Table 2: Price-to-rent and price-to-income ratios (2010=100)

	Price-to-rent ratio			Price-to-income ratio		
	I	II	III	IV	V	VI
	Average	Last quarter	(II)/(I)x100	Average	Last quarter	(V)/(IV)x100
Austria	102	114	112	99	118	119
Belgium	66	101	153	70	103	147
Finland	75	98	131	97	98	100
France	76	94	124	78	97	124
Germany	125	120	96	128	115	90
Greece	96	81	84	93	84	90
Ireland	76	85	111	88	90	102
Italy	92	83	90	84	90	107
Netherlands	74	76	102	71	81	114
Portugal	115	81	70	117	90	77
Spain	73	72	99	71	71	100
UK	74	105	142	84	109	130
US	99	103	105	110	101	92

Source: OECD

Note: Average considering information available since 1980.

Last observation 4Q2014.



(A) Austria (B) Belgium (C) Finland

(D) France (E) Germany (F) Greece

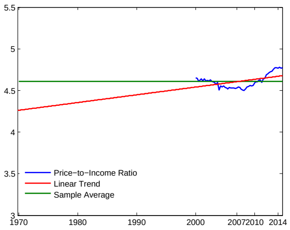
(G) Ireland (H) Italy (I) Netherlands

(J) Portugal (K) Spain (L) UK

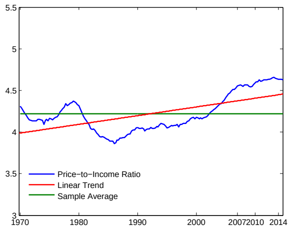
(M) US

FIGURE 3: Price-to-rent ratio. (in logs, base 2010, 70Q1 to 14Q4).

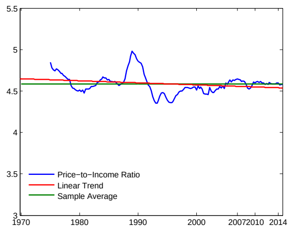
Source: OECD and Authors' calculations.



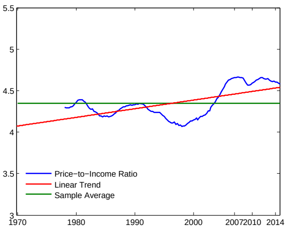
(A) Austria



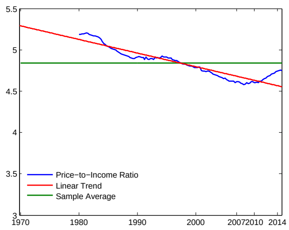
(B) Belgium



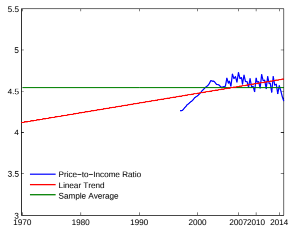
(C) Finland



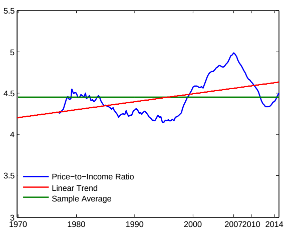
(D) France



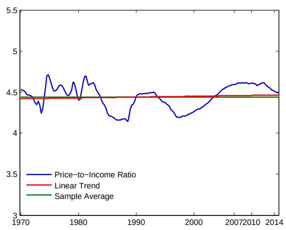
(E) Germany



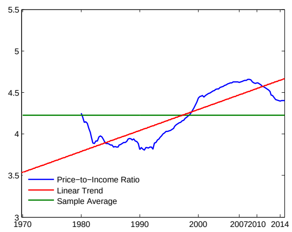
(F) Greece



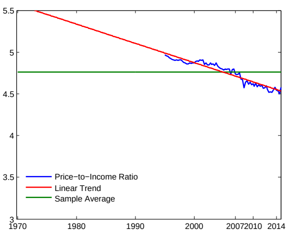
(G) Ireland



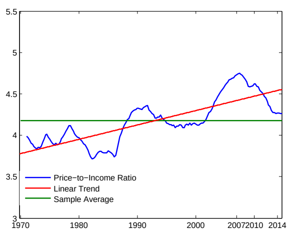
(H) Italy



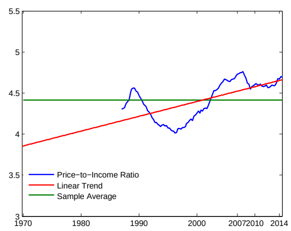
(I) Netherlands



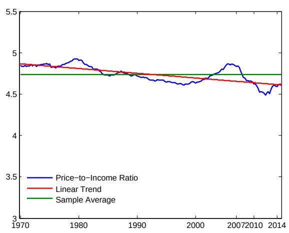
(J) Portugal



(K) Spain



(L) UK



(M) US

FIGURE 4: Price-to-income ratio. (in logs, base 2010, 70Q1 to 14Q4).

Source: OECD and Authors' calculations.

3.4. Housing Cycles and Business Cycles

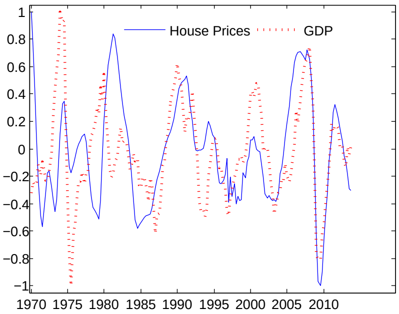
For further analysing the dynamics of house prices, it will be relevant to relate the house price cycle to the business cycle. Hence, comparing real house price cycles and business cycles for several economies we see that the turning points roughly coincide from 1970 to 2013 (Figure 5). The results using the Hodrick-Prescott filter are in line with the business cycle peaks and troughs dating by the Economic Cycle Research Institute.

Table 3: House Price Cycle and Business Cycle Statistics

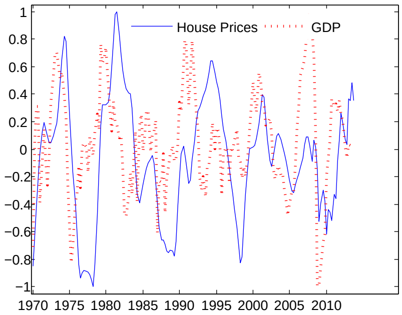
	DE		ES		FR		PT		UK		US	
	GDP	HP	GDP	HP	GDP	HP	GDP	HP	GDP	HP	GDP	HP
Pearson	0.24		0.40		0.44		0.52		0.52		0.46	
Lead (+)/Lags (-)	-10		1		1		-12		1		-11	
Sincronicity (%)	58.29		52.05		52.00		56.31		56.00		56.00	
σ	0.37	0.44	0.38	0.34	0.35	0.39	0.38	0.38	0.38	0.43	0.36	0.37
ρ_1	0.79	0.94	0.86	0.92	0.90	0.92	0.84	0.92	0.84	0.93	0.88	0.92
ρ_2	0.59	0.84	0.74	0.76	0.72	0.78	0.68	0.80	0.66	0.79	0.70	0.81
ρ_3	0.40	0.71	0.55	0.55	0.47	0.60	0.55	0.67	0.47	0.59	0.50	0.68

Note: $\rho_i, i = 1, 2, 3$ corresponds to the autocorrelation in period i, σ refers to the standard deviation, Pearson refers to Pearson's correlation coefficient. DE stands for Germany, ES for Spain, FR for France, PT for Portugal, UK for the United Kingdom and US for the United States. Source: OECD.

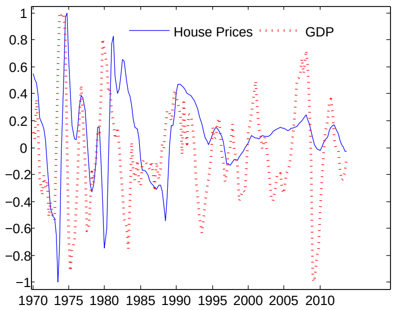
From the analysis of Table 3, we observe that House Prices (HP) display stronger persistence than GDP (the autocorrelations of HP are larger than those of GDP). We further observe that the volatility of the cycles measured through the standard deviation (σ) is also larger for the HP cycle than for the GDP cycle. Moreover, the correlation (Pearson) between the HP cycle and the GDP cycle is strongest in Portugal (0.52) and the UK (0.52), followed by the US (0.46), France (0.44), and Spain (0.40). The lowest correlation is observed for Germany (0.20). Sincronicity, on the other hand, between cycles is higher in Germany, followed by Portugal, the UK, the US, Spain and France.



(A) France

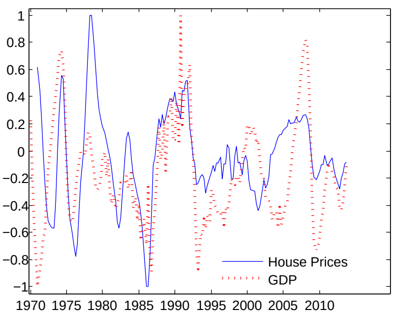


(B) Germany

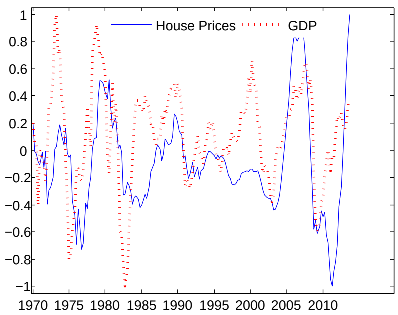


(C) Italy

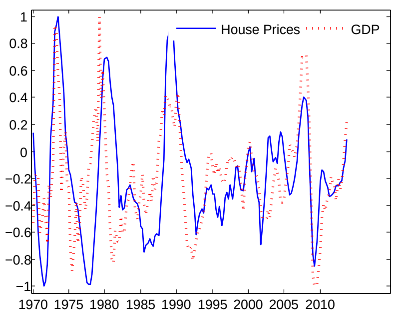
(D) Portugal



(E) Spain



(F) UK

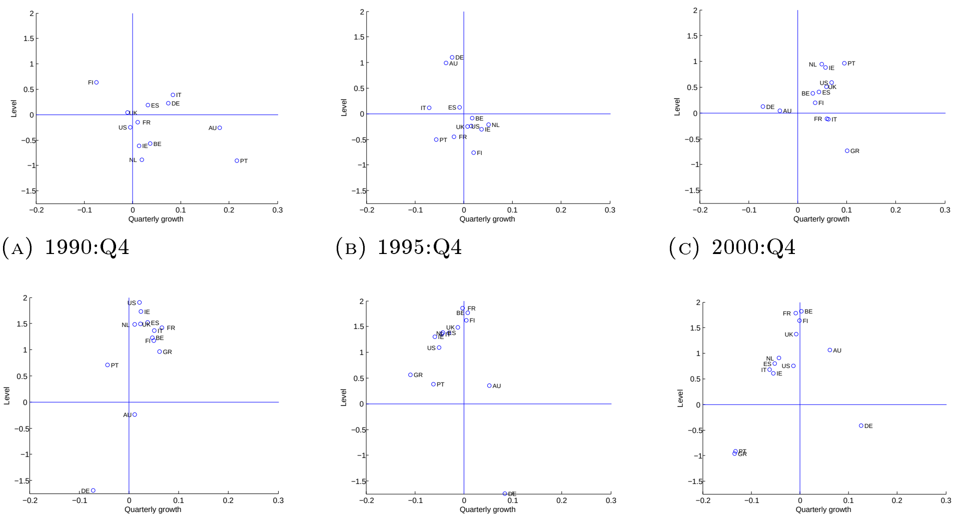


(G) US

Figure 5: House Price Cycles and Business Cycles

Source: OECD and Authors' calculations.

A further important indicator of the cyclical behaviour of HP is the house price dynamics indicator which is produced based on the house price index, resorting to a simple visualization tool (the Economic Climate Tracer) proposed by Gayer (2010). This approach consists of the graphical representation of the standardized level of a smoothed indicator (using for instance the Hodrick-Prescott filter, in order to eliminate short-term fluctuations) on its quarter-on-quarter changes. The resulting diagrams can be divided into four quadrants, allowing for the association of the temporal evolution of the smoothed variables to the different phases of the house price growth cycle: first quadrant – expansion – when the standardized series is above its mean and increasing; second quadrant – downs wing – when the standardized series is above its mean but decreasing; third quadrant – recession – when the standardized series is below its mean and decreasing; and the fourth quadrant – upswing – when the standardized series is below its mean but increasing.



(A) 1990:Q4 (B) 1995:Q4 (C) 2000:Q4

(D) 2005:Q4 (E) 2010:Q4 (F) 2013:Q4

FIGURE 6: Cross-section plots of the position of house prices in the 4th quarter of several years (1990, 1995, 2000, 2005, 2007 and 2013).

Source: Authors' calculation.

The graphs in Figure 6 show that the cyclical dynamics across countries were relatively more heterogeneous in 1990 and 1995, while becoming gradually more similar for most countries in 2000, 2005, 2010 and 2013. Take for instance the example of the US, Spain, Germany and the UK, which between 1990 and 1995 evolved from recession to upswing (US), expansion to down swing (Spain and Germany) and down swing to recession (UK). In 2000, the US, Spain and the UK had shifted into expansion which strengthened in 2005, going into a down swing in 2010, while Germany had moved to a recession in 2005 and an upswing in 2010. In 2013 two groups of countries can be distinctly identified. On the upswing/expansion quadrants: four countries belonging to Northern and Western Europe (Belgium, Finland, Austria and Germany); and in the down swing/recession quadrants the remaining countries: among which, the indebted economies of Southern Europe (Greece, Portugal, Spain and Italy).

3.5. Quantile Regression Analysis

One of the more formal approaches of analysis in our paper consists in the application of a quantile regression (QR) based approach, introduced by Machado and Sousa (2006), to house prices; see also Gerdesmeier, Lenarčič and Roffia (2012). The advantage of using this approach results from the fact that the evaluation of the tails of the empirical distribution of the series allows us to detect periods in which prices were misaligned with their macroeconomic determinants (Machado and Sousa, 2006).

Ordinary least squares (OLS) regressions focus on modelling the conditional mean of a response variable, whereas QR, introduced by Koenker and Bassett (1978), focus on the analysis of the conditional quantiles of a response variable, providing in this way a more detailed analysis of the conditional distribution of a response variable conditional on a set of determinants. The main advantage of QR over OLS regression is its flexibility for modelling data with heterogeneous conditional distributions (Koenker and Hallock, 2001). QR provide a complete analysis of the covariate effect when a set of quantiles is modelled and makes no distributional assumptions about the error term in the model.

There is a vast number of studies that analyses the determinants of house prices. The findings in the literature indicate that models that explain changes in house prices in the long run include a wide set of fundamentals, such as income, population, employment, taxes, borrowing costs, construction costs or returns on alternative assets (Poterba, 1991, Englund and Inoannides 1997, Tsatsaronis and Zhu, 2004). However, in our analysis given the length of the samples and to keep the models tractable we decided to focus on the most consensual fundamentals, namely disposable income (to capture the affordability of house purchases) and the short-term interest rate (which affects mortgage interest rates and thereby captures the cost of financing house purchases). In a second stage, we have also included the labour force. Growth in real disposable income and in labour force is expected to have a positive impact on the housing market. In turn, an increase in the short term interest rate is expected to drive borrowing rates up, increasing the cost of servicing mortgages, which leads to a decrease in the demand for properties and a subsequent fall in house prices.

Hence, our quantile regression is described as:

$$Q_{rhp_t}(\tau|\mathcal{F}_{t-1}) = \alpha_0(\tau) + \alpha_1(\tau)rdi_t + \alpha_2(\tau)rmmi_t + \alpha_3(\tau)labour_t \qquad (10)$$

where $\tau \in (0,1)$ is the quantile of interest, rhp_t corresponds to the natural logarithm of the real house price index, rdi_t is the natural logarithm of the real disposable income, $rmmi_t$ is a real 3-month money market rate and $labour_t$ the logarithm of the labour force.

Estimating[2] the conditional quantile function in (10) involves the minimisation of the weighted residuals

$$\min_{\alpha \in R^k} \sum_{t:y_t \geq X_t'\alpha} \rho_t(y_t - X_t'\alpha(\tau))$$

where $\rho_t(\varepsilon) = \varepsilon(\tau - I(\varepsilon < 0))$ is a check function with I denoting an indicator taking the value of 1 if the expression in parentheses is true and 0 otherwise, $X_t = (1,\, rdi_t,\, rmmi_t,\, labour_t)'$ and $\alpha(\tau) = (\alpha_0(\tau),\, \alpha_1(\tau),\, ...,\, \alpha_3(\tau))'$.

As argued in Machado and Sousa (2006) quantile regressions allow for period by period changes in the conditional distribution of the asset prices to depend on a set of conditioning variables. Thus, such indicators are useful for detecting possible episodes of price misalignment as well as for providing information on the evolution of price uncertainty over time.

For the purpose of investigating periods of misalignment (bubbles) it is preferable to work with variables in levels rather than in growth rates. In

2. The estimation of the conditional quantile model was performed using the "quantreg" package in R.

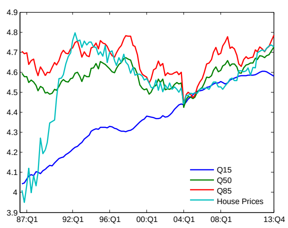
fact the concept of price misalignment is usually understood as a deviation between the level of the asset price and its fundamental value. Hence, since variables in levels are considered, (10) can be seen as a quantile specific long-run relationship. However, since the variables in levels used are nonstationary (confirmed through the application of conventional unit root tests) for the purpose of analysis we need to first analyse the validity of each quantile specific long-run equation considered. In specific, based on the fluctuation of the residuals from the quantile regression, Xiao (2009) proposes a quantile cointegration test denoted as $\sup |Y_T|$ to examine the null hypothesis of quantile cointegration (see Appendix B for details).

The results of application of Xiao's test for cointegration are presented next in Table 4.

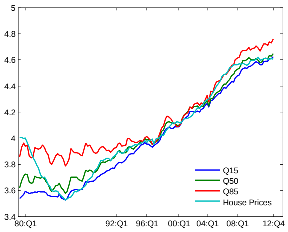
Table 4: Cointegration Tests (Cusum)

Country	OLS	Q10	Q50	Q90
AUSTRIA	0.6579	0.5865	0.6788	0.6913
BELGIUM	0.8225	0.6551	0.5875	0.8053
FINLAND	0.6885	0.7288	0.6659	0.8113
FRANCE	0.6391	0.8160	0.6700	0.6459
GERMANY	0.7124	0.6942	0.7308	0.8099
IRELAND	0.8280	1.1400	0.7507	0.9550
ITALY	0.5556	0.7423	0.6638	0.6048
NETHERLANDS	0.7631	0.8535	0.9422	0.7214
PORTUGAL	0.6759	0.5554	0.8192	0.8888
SPAIN	0.5323	0.6582	0.6933	0.4823
UK	0.5534	0.5878	0.6675	0.6979
US	0.6311	0.5052	0.5787	0.6020
CV	0.9938	1.2228	1.0533	1.2175

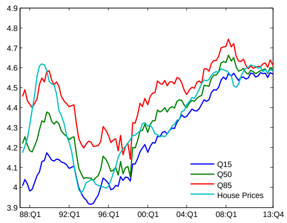
Since, the test considers as null hypothesis that the variables are cointegated we observe from Table 4, that this hypothesis is not rejected for all countries. In Figure 7 we plot these long-run relationships, i.e., the fitted values from the quantile regression at quantiles $\tau = \{0.15, 0.50, 0.85\}$. This approach, as indicated by Machado and Sousa (2006) identifies misalignments as instances where the real asset price is in the tails of its distribution conditional on some macroeconomic determinants. In our application, given the relatively small sample sizes, we opted for evaluating the tails at $\tau = 0.15$ and $\tau = 0.85$.



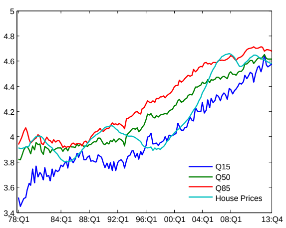
(A) Austria



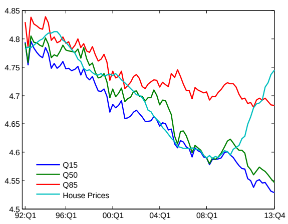
(B) Belgium



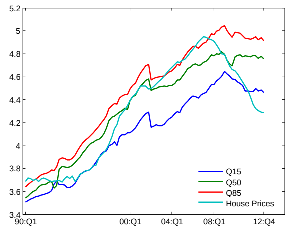
(C) Finland



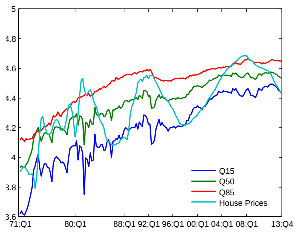
(D) France



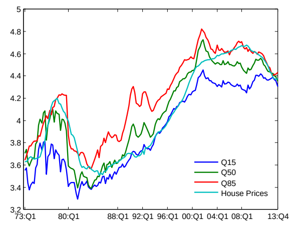
(E) Germany



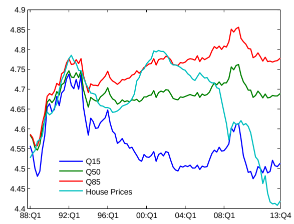
(F) Ireland



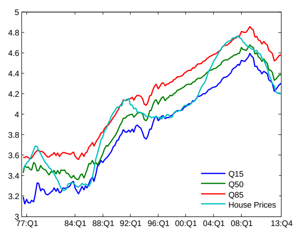
(G) Italy



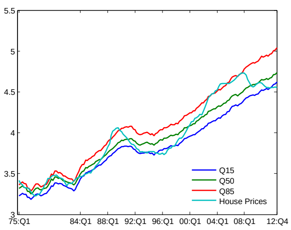
(H) Netherlands



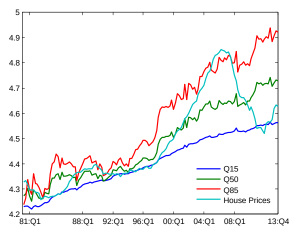
(I) Portugal



(J) Spain



(K) UK



(L) US

FIGURE 7: House price behaviour at different quantiles.

Source: OECD, ECB and Authors' calculations.

Using the quantile regression fits provided in Figure 7 as indicators of potential misalignments of house prices we observe that in most of the countries under analysis periods of over and under-evaluation can be observed. Focusing, for instance, on the period between 2000 and 2014, we note an over-valuation of house prices in Belgium, France, Ireland, Italy, the Netherlands, Spain, the UK and the US between 2002 and 2008. We also observe considerable under-valuations towards the end of the sample in Ireland, Italy, the Netherlands, Portugal, Spain, the UK and the US. In contrast, to all countries considered, Germany presents a considerable increase from around 2010 onwards. Furthermore, in general the dynamics of the quantiles also shows that for some countries the dispersion increases (France, Germany, Ireland, UK and US) whereas in others it decreases (Austria and Finland) over time.

3.6. Time Series Test Approach

Finally, to complement the previous analysis, a method recently proposed by Phillips, Shi and Yu [PSY] (2015) will also be used. This methodology is based on a general arbitrage-free model in line with what we discussed in Section 2 and allows for the detection of periods that may be associated with speculative bubbles.

A prevalent method to detect periodically collapsing bubbles is the forward recursive augmented Dickey-Fuller test [SADF henceforth] put forward by Phillips, Wu and Yu (2009) [PWY hereafter]. They propose the implementation of a right-sided unit root test repeatedly on a forward expanding sample sequence and make inference based on the *supremum* value of the corresponding right-sided ADF statistics sequence.

PSY generalise and improve the SADF test of PWY by developing an approach which is robust to multiple episodes of exuberance and collapse. This is an important contribution since the SADF test may suffer from reduced power and lead to inconsistent results in this context and consequently fail to reveal the existence of bubbles. This is particularly important when analysing long time series or rapidly changing market data where more than one episode of exuberance is suspected. The testing approach which PSY named the generalized sup ADF (GSADF) test, is also based (as is the SADF test) on the idea of repeatedly implementing a right-sided ADF test, but extends the sample sequence to a broader and more flexible range than SADF.

The sample sequences used in the SADF and GSADF tests are designed to capture any explosive behaviour manifested within the overall sample and ensure that there are sufficient observations to initiate the recursion. PSY show that the GSADF test outperforms the SADF test in detecting explosive behaviour in multiple episodes. The GSADF test extends the sample sequence by changing both the starting point and the ending point of the sample over a feasible range of flexible windows.

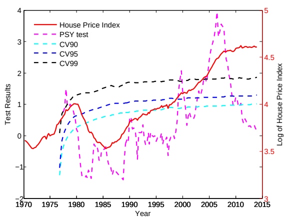
Table 5: PSY test results

Country	T	SADF	GSADF
AUSTRIA	110	-1.0956	1.3729
BELGIUM	176	1.4136**	3.9548***
FINLAND	176	0.3859	1.6161
FRANCE	176	-0.0237	2.491**
GERMANY	176	-0.7990	1.7677*
GREECE	68	-0.3923	3.0201***
IRELAND	176	2.0695***	4.4893***
ITALY	176	-0.6045	2.1936**
NETHERLANDS	176	1.4181**	3.8941***
PORTUGAL	104	-1.9343	0.1445
SPAIN	172	-0.5280	3.7537***
UK	176	-0.6700	4.517***
US	176	1.2924**	3.8249***

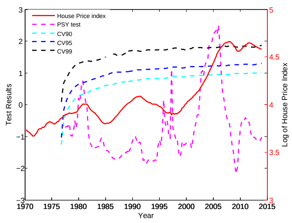
Note: ** and *** indicates statitical significance at the 5% and 10% significance level.

The results in Table 5 correspond to the test statistics proposed by PSY for bubble detection. Hence, we observe that, with the exception of Austria, Finland and Portugal for which the tests are not statistically significant, for all other countries possible exuberant behaviour is detected.

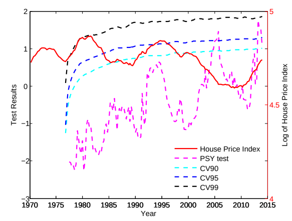
A further contribution of PSY is the proposal of a bubble dating strategy; see also Homm and Breitung (2012). The recursive ADF test is used in PWY to date the origination and termination of a bubble. More specifically, the recursive procedure compares the ADF statistic sequence against critical values for the standard right-tailed ADF statistic and uses a first crossing time occurrence to date origination and collapse. For the generalized sup ADF test, PSY recommend a new dating strategy, which compares the backward sup ADF (BSADF) statistic sequence with critical values for the sup ADF statistic, where the BSADF statistics are obtained from implementing the right-tailed ADF test on backward expanding sample sequence.



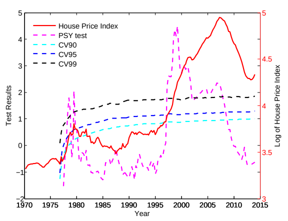
(A) Belgium



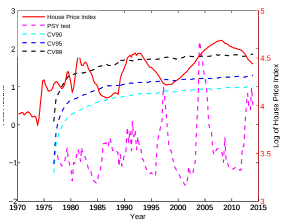
(B) France



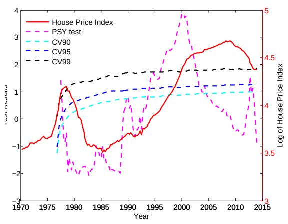
(C) Germany



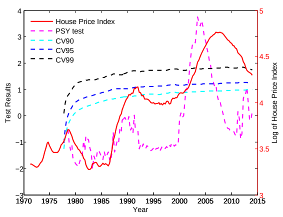
(D) Ireland



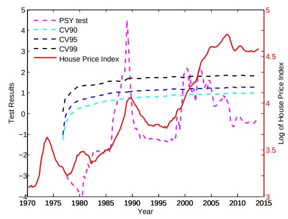
(E) Italy



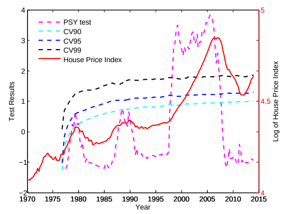
(F) Netherlands



(G) Spain



(H) UK



(I) US

FIGURE 8: PSY Test Results

Source: OECD and Authors' calculations.

Interestingly the PSY test results confirm in general the mispricing conclusions drawn with the QR approach. In particular, we observe that the mispricing observed between 2002 and 2008 for several countries in Figure 7 is, according to the PSY test, associated to a bubble. In specific, for Belgium, France, Ireland, the Netherlands, Spain and the US. For Italy and the UK the evidence is not so compelling.

4. Conclusion

This paper analysed the dynamic behaviour of house prices for twelve European countries and the US from 1970 until 2014 to determine whether evidence of house price bubbles in these series could be found. In the years prior to the financial crisis, which initiated in 2007, house prices had stepped up strongly (or at least significantly) in a large number of countries, including Ireland, the UK and Spain, following which the collapse of the US subprime market prompted a widespread downward correction of house prices. Conventional measures such as the price-to-rent and the price-to-income ratios indicate that, in some periods, particularly before the crisis, house prices were overvalued relatively to the true rental prices and households' affordability of housing given their stream of income. We used different techniques to obtain conclusive evidence for the presence or absence of housing bubbles booms and busts in the period under review.

Given the distinct nature of potential bubble behaviour we firstly revisit the concepts of the most commonly cited bubbles in the literature centring on rational bubbles. Following the standard present value model of asset prices and considering risk neutral agents with rational expectations we arrive to one asset price solution that corresponds to the fundamental value of the asset. The idea behind the rational bubble model is that there is also another solution where the price of an asset can be written as the sum of the fundamental value of the asset and a bubble term. In other words, a rational bubble is thus a component of the asset price rather than a mispricing effect in a setup where there are no arbitrage opportunities.

We apply a quantile regression approach to house prices in each country to evaluate the tails of the distribution of real house prices in order to detect periods in which prices were misaligned with their macroeconomic determinants, here short-term real interest rate, real disposable income and labour force. It is observed that house prices deviate from their long-run relationship in several periods and for several countries, meaning that real house prices are not explained by their fundamental values only, suggesting possible exuberant/bubble behaviour. There are examples in the late eighties', mid 2000' in Ireland, Italy, the Netherlands, the UK, France and the US, and more recently in Germany. Finally, we also use a time series approach introduced by Philips, Shy and Yu (2015) to detect and date periods that may be associated with speculative bubbles (see also Homm and Breitung, 2012). The reasoning behind this approach is that real estate prices, can be explained by two components, the market price and a bubble and that the latter typically originates explosive behaviour in house prices which temporarily dominate the behaviour of the time series. Our findings suggest that we cannot exclude country episodes of housing bubbles over the last four decades. For instance, episodes of misalignment can be found in the late seventies', early eighties', and in the nineties' in France, the Netherlands, the UK and the US, in mid 2000' in Germany, Spain and the US, and more recently some evidence seems to be emerging for Germany. However, overall, our results suggest that, in recent years (since 2010), the aggregate house price index in Europe does not show evidence of exuberant behaviour.

References

Agnello, L., and L. Schuknecht. 2009. "Booms and Busts in Housing Markets: Determinants and Implications." ECB Working Papers Series No. 1071.

Allen, F., and D. Gale. 2000. "Bubbles and Crises." *The Economic Journal* 110(460): 236-255.

Blanchard, O. and M. Watson. 1982. "Bubbles, Rational Expectations and Financial Markets." P. Watchel (ed.), *Crisis in the Economic and Financial System*, 295-315, Lexington Books, Lexington, MA.

Blanchard, O. 1979. "Backward and Forward Solutions for Economies with Rational Expectations." *American Economic Review* 69: 114-118.

Bordo, M.D., and O. Jeanne. 2002. "Boom-Busts in Asset Prices, Economic Instability, and Monetary Policy." National Bureau of Economic Research, Cambridge, MA, NBER Working Paper (8966).

Camerer, C. 1989. "Bubbles and Fads in Asset Prices." *Journal of Economic Surveys* 3(1).

Campbell, J.Y., A. Lo, and A.C. MacKinlay. 1997. *The Econometrics of Financial Markets.* Princeton University Press, Princeton, N.J.

Case, K.E., J.M. Quigley and R.J. Shiller. 2005. "Comparing Wealth Effects: the Stock Market versus the Housing Market." *Advances in Macroeconomics* 5(1), Article 1.

Crowe, C., G. Dell'Ariccia, D. Igan, and P. Rabanal. 2013. "How to deal with real estate booms: Lessons from country experiences." *Journal of Financial Stability* 9: 300–319.

Cuthberston, K. 1996. *Quantitative Financial Economics: Stocks, Bonds and Foreign Exchange.* John Wiely & Sons, New York.

Detken, C., and F. Smets. 2004. "Asset price booms and monetary policy," Working Paper Series 0364, European Central Bank.

Diba, B.T., and H.I. Grossman. 1988. "Explosive Rational Bubbles in Stock Prices?" *American Economic Review* 78(3): 520-530.

Duca, J.V., J. Muelbauer and A. Murphy. 2010. "Housing Markets and the Financial Crisis of 2007-2009: Lessons for the Future." *Journal of Financial Stability* 6: 203-217.

Dusak, K. 1973. "Futures Trading and Investor Returns: An Investigation of Commodity Market Risk Premiums." *Journal of Political Economy* 81: 1387-1406.

Englund, P., M. Hwang and J.M. Quigley. 2002. "Hedging Housing Risk." *Journal of Real Estate Finance and Economics* 24: 167-200.

Englund, P. and Y. Ioannides. 1997. "House Price Dynamics: An International Empirical Perspective." *Journal of Housing Economics* 6:119-136.

Evans, G. W. 1991. "Pitfalls in testing for explosive bubbles in asset prices." *American Economic Review* 81(4): 922-930.

Fama, E. 1976. *Foundations of Finance.* New York. Basic.

Flood, R.P. and R.J. Hodrick. 1990. "On Testing Speculative Bubbles." *Journal of Economic Perspectives* 4(2): 85-101.

Friedman, D. and S. Vandersteel. 1982. "Short-run fluctuations in foreign exchange rates: Evidence from the data 1973-1979." *Journal of International Economics* 13(1-2): 171-186.

Froot, K.A. and M. Obsfeld. 1991. "Intrinsic Bubbles: The Case of Stock Prices." *American Economic Review* 81(5): 1189-1214.

Funke, M., S. Hall and M. Sola. 1994. "Rational Bubbles during Poland's Hyperinflation: Implications and Empirical Evidence." *European Economic Review* 38: 1257-1276.

Garino, G. and L. Sarno. 2004. "Speculative Bubbles in UK House Prices: Some New Evidence." *Southern Economic Journal* 70(4): 777-795.

Garber, P. 1990. "Famous First Bubbles." *Journal of Economic Perspectives* 4(2): 35-54.

Gayer, C. 2010. "Report: The Economic Climate Tracer: A tool to visualise the cyclical stance of the economy using survey data", European Commission.

Gerdesmeier, D., A. Lenarčič and B. Roffia. 2012. "An alternative method for identifying booms and busts in the euro area housing market," Working Paper Series 1493, European Central Bank.

Gürkaynak, R.S. 2008. "Econometric Tests of Asset Price Bubbles: Taking Stock." *Journal of Economic Surveys* 22(1): 160-186.

Hall, S.G., Z. Psaradakis and M. Sola. 1999. "Detecting Periodically Collapsing Bubbles: a Markov-Switching Unit Root Test." *Journal of Applied Econometrics* 14(2): 143-154.

Helbling, T. and M. Terrones. 2003. "Real and Financial Effects of Bursting Asset Price Bubbles", IMF World Economic Outlook, Chapter 2. April.

Himmelberg, C., C. Mayer and T. Sinnai. 2005. "Assessing High House Prices: Bubbles, Fundamentals and Misperceptions." *Journal of Economic Perspectives* 19(4): 67-92.

Homm, U. and J. Breitung. 2012. "Testing for speculative bubbles in stock markets: a comparison of alternative methods." *Journal of Financial Econometrics* 10: 198-231.

Hunt, B. 2005. "How Should Policymakers Respond to a Decline in House Prices?" in United Kingdom: Selected Issues, IMF Country Report No. 05/81.

Kemme, D.M. and R. Saktinil. 2012. "Did the Recent Housing Boom Signal Global Financial Crisis?" *Southern Economic Journal* 78(3): 999-1018.

Kindleberger, C. and R. Aliber. 2005. *Manias, Panics and Crashes: a History of Financial Crises* Wiley Investment Classics, 5th Edition.

Koenker, R. and G. Bassett Jr. 1978. "Regression Quantiles." *Econometrica* 46(1): 33-50.

Koenker, R. and K.F. Hallock. 2001. "Quantile Regression." *Journal of Economic Perspectives* 15(4): 143-156.

LeRoy, S. and R. Porter. 1981. "The Present-Value Relation: Tests Based on Implied Variance Bounds." *Econometrica* 49: 555-574.

Lo, A.W. and A.C. MacKinlay. 1986. "Stock Market Prices Do Not Follow Random Walks: Evidence from a Simple Specification Test." *Review of Financial Studies* 1(1): 41-66.

Machado, J.A.F. and J. Sousa. 2006. "Identifying Asset Price Booms and Busts with Quantile Regressions." Banco de Portugal, Estudos e Documentos de Trabalho, Working Papers 8.

Nneji, O., C. Brooks and C. Ward. 2011. "Intrisinc and Rational Speculative Bubbles in the U.S. Housing Markets 1960-2009", ICMA Centre Discussion Papers in Finance DP 2011-01.

Okina, K. 1985. "Empirical Tests of 'Bubbles' in the Foreign Exchange Markets" *Monetary and Economic Studies Bank of Japan* 2: 81-118.

Phillips, P.C.B., S.P. Shi and J. Yu. 2015. "Testing for multiple bubbles: Historical Episodes of Exuberance and Collapse in the S&P500." *International Economic Review* 56 (4): 1043-1078.

Phillips, P.C.B., Y. Wu and J. Yu. 2009. "Explosive Behavior in the 1990s Nasdaq: When Did Exuberance Escalate Asset Values?" *International Economic Review* 52(1): 201-226.

Poterba, J. 1984. "Tax Subsidies to Owner-Occupied Housing: an Asset Market Approach" *Quarterly Journal of Economics* 99(4): 729-752;

Poterba, J. 1991. "House Price Dynamics: The Role of Tax Policy and Demography." *Brookings Papers on Economic Activity* 2: 143 83.

Psaradakis, Z., M. Sola and F. Spagnolo. 2001. "A Simple Procedure for Detecting Periodically Collapsing Rational Bubbles" *Economics Letters* 72: 317-323.

Rapach, D. and J.K. Strauss. 2006. "The Long-Run Relationship Between Consumption and Housing Wealth in the Eight District States", Federal Reserve Bank of St. Louis, Regional Economic Development, 2(2).

Reinhart, C.M. and K.S. Rogoff. 2013. "Banking crises: An equal opportunity menace." *Journal of Banking and Finance* 37(11): 4557-4573.

Shiller, R.J. 2008. *The Subprime Solution: How Today's Global Financial Crisis Happened, and What to Do about It.* Princeton University Press.

Shiller, R.J. 1981. "Do Stock Prices Move too Much to be Justified by Subsequent Changes in Dividends? Do Stock Prices Move Too Much to Be Justified by Subsequent Changes in Dividends?" *American Economic Review* 71(3): 421-436.

Shiller, R.J. 2005. *Irrational Exuberance.* Princeton, NJ: Princeton University Press.

Shiller, R.J. and P. Perron. 1985. “Testing the Random Walk Hypothesis: Power versus Frequency of Observation.” *Economics Letters* 18(4): 381–386.

Stiglitz, J.E. 1990. "Symposium on Bubbles." *Journal of Economic Perspectives* 4(2): 13-18.

Sola, M. and J. Driffill. 1994. “Testing the Term Structure of Interest Rates from a Stationary Switching Regime VAR." *Journal of Economic Dynamics and Control* 8: 601-628.

Summers, L.H. 1986. "Does the Stock Market Rationally Reflect Fundamental Values?" *Journal of Finance* 41(3): 591-601.

Taylor, M. and D. Peel. 1998. “Periodically Collapsing Stock Price Bubbles: A Robust Test.” *Economics Letters* 61: 221-228.

Topel, R. and S. Rosen. 1988. "Housing Investment in the United States." *Journal of Political Economy*, 718-740.

Tsatsaronis K. and H. Zhu. 2004. "What drives Housing Price Dynamics: Cross Country Evidence" BIS Quarterly Review, BIS. March.

Tsong, C.C. and C.F. Lee. 2013 "Quantile cointegration analysis of the Fisher hypothesis." *Journal of Macreconomics* 35: 186-198.

Tsong, C.C. and A. Hachicha. 2014. "Revisiting the Fisher hypothesis for several selected developing economies: a quantile cointegration approach." *Economic Issues* 19(1): 57-72.

Van Norden, S. and R. Vigfusson. 1998. "Avoiding the Pitfalls: Can Regime-Switching Tests Detect Bubbles?" *Studies in Nonlinear Dynamics and Econometrics* 3: 1-22.

West, K. 1987. “A Specification Test for Speculative Bubbles.” *The Quarterly Journal of Economics* 102(August): 553-580.

Xiao, Z. 2009. "Quantile cointegrating regression." *Journal of Econometrics* 150: 248-260.

Yoon G. 2012. "Some properties of periodically collapsing bubbles." *Economic Modelling* 29: 299-302.

Appendix A: Synchronisation of cycles

In this section we discuss several measures that help understand the degree of cycle synchronisation.

A.1. The concordance index and correlation coefficient

Harding and Pagan (2001) introduce an approach to measure the degree of cycle synchronisation, i.e., to measure the fraction of time cycles coexist in the same phase. This indicator is defined as the concordance index ($\mathcal{CI}$), viz.,

$$\mathcal{CI} = \frac{1}{T}\left\{\sum_{t=1}^{T} I_{i,t}I_{j,t} + \sum_{t=1}^{T}\left(1 - I_{i,t}\right)\left(1 - I_{j,t}\right)\right\} \tag{A.1}$$

where i and j identify specific cycles and the indicator function, $I_{j,t}$, of a cycle is defined from the cycle's turning points as,

$$I_{j,t} = \begin{cases} 1 & if \quad recession \\ 0 & if \quad expansion \end{cases} \tag{A.2}$$

with $j = 1, ..., N$ and where N represents the number of countries considered. This indicator function is constructed from the turning points generated through the dating method proposed by Harding and Pagan (2001) which defines turning points considering that a peak occurs at time t if,

$$\left\{\left(y_{t-\tau}, y_{t-\tau-1}, ..., y_{t-1}\right) < y_t > \left(y_{t+1}, ..., y_{t+\tau-1}, y_{t+\tau}\right)\right\} \tag{A.3}$$

and that a trough is observed at time t if

$$\left\{\left(y_{t-\tau}, y_{t-\tau-1}, ..., y_{t-1}\right) > y_t < \left(y_{t+1}, ..., y_{t+\tau-1}, y_{t+\tau}\right)\right\}. \tag{A.4}$$

This method ensures that the phases of the cycles have a minimum duration of τ periods. The maximum lag order, τ, can be viewed as a "censoring rule" to ensure the duration and amplitudes of phases and complete cycles, respectively. This non-parametric method represents a simple, robust (to false turning points *i.e.*, cycles with insufficient amplitude which result from short-run movements), transparent and replicable dating rule. In short, a useful way to construct economic cycle information.

Moreover, in order to obtain further insights on the contemporaneous relationship between the cyclical components we also use Pearson's correlation coefficient,

$$\rho = \frac{\sum_{t=1}^{T}\left(C_{i,t}-\overline{C}_i\right)\left(C_{j,t}-\overline{C}_j\right)}{\sqrt{\sum_{t=1}^{T}\left(C_{i,t}-\overline{C}_i\right)^2\sum_{t=1}^{T}\left(C_{j,t}-\overline{C}_j\right)^2}}.$$

If $\rho = 1$ it denotes full cycle convergence, while if $\rho = -1$ it suggests full cycle divergence. Therefore, regions with low correlation coefficients are less synchronised.

Appendix B: Testing for Quantile Cointegration

Following Xiao (2009), considering $\psi_\tau(u) = \tau - I(u < 0)$ and the quantile regression residual

$$\varepsilon_{t\tau} = y_t - Q_{y_t}(\tau|\mathcal{F}_{t-1}) = y_t - \Theta(\tau)'Z_t = \varepsilon_t - F_\varepsilon^{-1}(\tau),$$

we have that $Q_{\varepsilon_{t\tau}}(\tau) = 0$, where $Q_{\varepsilon_{t\tau}}(\tau)$ is the $\tau - th$ quantile of $\varepsilon_{t\tau}$ and $E\psi_\tau(\varepsilon_{t\tau}) = 0$.

Hence, the cointegration relationship may be tested by directly looking at the fluctuation in the residual process $\varepsilon_{t\tau}$ from the quantile cointegration regression. In the case of cointegration the residual process should be stable and the fluctuations in the residuals should reflect only equilibrium errors. Otherwise, the fluctuations in the residuals can be expected to be of a larger order of magnitude. Thus, cointegration can be tested based on $\varepsilon_{t\tau}$. If we consider the following partial sum process

$$Y_T(r) = \frac{1}{\omega_\psi^* \sqrt{T}} \sum_{j=1}^{[rT]} \psi_\tau(\varepsilon_{j\tau})$$

where ω_ψ^{*2} is the long-run variance of $\psi_\tau(\varepsilon_{j\tau})$, under appropriate assumptions, the partial sum process follows an invariance principle and converges weakly to a standard Brownian motion $W(r)$. Choosing a continuous functional $h(.)$ that measures the fluctuation of $Y_T(r)$ (notice that $\psi_\tau(\varepsilon_{j\tau})$ is indicator based), a robust test for cointegration can be constructed based on $h(Y_T(r))$. By the continuous mapping theorem under regularity conditions and the null of cointegration,

$$h(Y_T(r)) \Rightarrow h(W(r)),$$

see Xiao (2009) for details.

In this context the classical Kolmogorov-Smirnoff and the Cramer-von Mises type measures are of particular interest. Under the alternative of no cointegration these statistics diverge to ∞. In Table A.1, we report results for the application of this approach using the Kolmogorov-Smirnoff metric, thus the test is $\sup |Y_T(r)|$.

Appendix C: The Phillips, Shu and Yu test

The test procedure introduced by Phillips, Shi and Yu [PSY] (2015) is implemented in three steps:

1. test the null hypothesis that there are no mildly explosive periods in the sample against the alternative that there is at least one such period;
2. if the test rejects, then date-stamping the mildly explosive period(s) in the sample follows;
3. setting the results in the context of a rational asset pricing model and using fundamentals proxy variables to assess whether or not the detected periods of mild explosivity are consistent with departures from house price fundamentals.

C.1. Methodology of the PSY procedure

To implement the procedure we consider, as suggested by PSY, a starting fraction r_1 and an ending fraction r_2 of the total sample, with window size $r_w = r_2 - r_1$, and fit the augmented Dickey-Fuller (ADF) test regression,

$$\Delta y_t = \alpha_{r_1,r_2} + \varphi_{r_1,r_2} y_{t-1} + \sum_{i=1}^{p} \vartheta^i_{r_1,r_2} \Delta y_{t-i} + \varepsilon_t \tag{A.1}$$

where p is the lag order chosen on sub-samples using some information criteria (e.g. BIC or AIC) and $\varepsilon_t \sim i.i.d.(0, \sigma^2_{r_1,r_2})$. The number of observations used to run the regression is $T_w = [r_w T]$ and we denote the unit root t-statistics, i.e., the t-statistics that tests the null hypothesis $H_0 : \varphi = 0$, computed from (A.1) as $ADF^{r_2}_{r_1}$.

PSY (2015) introduce two statistics to detect bubble episodes, namely the backward sup ADF (BSADF) and the generalised sup ADF (GSADF), which are defined as,

$$BSADF_{r_2}(r_0) = \sup_{r_1 \in [0, r_2 - r_0]} \left\{ADF_{r_1}^{r_2}\right\}$$

and

$$GSADF(r_0) = \sup_{r_2 \in [r_0, 1]} \{BSADF_{r_2}(r_0)\}$$

where the endpoint of the sample is fixed at r_2 and the window size is allowed to expand from an initial fraction r_0 of the total sample r_2. PSY suggest that r_0 is chosen to minimise size distortions, according to the rule $r_0 = 0.01 + 1.8/\sqrt{T}$, where T is the sample size. This procedure defines a particular BSADF statistic and the GSADF statistic is computed through the repeated implementation of the BSADF test for $r_2 \in [r_0, 1]$. Critical values are obtained by simulation (in Table B.1 we provide the critical values used in our empirical application). Limit theory of the procedure and small sample performance have been provided by PSY.

The null hypothesis of no mildly explosive periods is based on the GSADF statistic and date-stamping of the periods is accomplished through the BSADF statistic: the start and end points of a bubble, $r_{1,s}$ and $r_{1,f}$ are estimated subject the minimum duration conditions,

$$\widehat{r}_{1,s} = \inf_{r_2 \in [r_0, 1]} \left\{r_2 : BSADF_{r_2}(r_0) > scv_{r_2}^{\beta_r}\right\}$$

and

$$\widehat{r}_{1,f} = \inf_{r_2 \in [\widehat{r}_{1,s} + \delta \log(T)/T, 1]} \left\{r_2 : BSADF_{r_2}(r_0) > scv_{r_2}^{\beta_r}\right\}$$

where $scv_{r_2}^{\beta_r}$ is the 100(1-β_T)% right-sided critical value of the BSADF statistic based on $[r_2 T]$ observations and δ is a tuning parameter that can be chosen based on the sampling frequency. A tuning parameter of 1 implies a minimum duration condition of $\log(T)$ observations. A mildly explosive period is declared if and when the BSADF test has been above its critical value for at least $[\widehat{r}_{1,s}T]$+$[\log(T)]$ observations. Conditional on a first mildly explosive period having been found and estimated to have terminated at $\widehat{r}_{1,f}$ the procedure is then repeated in search of a second and possibly more such periods. PSY show that subject to rate conditions, the sequential procedure provides consistent estimates of the origination and termination dates of one or more bubbles (see also Homm and Breitung, 2012).

The final element of the PSY procedure assesses whether the mildly explosive periods detected are bubbles. The test procedure is interpreted as a test for (rational) bubbles under the standard asset pricing equation (3).

C.2. Critical values of the PSY test

Table B.1: Phillips, Shi and Yu test critical Values (based on 5000 replications)

cv	SADF			GSADF		
T	0.90	0.95	0.99	0.90	0.95	0.99
176	1.0023	1.2779	1.8399	1.6928	1.9621	2.4966
172	0.9921	1.3254	1.8159	1.6876	1.9435	2.4900
110	0.8849	1.2136	1.7251	1.4495	1.7210	2.2715
104	0.8719	1.1788	1.855	1.4006	1.6717	2.2549
68	0.6457	0.9563	1.5573	1.0683	1.4076	1.9402

Appendix D: Data of Sources Fundamentals

- **Nominal disposable income**. Source: OECD (Underlying quarterly disposable income are estimated by interpolation from OECD annual data) and Banco de Portugal. Available until 4Q2014 and since 1Q1970 (except for Portugal 1Q1977, France 1Q1978, Germany 1Q1980, Greece 1Q1995).
- **Private consumption deflator.** Source: OECD. Available until 4Q2014 and since 1Q1970 (except for Portugal 1Q1978 and Greece 1Q1992). Data are obtained from the national account statistics. In case of Greece Greek quarterly PCP is OECD estimate.
- **Price to income ratio.** Source: OECD. Nominal house price divided by nominal disposable income per head. Available until 4Q2014 and since 1Q1970 (except for Spain 1Q1971, Portugal 1Q1995, Greece 1Q1997, Austria 1Q2000).
- **Price to rent ratio.** Source: OECD. Nominal house price divided by rent price. Available until 2Q2014 and since 1Q1970 (except for Spain 1Q1971, Portugal 1Q1991, Greece 1Q1997, Austria 1Q2000).
- **Money Market Rates** Source: ECB (Financial market data), Money Market, Interbank 3-month for each country, Yield, average through period. Available until 4Q2013 and since 1Q1970 (except for Portugal, 2Q1983 and Greece 1Q1992).
- **GDP** Source: OECD and Banco de Portugal. GDP in volume at market prices. Available until 4Q2013 and since 1Q1970 (except for Portugal 1Q1978 and Ireland 1Q1990). No data for Greece.
- **Labour force.** Source: OECD and Banco de Portugal. Total labour force, quarterly, thousands of persons. Available until 4Q2014 and since 1Q1970 (except for Portugal 1Q1977, Spain 1Q1976, Germany 1Q1992 and Ireland 1Q1990). No data for Greece.
- **Gross disposable income.** Source: European Commission (AMECO database), OECD and authors' calculations. End of period data. Available unil 4Q2014.
- **Mortgage loans.** Source: ECB, Central Bank of Ireland, Bank of Spain, Banco de Portugal and authors' calculations. Outstanding amounts. End of period data. Available unil 4Q2014. In the case of Ireland, Spain and Portugal mortgage loans are adjusted for securitization.

Table D.2: Sources of Nominal House Prices Used

Country name	Source	Series	Frequency	sa	Availability
Germany	Deutsche Bundesbank	Residential property prices	annual[a]		1970:Q1 - 2014:Q4
France	Institut National de la Statistique et des Études Économiques (INSEE)	Indice trimestriel des prix des logements anciens - France métropolitaine -	quarterly	yes	1970:Q1 - 2014:Q4
Italy	Eurostat Residential Property Price Index for recent indicator and Nomisma for the past	Eurostat : Residential property prices, existing dwellings, whole country Nomisma : 13 Main Metropolitan Areas - Average current prices of used housing	quarterly semi-annual	no no	1970:Q1 - 2014:Q4
Austria	European Central Bank	Residential property prices, new and existing dwellings	quarterly	no	1986:Q1 - 2014:Q4
Belgium	Banque National de Belgique	Residential property prices, existing dwellings, whole country	quarterly	no	1970:Q1 - 2014:Q4
Finland	Statistics Finland	Prices of dwellings	quarterly	no	1970:Q1 - 2014:Q4
Greece	Bank of Greece	Prices of dwellings	quarterly	no	1997:Q1 -2014:Q4
Ireland	Central Statistics Office	Residential property price index	monthly	no	1970:Q1 - 2014:Q4
Netherlands	Kadaster	House Price Index for existing own homes	monthly	no	1970:Q1 - 2014:Q4
Portugal	European Central Bank	Residential property prices, new and existing dwellings	quarterly	no	1988:Q1 - 2014:Q4
Spain	Banco de España	Precio medio del m2 de la vivienda libre (>2 años de antigüedad)	quarterly	no	1970:Q1 - 2014:Q4
UK	Department for Communities and Local Government	Mix-adjusted house price index	quarterly	no	1970:Q1 - 2014:Q4
US	Federal Housing Finance Agency (FHFA) (from 1991 and OECD adjusted all-transaction index previously)	Purchase and all-transactions indices	quarterly	yes	1970:Q1 - 2014:Q4

Note: [a] use of quarterly series (owner-occupied apartments in 7 cities) for the quarterly profile.

WORKING PAPERS

2013

01|13 Macroeconomic forecasting using low-frequency filters
João Valle e Azevedo | Ana Pereira

02|13 Everything you always wanted to know about sex discrimination
Ana Rute Cardoso | Paulo Guimarães | Pedro Portugal

03|13 Is there a role for domestic demand pressure on export performance?
Paulo Soares Esteves | António Rua

04|13 Ageing and fiscal sustainability in a small euro area economy
Gabriela Castro | José R. Maria | Ricardo Mourinho Félix | Cláudia Rodrigues Braz

05|13 Mind the gap! The relative wages of immigrants in the Portuguese labour market
Sónia Cabral | Cláudia Duarte

06|13 Foreign direct investment and institutional reform: Evidence and an application to Portugal
Paulo Júlio | Ricardo Pinheiro-Alves | José Tavares

07|13 Monetary policy shocks: We got news!
Sandra Gomes | Nikolay Iskrev | Caterina Mendicino

08|13 Competition in the Portuguese Economy: Estimated price-cost margins under imperfect labour markets
João Amador | Ana Cristina Soares

09|13 The sources of wage variation: a three-way high-dimensional fixed effects regression model
Sonia Torres | Pedro Portugal | John T. Addison | Paulo Guimarães

10|13 The output effects of (non-separable) government consumption at the zero lower bound
Valerio Ercolani | João Valle e Azevedo

11|13 Fiscal multipliers in a small euro area economy: How big can they get in crisis times?
Gabriela Castro | Ricardo M. Felix | Paulo Julio | Jose R. Maria

12|13 Survey evidence on price and wage rigidities in Portugal
Fernando Martins

13|13 Characterizing economic growth paths based on new structural change tests
Nuno Sobreira | Luis C. Nunes | Paulo M. M. Rodrigues

14|13 Catastrophic job destruction
Anabela Carneiro | Pedro Portugal | José Varejão

15|13 Output effects of a measure of tax shocks based on changes in legislation for Portugal
Manuel Coutinho Pereira | Lara Wemans

16|13 Inside PESSOA - A detailed description of the model
Vanda Almeida | Gabriela Castro | Ricardo M. Félix | Paulo Júlio | José R. Maria

17|13 Macroprudential regulation and macroeconomic activity
Sudipto Karmakar

18|13 Bank capital and lending: An analysis of commercial banks in the United States
Sudipto Karmakar | Junghwan Mok

2014

1|14 Autoregressive augmentation of MIDAS regressions
Cláudia Duarte

2|14 The risk-taking channel of monetary policy – exploring all avenues
Diana Bonfim | Carla Soares

3|14 Global value chains: Surveying drivers, measures and impacts
João Amador | Sónia Cabral

4|14 Has US household deleveraging ended? a model-based estimate of equilibrium debt
Bruno Albuquerque | Ursel Baumann | Georgi Krustev

5|14 The weather effect: estimating the effect of voter turnout on electoral outcomes in italy
Alessandro Sforza

6|14 Persistence in the banking industry: fractional integration and breaks in memory
Uwe Hassler | Paulo M.M. Rodrigues | Antonio Rubia

7|14 Financial integration and the great leveraging
Daniel Carvalho

8|14 Euro area structural reforms in times of a global crisis
Sandra Gomes

9|14 Labour demand research: towards a better match between better theory and better data
John T. Addison | Pedro Portugal | José Varejão

10|14 Capital inflows and euro area long-term interest rates
Daniel Carvalho | Michael Fidora

11|14 Misallocation and productivity in the lead up to the Eurozone crisis
Daniel A. Dias | Carlos Robalo Marquesz | Christine Richmond

12|14 Global value chains: a view from the euro area
João Amador | Rita Cappariello | Robert Stehrer

13|14 A dynamic quantitative macroeconomic model of bank runs
Elena Mattana | Ettore Panetti

14|14 Fiscal devaluation in the euro area: a model-based analysis
S. Gomes | P. Jacquinot | M. Pisani

15|14 Exports and domestic demand pressure: a dynamic panel data model for the euro area countries
Elena Bobeica | Paulo Soares Esteves | António Rua | Karsten Staehr

16|14 Real-time nowcasting the US output gap: singular spectrum analysis at work
Miguel de Carvalho | António Rua

2015

1|15 Unpleasant debt dynamics: can fiscal consolidations raise debt ratios?
Gabriela Castro | Ricardo M. Félix | Paulo Júlio | José R. Maria

2|15 Macroeconomic forecasting starting from survey nowcasts
João Valle e Azevedo | Inês Gonçalves

3|15 Capital regulation in a macroeconomic model with three layers of default
Laurent Clerc | Alexis Derviz | Caterina Mendicino | Stephane Moyen | Kalin Nikolov | Livio Stracca | Javier Suarez | Alexandros P. Vardoulakis

4|15 Expectation-driven cycles: time-varying effects
Antonello D'Agostino | Caterina Mendicino

5|15 Seriously strengthening the tax-benefit link
Pedro Portugal | Pedro S. Raposo

6|15 Unions and collective bargaining in the wake of the great recession
John T. Addison | Pedro Portugal | Hugo Vilares

7|15 Covariate-augmented unit root tests with mixed-frequency data
Cláudia Duarte

8|15 Financial fragmentation shocks
Gabriela Castro | José R. Maria | Paulo Júlio | Ricardo M. Félix

9|15 Central bank interventions, demand for collateral, and sovereign borrowing cost
Luís Fonseca | Matteo Crosignani | Miguel Faria-e-Castro

10|15 Income smoothing mechanisms after labor market transitions
Nuno Alves | Carlos Martins

11|15 Decomposing the wage losses of displaced workers: the role of the reallocation of workers into firms and job titles
Anabela Carneiro | Pedro Raposo | Pedro Portugal

12|15 Sources of the union wage gap: results from high-dimensional fixed effects regression models
John T. Addison | Pedro Portugal | Hugo Vilares

13|15 Assessing european firms' exports and productivity distributions: the compnet trade module
Antoine Berthou | Emmanuel Dhyne | Matteo Bugamelli | Ana-Maria Cazacu | Calin-Vlad Demian | Peter Harasztosi | Tibor Lalinsky | Jaanika Meriküll | Filippo Oropallo | Ana Cristina Soares

14|15 A new regression-based tail index estimator: an application to exchange rates
João Nicolau | Paulo M. M. Rodrigues

15|15 The effect of bank shocks on firm-level and aggregate investment
João Amador | Arne J. Nagengast

16|15 Networks of value added trade
João Amador | Sónia Cabral

17|15 House prices: bubbles, exuberance or something else? Evidence from euro area countries
Rita Fradique Lourenço | Paulo M. M. Rodrigues