

When Bubble Meets Bubble: Contagion  
in OECD Countries

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# When Bubble Meets Bubble: Contagion in OECD Countries<sup>1</sup>

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## Abstract

We study the existence and international migration of housing market bubbles, using quarterly information of twenty OECD countries for the period comprised between 1970 and 2015. We find that housing bubbles are present in all the countries included in our sample. Multiple bubbles are found in all but two of those countries. We find ten episodes of migration. All of them had origin in the US housing bubble preceding the subprime crisis. Most migrations were to European countries. Notably, the Spanish housing bubble was not a direct consequence of the US housing bubble. Its origin must be found in other causes.

**Keywords:** Housing bubbles; International migration of bubbles; Recursive right-tailed unit root tests.

**JEL Classification:** G01; G12; C22.

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## 1. Introduction

Bubbles have always fascinated people. Their symmetrical shapes, brilliant colors and their unbelievable fragility have delighted both kids and scientists for centuries. But while people love inflating and bursting spherical soap bubbles, financial bubbles are widely feared.

Financial crises and asset price bubbles are closely related. History has often witnessed the development of financial crises triggered by the rise and collapse of asset price bubbles. Notable examples abound. Arguably, the most notorious bubbles to be documented include the seventeenth century Dutch Tulipmania, England's eighteenth century South Sea Bubble, the Mississippi Bubble, the Railway Mania of the 1840s, the Melbourne Land Boom of the early 1890s, and the bubble of the Roaring Twenties that came to a sudden halt in October 1929.

Some more recent examples include bubbles in Japan in the late 1980s and early 1990s, several Latin American economies in the 1980s, South East Asian Economies in the late 1990s, the Mexican Tequila crisis, Russia in the late 1990s, the Dot-Com bubble, and several housing price bubbles that developed in a set of industrialized economies in the recent international financial crisis.

All bubbles share some common features. In all cases, first people cheer for a bubble's birth and then mourn its death. During the early stages of the bubble supporters of more investment in the asset assure 'this time it will be different'. But bubbles have a tendency to burst, some quicker than others. Stock market and exchange rate bubbles are usually short-lived. Housing price bubbles frequently last longer.

Price bubble detection has been widely studied in the literature. Recently, most papers have used the methodology proposed by Phillips et al. (2015), based on recursive right-tailed unit root tests. Some examples include Harvey et al. (2015), Jiang et al. (2015), Shi et al. (2015), Gómez-González et al. (2015a), and Greenaway-McGrevy and Phillips (2016). In all of these papers multiple episodes of asset price exuberance have been encountered.

While the literature on bubble existence is relatively ample and has grown fast after the subprime financial crisis, few papers have focused on studying bubble migration. Some studies have argued that asset price bubbles developed in different countries and markets may be related. Particularly, Caballero et al. (2008) pose that the Dot-Com Bubble, the housing price bubbles of the 2000s, and the subprime mortgage crisis of 2007-09 are all related. Using a general equilibrium model, they propose that these bubble episodes may be sequentially related due to bubble migration.

Building on this model, Phillips and Yu (2011) propose an econometric test for bubble migration within markets. In their empirical application they encounter bubble migration

among the housing market, the crude oil market and the bond market. Applications of this test are scarce. Up to our knowledge, this migration test has only been applied additionally by Gómez-González et al. (2015a), who applied it for detecting migration of asset-price bubbles in the housing, currency and stock markets of seven countries. However, they only study migration of bubbles within a country. Specifically, they test for bubble migrations among these three markets for each individual country. International bubble migrations are not studied.

In this paper we focus in the housing market, and study the international migration of bubbles. Following the center-periphery literature, we consider international migrations originated in a bubble occurring either in the US or in the UK. We use housing data for a set of twenty OECD countries for a period comprised between 1970 and 2015. We find evidence of multiple bubbles for all but two countries included in our sample. Moreover, we are able to identify ten episodes of bubble migration. All of them had origin in the US and lie around the upshot of the subprime financial crisis.

These results agree with the notion that the development and burst of the US housing bubble influenced the creation and rupture of property bubbles in other developed and emerging countries. Our results shed light on the increasingly importance of international financial linkages and their relation with worldwide financial fragility. In this sense, our results are relevant for the literature on financial cross-border spillovers.

Our results have important policy implications. On the one hand, whenever national policies have relevant cross-border effects, then international policy coordination is a must. For instance, if national policies tending to stimulate the housing market in some developed economies have effects on other countries, then housing policies should be coordinated in international forums.

On the other hand, our results highlight the importance of developing macro-prudential policies for diminishing the potentially harmful effects of shocks originated in international financial markets. Of particular relevance, small open economies should consider the implementation of temporary capital controls for limiting the noxious effects that capital flow cycles may have, as the development of housing bubbles.

Section 2 is a literature review section. In the next section we explain the baseline theoretical models, the detection methodology and the bubble migration test. Section 4 consists of a description of the data used in the empirical analysis. In section 5 we present our estimation results. The last section concludes.

## 2. Brief Literature Review

In this section we present a brief literature review, focusing in papers that have used similar methodologies for detecting and date stamping bubbles. In this review we include the only two papers that, up to our knowledge, have tested for financial bubble migrations.

The existence of bubbles has been widely studied in the literature. The most commonly used detection methods follow the present value model under the assumption of rational bubbles. Under this setting, bubbles can emerge if assets are infinitely-lived and the bubble's growth rate equals the economy's discount rate. Under full rationality, bubbles can also exist in a finitely-lived economy if informational asymmetries exist and short-sale constraints are binding (Allen et al., 1993).

Early proposals include Shiller's variance bound test (Shiller, 1981), and West's two step test (West, 1987). Campbell and Shiller (1988) and Diba and Grossman (1988) introduced the most commonly used methods for detecting asset price bubbles in the literature, namely the right-tailed unit root test and the cointegration test.

These two frequently used methods, however, suffer from the so-called Evan's critique. Evans (1991) shows that these tests are not able to detect the existence of explosive bubbles when the sample data includes periodically collapsing bubbles. Phillips et al. (2015) propose an identification test that overcomes Evan's critique. This test improves power significantly with respect to the conventional unit root and cointegration tests (see Taipalus, 2012), and has the advantage of allowing the date-stamping of bubbles.

The methodology proposed by Phillips et al. (2015) has been used extensively for identifying asset price bubbles in different countries and markets. Applications include bond, stock, exchange rate and housing markets. Housing market applications have been successful in identifying bubbles in countries and periods in which there was ample agreement of the presence of a bubble, but other testing procedures had been unable to find evidence confirming the bubble hypothesis. See, for instance Yiu et al. (2013) for the case of Hong Kong and Gómez-González et al. (2015b) for the case of Colombia.

Phillips and Yu (2011) study the case of the US and report evidence of exuberant behavior in this country's housing market between May 2002 and December 2007. Other country studies include Jiang et al. (2015), who study the residential property market of Singapore and find evidence of a bubble between the second quarter of 2006 and the first quarter of 2008. Of special relevance, the authors find evidence of explosive behavior arising two quarters earlier than in previous studies.

Shi et al. (2015) find housing price bubbles in all major Australian capital cities during the early 2000s. Greenaway-McGrevy and Phillips (2015) document evidence of episodic bubbles in the New Zealand property market over the past two decades.

Some multi-country studies have also appeared in the literature recently. Pavlidis et al. (2014) study housing prices in a set of developed countries including the US, the UK and Spain. Their results suggest that the three countries experienced periods of price exuberance between 1999 and 2007.

Engsted et al. (2016) perform an econometric analysis of bubbles in housing markets in the OECD area, using quarterly OECD data for 18 countries from 1970 to 2013. They find evidence of explosiveness in many housing markets, supporting the bubble hypothesis.

Several recent theoretical studies have shown that bubbles in housing markets may be contagious (see, for instance, Riddell, 2016). In other words, bubbles in the housing market may migrate from a central location to the periphery. Some empirical papers have tested this hypothesis, using data for cities in a particular country and different econometric techniques than those used in this paper. For instance, Teng et al. (2016) show evidence supporting the hypothesis that housing bubbles migrate from Taipei City (city center) to New Taipei City (suburbs).

However, up to our knowledge only two papers have used the methodology developed by Phillips and Yu (2011) for testing migration. The first one is Phillips and Yu (2011) itself. In their empirical application they encounter bubble migration among the housing market, the crude oil market and the bond market. The second is Gómez-González et al. (2016), who apply the test for detecting migration of asset price bubbles in the housing, currency and stock markets of seven countries. However, they only study migration of bubbles within a country. Specifically, they test for bubble migrations among these three markets for each individual country. International bubble migrations are not studied.

This paper is the first to study the international migration of bubbles. Following the center-periphery literature, we consider international migrations originated in a bubble occurring either in the US or in the UK. We use housing data for a set of twenty OECD countries for a period comprised between 1970 and 2015 and find evidence of multiple bubbles for all the countries included in our sample. Moreover, we identify ten episodes of bubble migration, all of them originating in the US around the upshot of the subprime financial crisis.

### 3. Baseline Model and Econometric Methods

Consider a standard asset-pricing model with a constant discount factor:

$$P_t = \frac{1}{1+r_f} E_t(P_{t+1} + D_{t+1}) \quad (1)$$

The after-dividend price of the asset at time  $t$  is  $P_t$ , the payoff (dividend) received from the asset at time  $t+1$  is  $D_{t+1}$ ,  $E_t$  represents the expectations operator with information until period  $t$ , and  $r_f$  stands for the constant risk-free interest rate.

Equation (1) is a linear first order differential equation. Solving this equation recursively we obtain an expression for the price of the asset as a function of the expected flow of future payoffs:

$$P_t = \sum_{i=0}^{\infty} \left( \frac{1}{1+r_f} \right)^i E_t(D_{t+i}) + B_t \quad (2)$$

Defining the fundamental price of the asset as the discounted sum of expected future payoffs, i.e.,  $P_t^F = \sum_{i=0}^{\infty} \left( \frac{1}{1+r_f} \right)^i E_t(D_{t+i})$ , the bubble component can be defined from Equation (2) as  $B_t = P_t - P_t^F$ . Diba and Grossman (1988) show that this bubble component has an explosive behavior:

$$E_t(B_{t+1}) = (1 + r_f)B_t \quad (3)$$

It is important to note that in this context bubbles can arise even under rational expectations, which differs greatly with behavioral economics and behavioral finance approaches that consider alternative definitions<sup>3</sup>.

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<sup>3</sup> In behavioral bubble models at least some of the agents are not rational, and bubbles appear from difference of opinions between bounded-rational agents or from behavioral rules, such as feedback-trading, that some

For empirically testing the presence of rational bubbles, Phillips et al (2015) suggest applying econometric tests to the price-dividend ratio,  $\frac{P_t}{D_t}$ , which cannot behave explosively in the absence of bubbles (see Gurkaynak, 2008).

It is important to note that the asset pricing model in which we base our bubble tests imposes some restrictions on the statistical characteristics of the price-rent ratio. Relaxations of the model can change the statistical characteristics of the price process. For instance, the existence of a time-varying discount factor may generate a mildly explosive behavior of this ratio for a while, even if rational bubbles are ruled-out. Taipalus (2012) and other studies have either used or identified approximations of the present-value formula that incorporate the possibility of time-variation in the discount rate. Therefore, the same econometric techniques applied here are amenable, if data permits, to a richer exploration that incorporates the behavior of interest rates in the prices of assets. However, we leave this issue for future research.

In this paper we detect periods of exuberance of a significant duration of at least twenty-four quarters and study the patters of migration from the US and the UK to other OECD countries.

The econometric implementation is based in the augmented Dickey-Fuller (ADF) unit root test, performed by using the following linear regression<sup>4</sup>:

$$\Delta p_t = \mu + (\rho - 1)p_{t-1} + \sum_{i=1}^k \Delta p_{t-k} + \varepsilon_t \quad (4)$$

Where  $p_t$  stands for the price-dividend ratio,  $\varepsilon_t$  is an i.i.d. error term and  $\mu$  represents a constant deterministic component. The null hypothesis is the existence of a unit root and the alternative hypothesis is the existence of an explosive behavior in the price-dividend ratio. The methodology we follow consists in calculating this test in multiple recursive regressions which vary in both the number of observations and the starting date of the estimation.

The GSADF statistic is the sup sup of the ADF tests, or in other words the supremum of the set of all ADF tests corresponding to different stating dates and window sizes. The GSADF statistic is used for testing the existence of at least one bubble in the whole sample. In order

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non-rational agents might follow. For example, in Scheinkman and Xiong (2003), bubbles emerge due to the combined effect of finitely supplied assets being traded by agents that are bounded rational and a market with short-selling restrictions.

<sup>4</sup> The number of lags for each regression was selected following traditional information criteria, i.e., the Bayesian Information Criterion and the Akaike Information Criterion.



to estimate the origination and collapse dates of every bubble, a sup ADF (BSADF) statistic with respect to the number of observations is computed for each alternative last observation in every regression. The resulting series of ADF statistics is then compared with an appropriate series of critical values.

We calculate our GSADF and BSADF statistics following Phillips et al. (2015). We use a minimum window size of twenty-four quarters and calculate critical values for each test performing Monte Carlo simulations. We performed 10,000 replications in each case.

For analyzing pairwise housing bubble migrations from the US and the UK to other OECD countries, we follow the methodology proposed by Phillips and Yu (2011). Specifically, once the presence of bubbles is identified, the persistence of each time series is estimated using the AR(1) component computed with a recursive method. This time-varying coefficient allows capturing persistent changes that occurred during periods of bubble formation and collapse.

Let  $\{X_t\}$  and  $\{Y_t\}$  be two stochastic processes. We estimate AR(1) coefficients for both of them. Let  $\widehat{\theta}_X(\tau)$  and  $\widehat{\theta}_Y(\tau)$  be their autoregressive coefficients, respectively. Bubbles are associated with peaks in the series of persistence coefficients. To test for possible migrations within bubbles, moments in which  $\widehat{\theta}_X(\tau)$  and  $\widehat{\theta}_Y(\tau)$  present local maxima in a close time interval are identified. Then, we perform the following regression:

$$\theta_Y(\tau) - 1 = \beta_{0n} + \beta_{1n}(\theta_X(\tau) - 1) \frac{\tau - \tau_{pX}}{m} + \text{error} \quad (5)$$

In Equation (5),  $\tau$  represents the time period of the estimation,  $\tau_{pX}$  is the moment in which  $\widehat{\theta}_X(\tau)$  reaches a local maximum, and  $m$  represents the length of the estimation period. The hypotheses being tested are:  $H_0: \beta_{1n} = 0$ , and  $H_1: \beta_{1n} < 0$ , and the corresponding test statistic is:

$$Z_\beta = \frac{\widehat{\beta}_{1n}}{a \log(m)} \quad (6)$$

The corresponding critical values are those of the standard normal distribution. We set  $a = \frac{1}{3}$  for normalizing, following Phillips and Yu (2011). However, results are qualitatively identical if we use other values for normalization, such as  $a = 3$  or  $a = 1$ .

#### **4. Data**

In this paper we study international housing bubble migrations. Following center-periphery models, we focus on migrations originating either in the US or the UK, and test for contagion to other OECD countries. For doing so, we use housing market data, i.e., house price indexes and rent price indexes, for a set of 20 countries. The rent price index is used as a proxy for the dividend in this market, as it is usually assumed in the related literature (see, for instance, Greenaway-McGrevy and Phillips, 2015; Engsted et al., 2016; and Gómez-González et al., 2016).

We use quarterly data for each series and each country, obtained from the OECD housing market data. Table 1 describes the time series used in this paper. Note that for most countries data comprises the period 1970Q1 to 2015Q2. However, the data for some countries begins in a later date.

It is noteworthy to mention that measuring the fundamentals in housing markets is a difficult task. Ideally rents and prices should be calculated separately for groups of identical, or at least homogeneous, houses. Even in the case in which disaggregated information on housing units is available, some problems must be solved. While rents and prices for rented units may be observed, it is hard to determine implied rents for owner-occupied houses. However, in our study (and in most studies of this market) we only count with aggregated data. One partial fix to this issue would be using price indices for different types of houses (i.e., luxury vs. mass segment houses). However, we do not have access to prices nor rents discriminated in this way for our period of study. Therefore, we use the ratio of the two indices for the whole market, following what is conventional in this literature.

**Table 1. Summary of the Data**

Country	Period of Analysis	Series	Source
United States	1970Q1-2015Q2	Sales of existing dwellings; single family dwellings, whole country, Purchase and all-transactions indices.	Federal Housing Finance Agency (FHFA).
Japan	1970Q1-2015Q2	Sales of existing dwellings; all types of dwellings, whole country, urban Land Price Index - Nationwide.	Japan Real Estate Institute.
Germany	1970Q1-2015Q2	Residential property prices in Germany.	Deutsche Bundesbank.
France	1970Q1-2015Q2	Sales of existing dwellings; all types of dwellings, whole country.	Institut National de la Statistique et des Études Économiques (INSEE).
Italy	1970Q1-2015Q2	Sales of newly-built and existing residential dwellings, whole country.	ISTAT RPPI for recent indicator and Nomisma for the past.
United Kingdom	1970Q1-2015Q2	Sales of newly-built and existing residential dwellings, all type of dwellings, whole country.	Department for Communities and Local Government.
Canada	1970Q1-2015Q2	Sales of newly-built and existing residential dwellings, all type of dwellings, whole country, Average existing home prices.	Teranet - National Bank National Composite House Price Index for recent indicator and Department of Finance for the past.
Australia	1972Q3-2015Q2	Total stock of newly-built and existing residential dwellings; all types of dwellings, Eight Capital Cities.	Australian Bureau of Statistics.
Belgium	1976Q2-2014Q4	Sales of existing dwellings; all types of dwellings, whole country.	Banque National de Belgique.
Denmark	1970Q1-2015Q2	Sales of newly-built and existing residential dwellings, all type of dwellings, whole country.	StatBank.
Finland	1970Q1-2015Q2	Sales of newly-built and existing residential dwellings, all type of dwellings, whole country.	Statistics Finland.
Greece	1997Q1-2015Q2	Total stock of newly-built and existing residential dwellings; all types of dwellings, whole country.	Bank of Greece.
Ireland	1970Q1-2015Q2	Sales of newly-built and existing residential dwellings, all type of dwellings, whole country.	Central Statistics Office from 2005 and ESRI former.
Israel	1994Q1-2015Q2	Total stock of newly-built and existing residential dwellings; all types of dwellings, whole country.	Central Bureau of Statistics.
Netherlands	1970Q1-2015Q2	Sales of newly-built and existing residential dwellings, all type of dwellings, whole country.	Eurostat-HPI.
Norway	1979Q1-2015Q2	Sales of existing dwellings; all types of dwellings, whole country.	Statistics Norway.
New Zealand	1970Q1-2015Q2	Sales of newly-built and existing residential dwellings, all type of dwellings, whole country.	Reserve Bank of New Zealand.
Spain	1971Q1-2015Q2	Sales of newly-built and existing residential dwellings, all type of dwellings, whole country.	Eurostat-HPI.
Sweden	1980Q1-2015Q2	Sales of newly-built and existing residential dwellings, all type of dwellings, whole country.	Eurostat-HPI
Switzerland	1970Q1-2015Q2	Sales of newly-built and existing residential dwellings, multi-family dwellings, whole country.	Banque Nationale Suisse.
Euro Area	1996Q1-2015Q1	Sales of newly-built and existing residential dwellings, all type of dwellings.	European Central Bank.
OECD	1970Q1-2015Q2	Sales of newly-built and existing residential dwellings, all type of dwellings.	<a href="http://www.oecd.org/eco/outlook/focusonhousesprices.htm">http://www.oecd.org/eco/outlook/focusonhousesprices.htm</a>

## 5. Results

### a). Bubble Detection and Date-Stamping

We applied the bubble detection test described in Section 3 for each of the twenty OECD countries considered in this study. Using recursive unit root tests with a minimum window size of 24 observations (quarters), we found at least one episode of housing price exuberance in each country, according to the GSADF statistics depicted in Table 2. Our results go in line with those obtained by Engsted et al. (2016) who perform a similar analysis for a group of eighteen OECD countries.

Results in Table 2 show that test statistics are significantly larger than critical values even at the 99% significance level for all countries. Values of the test statistics are particularly large for six countries, namely the US, Germany, Italy, France, Spain and Ireland. For these six countries bubbles would be detected even at extremely high confidence levels.

Table 3 (in the Appendix) shows periods for which housing price bubbles were encountered in each country. For all but two countries (Canada and Greece, for which only one bubble was found), multiple bubbles were identified in the sample period. Most housing bubbles evolved during the early 2000s, beginning before the subprime financial crisis. Interestingly, bubbles around this episode were also longer than bubbles occurring in other periods of time, such as the 1980s and early 1990s. While bubbles occurring around the time of the subprime financial crisis had on average a duration of thirteen quarters, bubbles happening in other decades had a duration of only seven quarters.

Norway, France, and the Netherlands are the countries for which more bubbles were encountered with a total of five each. We also found evidence of four bubbles in Switzerland and Germany. The rest of the countries included in this study register at most three housing bubbles. Interestingly, only two bubbles were detected for the US, but bubbles in this country tend to be longer than those observed in the other countries in our sample.

Figure 1 (in the Appendix) graphically depicts the periods in which housing bubbles were identified in each country. Both the price-rent ratio time series and the BASDF time series are shown in this figure. Notice that bubbles can be either positive or negative. Positive bubbles correspond to time periods in which the price-rent ratio grows explosively. Negative bubbles correspond to periods in which this ratio decreases at an increasing speed.

Positive bubbles are more frequent than negative bubbles and have a longer duration. An example of a negative bubble is the case of Norway in the late 1980s.

**Table 2. GSADF Results**

Country	Statistic	CV 90%	CV 95%	CV 99%
United States	7,52	1,02	1,25	1,75
United Kingdom	1,83	1,02	1,25	1,75
Japan	3,93	1,04	1,28	1,76
Germany	6,42	1,02	1,25	1,75
France	8,21	1,02	1,25	1,75
Italy	8,69	1,01	1,24	1,75
Canada	3,15	1,01	1,25	1,75
Australia	5,52	0,99	1,23	1,73
Belgium	3,71	0,95	1,19	1,70
Denmark	3,67	1,85	2,14	2,80
Finland	3,45	1,04	1,28	1,76
Greece	2,08	1,33	1,63	2,31
Ireland	6,19	1,04	1,28	1,76
Israel	2,54	0,63	0,90	1,43
Netherlands	4,97	1,74	1,25	1,02
Norway	2,72	0,9	1,14	1,66
New Zealand	4,23	1,01	1,25	1,76
Spain	6,94	1,01	1,25	1,72
Sweden	1,74	0,89	1,13	1,62
Switzerland	3,17	1,01	1,26	1,75
Euro Area	8,43	0,58	0,82	1,32
OECD	9,87	1,04	1,28	1,76

**b). Bubble Migration**

The emphasis of this paper is on studying housing bubble migrations. Initially, many migrations may be studied. However, following the literature on center-periphery, and the evidence of the recent international financial crisis, we focus on potential migrations originating in a bubble either in the US or the UK.

After identifying and date stamping bubbles for our set of twenty countries, we proceeded to test for possible international bubble migrations. As discussed in Section 3, migration testing follows two steps. In the first step, bubbles in different countries that are close in time were selected as possible bubble migration episodes. In the second step, formal tests of migration based on persistence were conducted for those selected episodes.

Various episodes of possible migration were selected and formally tested. Out of those, ten episodes of migration were encountered. All confirmed migrations had origin in the US housing bubble preceding the subprime crisis. According to our results, there were no migrations from UK housing bubbles to any other country in our sample. In other words, the UK housing bubble had no direct influence in the formation of housing bubbles in other OECD countries. Table 4 shows our main empirical results.

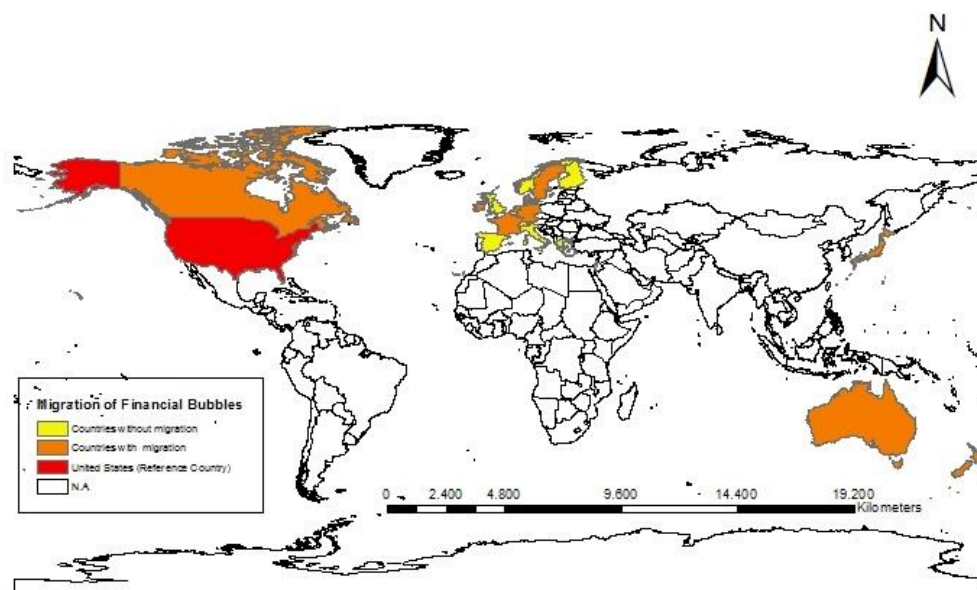
**Table 4. Housing Bubble Migration Results. Country of Origin: the US**

<b>Country</b>	<b>"a" Factor</b>	<b>Statistic</b>	<b>Period</b>
Japan	1/3	2,23	1998Q2-2006Q3.
France	1/3	2,14	1998Q2-2003Q4.
Canada	1/3	2,26	1998Q2-2006Q3.
Denmark	1/3	-2,35	1998Q2-2002Q4.
Ireland	1/3	-6,36	1998Q2-1999Q2.
Netherlands	1/3	-2,21	1998Q2-2000Q1.
Germany	1/3	4,14	1998Q2-2004Q1.
Australia	1/3	-6,06	1998Q2-2002Q1.
New Zealand	1/3	-4,26	1998Q2-2003Q2.
Sweden	1/3	6,11	2002Q3-2007Q4.

Table 4 shows the country to which the US housing bubble migrated and the period of time for which migration was encountered. For example, the US housing bubble that gave origin to the subprime financial crisis propagated to Japan between 1998Q2 and 2006Q3. Notice that most migrations were to European countries. Notably, the Spanish housing bubble was not a direct consequence of the US housing bubbles. Its origin must be found in other causes.

Figure 2 presents a map in which the encountered migrations are illustrated. The map shows in red the US, which is the country in which migrations originated. The countries to which migrations were encountered appear in orange in the map, while those to which bubbles occurred due to a different cause appear in yellow.

**Figure 2. Map of Housing Bubble Migrations.**



We only report results for the normalization  $a = \frac{1}{3}$ . However, our results were qualitatively identical under other normalizations. Especially relevant to mention, results remain unchanged with  $a = 1$  and  $a = 3$ .

In this study we do not seek to identify the causes of bubble migration. However, it is worthy to mention some hypotheses about the possible causes of migration. All migrations were originated in the US housing bubble that gave start to the subprime financial crisis. Many authors have proposed that the main cause of the US housing bubble were the persistence of extremely low mortgage interest rates, low short-term interest rates, relaxed standards for mortgage loans, and irrational exuberance (see, for instance, Holt, 2009).

These four facts led to the existence of abundant liquidity in international financial markets and a search for yield of international investors. Capital flows to other developed economies and to emerging markets increased considerably before the beginning of the subprime financial crisis. With many investors taking positions in housing markets and central banks maintaining low interest rates for avoiding the appreciation of their currencies with respect to the US dollar, the conditions for the formation of housing bubbles in many countries were set.

The international financial crisis of 2007-09 clearly showed that financial cross-border spillovers are a side-effect of increasing international financial markets integration. Therefore, our results have important policy implications. First, whenever national policies have relevant cross-border effects, then international policy coordination is a must. For instance, if national policies tending to stimulate the housing market in some developed economies have effects on other countries, then housing policies should be coordinated in international forums.

Second, our results highlight the importance of developing macro-prudential policies for diminishing the potentially harmful effects of shocks originated in international financial markets. Of particular relevance, small open economies should consider the implementation of temporary capital controls for limiting the noxious effects that capital flow cycles may have, as the development of housing bubbles.

## **6. Conclusions**

In this paper we study the existence and international migration of housing market bubbles. We use quarterly information of twenty OECD countries for the period comprised between 1970 and 2015, and test for the existence of bubbles following the methodology proposed by Phillips et al. (2015).

We find that housing bubbles are present in all the countries included in our sample. In fact, we were able to identify multiple bubbles in all but two of the countries included in our sample, namely Canada and Greece. We found that most of the bubbles are encountered during the late 1990s and early 2000s. This period of time also characterizes for being the one in which the longest bubbles developed.

While positive and negative bubbles exist, the first types of bubbles predominate. Interestingly, their duration is also higher than the duration of negative bubbles.

After identifying and date stamping bubbles for our set of OECD countries, we tested for possible international bubble migrations following Phillips and Yu (2011). Following the center-periphery literature, we consider only international migrations originated in a bubble occurring either in the US or in the UK.

Various episodes of potential migration were selected and formally tested. We found ten episodes of migration. All of them had origin in the US housing bubble preceding the subprime crisis. Most migrations were to European countries. Notably, the Spanish housing bubble was not a direct consequence of the US housing bubbles. Its origin must be found in other causes.



According to our results, there were no migrations from UK housing bubbles to any other country in our sample. In other words, the UK housing bubble had no direct influence in the formation of housing bubbles in other OECD countries.

Our results have relevant policy implications. Whenever national policies have important cross-border effects, then there is a case for international policy coordination. In the case of housing markets, if national policies tending to stimulate these markets in some developed economies have effect on other countries, then housing policies should be discussed in international forums.

Our results highlight the importance of developing macro-prudential policies for diminishing the potentially harmful effects of shocks originated in international financial markets.

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## Appendix

### Table 3. Bubble Date-Stamping

Period	Number of Bubbles	Dates of Bubbles
<b>United States</b>		
1970Q1 - 2015Q2	2	1981Q1 - 1982Q4, 1998Q2 - 2007Q1,.
<b>Japan</b>		
1970Q1 - 2015Q2	2	2006Q2-2009Q1, 2010Q3-Now.
<b>Germany</b>		
1970Q1 - 2015Q1	4	1989Q3 - 1990Q4, 2000Q2 - 2002Q1, 2006Q3 -2009Q1, 2009Q3 - Now.
<b>France</b>		
1970Q1 - 2015Q2	5	1986Q3 -1988Q3, 1991Q2 - 1992Q3, 1998Q4 - 2001Q4, 2003Q1 -2006Q2, 2008Q1 - 2009Q3.
<b>Italy</b>		
1970Q1 - 2015Q2	3	1988Q3 - 1991Q1, 1993Q2 - 1994Q4, 2006Q4 - 2009Q4.
<b>United Kingdom</b>		
1970Q1 - 2015Q2	2	1988Q1 -1989Q2, 1999Q2 - 2000Q3.
<b>Canada</b>		
1970Q1 - 2015Q2	1	2001Q4-2009Q1.
<b>Australia</b>		
1972Q3 -2015Q2	2	1980Q1 -1981Q2, 2000Q4 - 2004Q1.
<b>Belgium</b>		
1976Q2 - 2014Q4	3	1989Q1 -1990Q4, 1998Q4 - 2001Q3, 2003Q2 -2009Q3.
<b>Denmark</b>		
1970Q1 - 2015Q2	2	1981Q2-1982Q4, 2004Q3-2007Q2.
<b>Finland</b>		
1970Q1 - 2015Q2	3	1982Q4 -1984Q4, 1987Q3 - 1989Q3, 2007Q2 -2009Q2.
<b>Greece</b>		
1997Q1 - 2015Q2	1	2011Q3 -2013Q3.
<b>Ireland</b>		
1970Q1 - 2015Q2	2	Before- 1975Q4, 1998Q2-2000Q3.
<b>Israel</b>		
1994Q1 - 2015Q2	3	2006Q2-2008Q4, 2009Q2-2011Q3.

<b>Netherlands</b>		
1970Q1 - 2015Q2	5	1976Q2 -1978Q1, 1984Q1 - 1987Q4, 1996Q4 - 2002Q2, 2008Q4 - 2010Q1, 2011Q4 - 2013Q4
<b>Norway</b>		
1979Q1 -2015Q2	5	1985Q3 -1986Q4, 1989Q2 - 1991Q1, 1993Q2 -1998Q4, 1999Q1 -2000Q3, 2006Q1 -2002Q3
<b>New Zealand</b>		
1970Q1 - 2015Q1	3	1981Q1 -1982Q3, 1995Q4 - 1997Q3, 2002Q2 -2009Q1.
<b>Spain</b>		
1971Q1 - 2015Q2	3	1986Q3-1988Q1, 1991Q4-1993Q4, 2000Q4-2009Q3.
<b>Sweden</b>		
1980Q1 - 2015Q2	3	1992Q1 -1993Q2, 1999Q1 - 2001Q2, 2006Q3 - 2007Q4.
<b>Switzerland</b>		
1970Q1 - 2015Q2	4	1988Q2 -1989Q3, 2001Q4 - 2004Q4, 2010Q2 - 2012Q1, 2012Q3 -2014Q1.
<b>Euro Area</b>		
1996Q1 - 2015Q1	3	2004Q4 -2006Q2, 2008Q2 - 2009Q3, 2012Q2 -2012Q3.
<b>OECD</b>		
1970Q1 - 2015Q2	5	1981Q3-1982Q4, 1987Q1-1990Q1, 1998Q2-2011Q3, 2002Q1-2005Q1, 2007Q3-2009Q2.

**Figure 1. Housing Bubbles Date-Stamping**

