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ARE THERE SIGNALS OF A HOUSING BUBBLE? AN EMPIRICAL ANALYSIS OF THE PORTUGUESE CASE

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Abstract

Is there a housing bubble emerging in the Portuguese real estate market? Since similar questions have been raised among the popular press, and among economists and policymakers, the housing market in Portugal has becoming an extremely interesting topic to be investigated within the OECD area.

The foremost purpose of this dissertation is to evaluate whether there are bubble tendencies in the Portuguese housing market, or if the (apparently) continuous house price growth can be explained by economic fundamental factors. The first point we would like to stress is that, for the period where there is consistent and comparable data related to house prices in the OECD countries (since 1988), Portugal displays the smallest rate of growth of real house prices. Secondly, the multiple linear regression model suggests an unexpected finding: the hypothesis of an emerging housing bubble in the Portuguese market can be easily rejected.

As a matter of fact, and regardless of people's beliefs, there is no sound of an economic evidence of a boom-bust in real house prices. Portugal is not in an alarming situation and so we can throw away the idea that the country is facing a speculative momentum. Surprisingly, the increase in housing prices that have been distressing the whole Portuguese society seems to be nothing else than a typical price adjustment, which results from the large previous downward fall that house prices suffered in the aftermath of the recent sovereign debt crisis, which so dramatically affected the whole Portuguese economy.

Keywords: Housing Bubbles, Housing Market, Real Estate Prices, Macroeconomic Drivers, Multiple Linear Regression Model.

Resumo

Existe, de facto, uma bolha imobiliária a desenvolver-se no mercado Português? Desde que questões similares têm surgido entre a comunicação social, economistas e políticos, o mercado imobiliário em Portugal tornou-se num tópico extremamente interessante de ser analisado na área da OECD.

O propósito principal desta dissertação é o de analisar se existem tendências de uma bolha no mercado imobiliário em Portugal, ou se (aparentemente) a subida contínua do preço das casas pode ser explicada for fatores económicos fundamentais. O primeiro ponto que se pretende enfatizar é que, para o período em que existem dados consistentes e comparáveis relacionados com o preço das casas para países da OECD (desde 1988), Portugal apresenta a menor taxa de crescimento do preço real das casas. Em segundo lugar, o modelo de regressão linear múltipla sugere uma descoberta inesperada: a hipótese de uma bolha imobiliária emergente no mercado português é facilmente rejeitada.

Na verdade, e independentemente da convicção das pessoas, não existe qualquer evidência de um ciclo explosivo no preço real das casas. Portugal não se encontra numa situação alarmante e podemos, portanto, suprimir a ideia de que o país está a enfrentar um momento especulativo. Surpreendentemente, o aumento do preço das casas que tem vindo a perturbar toda a sociedade não é nada mais do que um típico ajustamento de preços, resultante da grande descida do preço das casas durante a recente crise económica, que afetou drasticamente toda a economia portuguesa.

Palavras-Chave: Bolha Imobiliária, Mercado de Habitação, Preços Imobiliários, Fatores Macroeconómicos, Modelo de Regressão Linear Múltipla.

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Countries and Abbreviations

Countries

BEL	Belgium
GER	Germany
IRE	Ireland
NOR	Norway
PRT	Portugal
SP	Spain
UK	United Kingdom
US	United States

Abbreviations

ADF	Augmented Dickey-Fuller
APEMIP	Associação Profissional de Empresas de Mediação Imobiliária
BdP	Banco de Portugal
BTL	Buy-to-Let
CLTV	Combined Loan-to-Value
DSR	Debt Service Ratio
DSTI	Debt Service-to-Income
DTI	Debt-to-Income
ECB	European Central Bank
ESRB	European Systemic Risk Board
EU	European Union
GDP	Gross Domestic Product
IMF	International Monetary Fund
LPS	Lender Processing Services
LTI	Loan-to-Income
LTV	Loan-to-Value
MaPP	Macro-Prudential Policies
NHP	Nominal House Price
NHR	Non-Habitual Resident
NPL	Non-Performing Loans
ODSR	Originating Debt Service Ratio
OECD	Organization for Economic Co-operation and Development
OLTV	Originating Loan-to-Value
PDI	Personal Disposable Income
PIR	Price-to-Income Ratio
REE	Rational Expectations Equilibrium
R&D	Research and Development
SVECM	Structural Vector Equilibrium Correction Model

1. Introduction and Problem Statement

Real estate markets symbolize an integral part of today's economy which is inevitably related to other areas and it requires the intervention of various agents from the economic activity. Housing can be considered one of the foremost assets of households' budgets. The state of the economy, interest rates, households' disposable income and changes in the size of the population influences the housing market. And besides these demand-side factors, house prices are also determined by the supply-side (see Figure 1.1.).

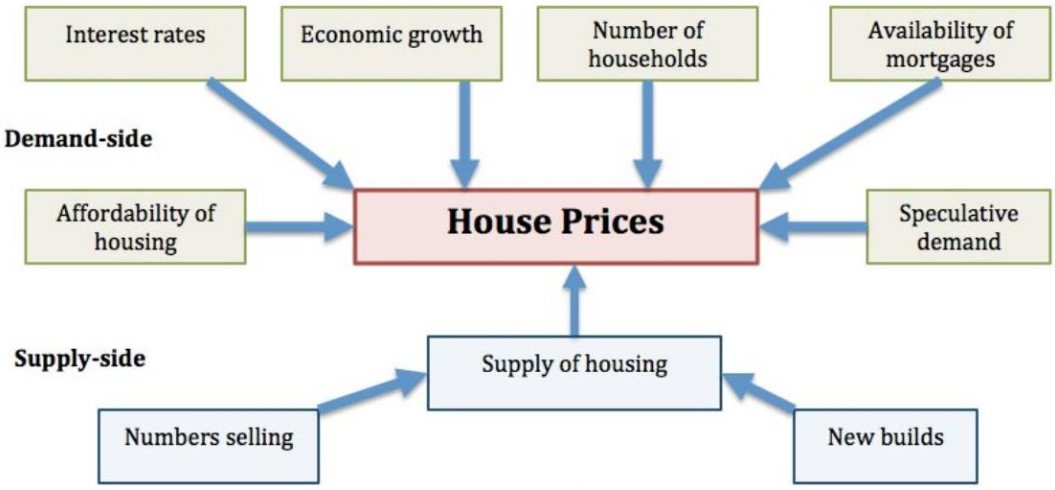

Figure 1.1. Factors Determining House Prices

Source: www.economicshelp.org

Residential real estate is a key factor of vulnerability in advanced and emerging economies likewise, such that volatility in can have far reaching consequences. As most of dwellings are purchased resorting to a mortgage, real estate has a major impact on the banking sector. Real estate assets are considered a medium-to-long term investment and so, they are affected by the outsized macroeconomic changes. Housing prices affect private consumption; hence the housing market and the consumer spending are closely associated. An increase in housing wealth will influence the expected lifetime income, leading consumption and housing prices to increase. In fact, the macroeconomic performance and financial stability are interrelated due to the many roles housing plays

for households, firms and financial intermediates, as a consumption good, long-term investment, store of wealth, and collateral for lending.

Furthermore, Central Banks and other international organizations, in the aftermath of the sovereign debt crisis, become concerned about the role of domestic housing markets in financial stability and the real economy (e.g., the IMF established the Global Housing Watch and the Federal Reserve Bank of Dallas created the International House Price Database)[1]. It is important to explore the boom-bust of prices by considering the linkages between real estate markets, financial markets and the economy. In fact, the macroeconomic development of a country depends on the real estate development. Since the Subprime crisis in the US, the European banking crisis and the third Portuguese rescue from Troika, the housing market gained a special attention and several studies have been developed around this theme. Researches in this field show that global real estate markets do not only depend on worldwide economic cycles, but a mix of global and local economic factors as affirmed by Goetzmann and Rouwenhorst (1999). Recent events prove this: at the begin, the Great Recession impacted the entire American economy; it can be confirmed today that such a market distress was felt by nearly every country in the world. The authors Goetzmann and Watcher (2001) have documented that "The recent US crash was a global crash". Further, Janssen (2010) argues that when a developed country faces a housing bust, economic activity in other countries experience the same downturn and consequences as well via international transmission effects.

The truth is that since the 2007-08 financial crisis, with the continuous rise in housing prices, the potential burning of real estate markets is attaining attention from regulatory sectors, industry and research alike. Decision-makers are feeling apprehensive regarding the real estate business. In fact, real estate prices are once again growing strongly worldwide. This steady increase brought the risk of a real estate bubble back into the notoriety for market agents. This topic has been widely debated, both nationally and internationally, and Portugal is nowadays a country within more and more warnings about a price bubble.

[1] The Global Housing Watch is a current database of house prices and ratios of valuation (house price-to-rent and house price-to-income ratios) when assessing housing markets. The IMF launched this programme to overwhelm the so-called "benign neglect" era – policymakers and regulators should consider the extremely negative effects a burst in house prices could have. Likewise, the Bank of Dallas established the International House Price Database which comprises quarterly data since 1975 regarding house prices and personal disposable income (PDI) for countries worldwide.

In the beginning of this study, a brief cross-country analysis was made in a way to observe and analyse the behaviour of some selected variables (such real gross domestic product, short- and long-term interest rates, real house price index, price-to-rent and price-to-income ratios, consumer confidence index, unemployment rate), then allowing to pick up the most relevant ones to include in the final statistical analysis. The concerning regarding the Portuguese housing market has been particularly strong over the last decades because recent house price growth has been rampant. Nationally, the largest cities have experienced exceptionally high house prices growth. The motivation of this empirical study is that a new problem may be emerging because of the exponential increase verified in house prices, mainly in the Portuguese market, as this is nurturing the fears of a repeat real estate bubble which were at the origin of the tremendous Global Financial crisis.

Portugal is a country that belongs to the European Union, the Euro Zone and the Schengen area, with a steady political and social environment, a strategic location with access to key markets, highly skilled labour force, competitive costs, and an excellent quality of life that offers an auspicious investment climate. Since 2009, Portugal introduced a range of tax benefits for both EU and non-EU citizens which turned the real estate market more financial lucrative. The main purpose was to encourage direct foreign investment in a way of recovering the economy from the distress after the Global Financial crisis. Since then, investors are coming from all over the world, being the Chinese culture the most significant one. According to the World Bank Group Doing Business 2018, Portugal is seen as a stable place to do business and it is ranked 29th out of 190. Hence, Lisbon is fast becoming an innovative and tech start-up hub. Noticeably, Portugal is being established as an eye-catching destination for entrepreneurs, investors and foreign research and in progress companies and nowadays is known as one of the leading EU countries for R&D and fresh technologies. The Portuguese Non-Habitual Resident (NHR) tax regime, granted for a 10 year-period, seeks to attract and retain high qualified expatriates and industries to perform high value-added activities.[2] Throughout the tax regime, non-habitual residents can benefit from a flat 20% income tax rate. Further, the NHR regime is beneficial for retirees in a way they will receive their foreign income completely tax-free (including pensions). For example, British pensions can be

[2] Residence means having a habitual residence in Portugal or living at least 183 (consecutive or not) in any period of 12 months starting or ending in the relevant tax year.

paid gross, that is, without deducting both UK and Portuguese taxes. Also, the Portuguese government's Golden Visa, which is only eligible for foreign investors from non-EU countries, helped Portugal becoming more and more popular for potential stakeholders.

As documented by economic researches, real house prices crashed in the wake of the financial crisis in 2007-08, but from 2009 on, Portugal experienced a period of retrieval (see Figure 1.2.). After the Troika intervention, a new scenario emerged indeed: positive economic conditions encouraged credit growth and demand to go up. It was intended at restoring confidence and enabling the safeguarding of financial stability in the Portuguese economy. At that time, positive economic conditions surfaced, and housing prices suffered an upward pressure. Besides the upturn of real house prices, Portugal did not witness a property boom and bust.

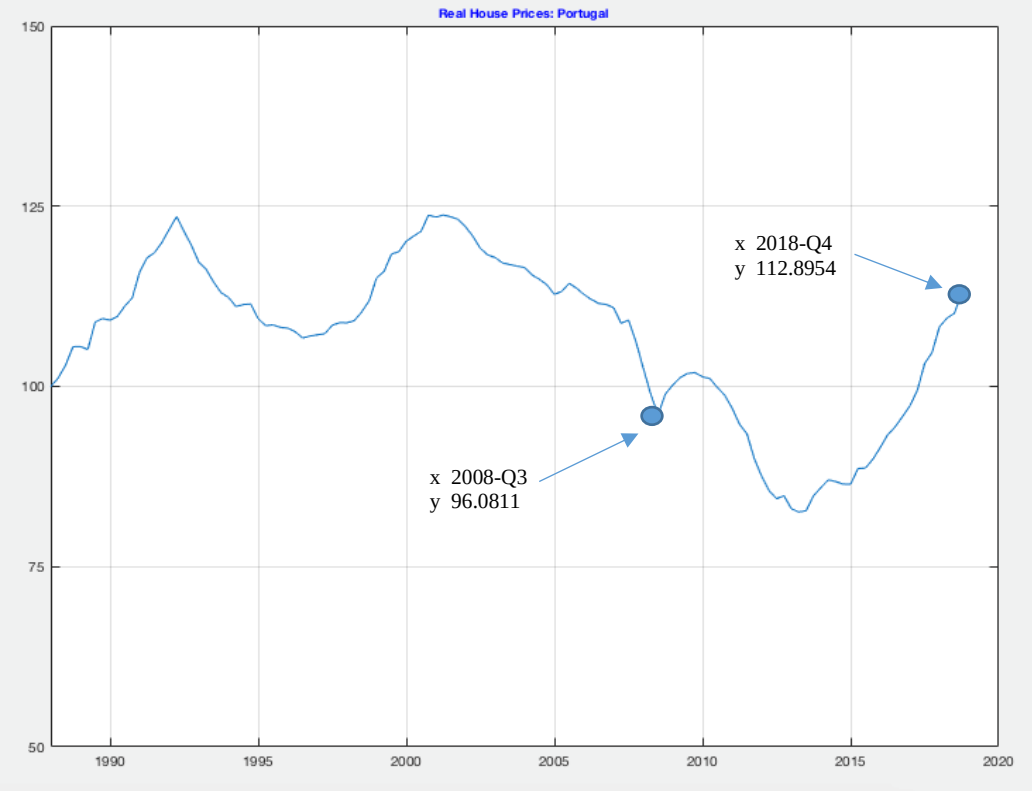

Figure 1.2. The Evolution of Real House Prices in Portugal (1988=100)[3]

[3] Note that when Portugal is compared with other OECD countries, the evolution of real house prices exhibits a "modest" behaviour. By analysing Figure 4.1., it is evident that there is no evidence of a housing bubble in Portugal.

This recovery has had a noteworthy impact for most of the households, as housing is of considerable importance for households generating a stream of utility for them and it constitutes the biggest asset of a household's portfolio. The speculative and quasi-irrational prices in Portugal were becoming progressively evident because of an excess of optimism on the part of property owners and, in fact, several experts began drawing attention to the possibility of the existence of a real estate bubble. Surprisingly, the Portuguese market is characterised by one of the lowest real house prices when compared with other OECD countries. Bankers defined the steeply rising in house prices as a normal consequence of the market correcting itself following years of minimal investment. Besides, it is difficult to affirm whether a housing bubble exists or not, as the housing market is extremely complex and driven by economic conditions, as well as expectations and speculations in numerous of variables.

Based on this, a problem statement is defined: Are there signals pointing towards a housing boom and burst in the Portuguese real estate market? If not, what, in fact, supports the exponential increase in the Portuguese real house prices? Can the excessive growth in house prices in Portugal be atypical, or it can be explained by underlying fundamental economic factors? A further analysis and a better understanding of the linkage between the real estate market and the macroeconomy is of great theoretical and practical significance and thus, the major motivation of this study. It is essential to comprehend the reasons behind the property prices mispricing, at a macroeconomic horizon, and which factors deviate real house prices from their fundamental valuation.

Moreover, and as commonly believed, in periods of exponential growth of demand and a limited supply, housing prices will consequently rise, as well as rents and the risk of homelessness. Our main findings suggest that besides the suddenly rise in housing prices during the post-crisis period, mainly since 2016, policymakers and researchers recognize that in the Portuguese economy there is, in fact, a "hot demand", but they throwaway the idea that Portugal is facing a speculative momentum. Portugal is nowadays in a manner of economic growth and urbanization. The euphoric rise in house prices comes from an increase in the demand-side that is not attended by a similar increase in the supply-side. In fact, the economic growth recovery, the attractiveness in the international market and the subsequent increase in tourism and immigration, the shortage of alternative investments, all of this combined with a developed and flexible mortgage market would be enough to drive housing prices up. Further, and according to the popular press, the assets in real estate market are few and those that already exist are not affordable

for most of the Portuguese families. As a matter of fact, the gap between demand and supply in the Portuguese market will continue to exist, until supply readjusts.

Although, the dominant opinion among Portuguese economists and policymakers is that there aren't macroeconomic indicators that point towards the existence of a real estate bubble in Portugal; and they claim that the incredible increase in house prices is due to the dynamics of the fundamental factors. A Bloomberg Economics research, "These Are the Countries Most at Risk of Housing Bubbles" stated that Portugal is not in an alarming situation, although nominal house prices will remain high. And by analyzing other macroeconomic variables, such gross domestic product and house price-income ratio, the conclusion remains the same: the Portuguese market is not among the most disquieting regions in the case of a real estate bubble. Further, Kholodilin and Michelsen (2018) analyse the signs of a new housing bubble in many OECD countries by using a statistical test methodology which includes information on the price-to-rent ratio from the OECD database on housing prices. Regarding the Portuguese economy, the main conclusion is that speculative bubbles in this country are relatively rare, although the results indicate a short-term housing price bubble since 2016.

Unexpectedly, the idea of a housing bubble in Portugal is left behind. The examined macroeconomic fundamental factors (gross domestic product and price-to-income ratio) sustain the exponential increase in Portuguese's nominal house price level over the years. The model proposed in this empirical work is intended according to the best practices in econometric applications.[4]

Even though, this empirical study faced some shortcomings. Short-term and long-term interest rates were supposed to be included in the final regression model, as these macroeconomic variables are crucial to investigate real estate developments. These variables have the power to reflect a household's capability to purchase residential property and can significantly impact the cost of financing and mortgage rates, consequently affecting demand and supply in the housing market.

First and foremost, the involved spreads in the long-term interest rates refer to public debt spreads and do not reflect the mortgage credit spreads, which were the relevant ones for this analysis. Moreover, during the sovereign debt crisis, public debt ratios increased substantially in most EU countries, attaining historically high levels. According to a study carried by Amador et al. (2016), public debt unsustainability

[4] The parameters of the final regression model were estimated throughout EViews 10 software.

widespread across the Euro Area, but it was particularly significant in countries such as Portugal. Further, historical evidence suggests that the mortgage credit spreads did not reach so high levels which, in fact, turns out the long-term interest rates time series in a skewed series with values that does not correspond to the real values practiced in real estate markets. In the late of the 80s, house prices increased abruptly because financial institutions initiated a war created by the easing in mortgage credit. Banks provided credit to all households, without even consider how risky they could be. As a matter of fact, this lessness of the credit standards distorted the effect of long-term interest rates in the Portuguese economy. Second, the challenge regarding the short-term interest rates was due to the absence of the spread term in this time series. Short-term interest rates were decreasing drastically until the Global Financial crisis and housing prices accompanied this downward fall. In the aftermath of the crisis, the rates exponentially increased, as well as house prices. In fact, interest rates suffered such a high rise because of the non-presence of mortgage credit spreads. For that reasons, interest rates were completely excluded from this empirical analysis. Unfortunately, it was not possible to gather a reliable database of the historical average of mortgage credit spreads. And it would not be trustworthy to include in the statistical investigation time series that does not correctly correspond to the real value of the interest rates within the mortgage credit spreads. The literature proposes that, both short- and long-term interest rates, and consumer confidence index should influence the dynamics of house prices. Although, these variables appear with a non-linear relationship which means that they are not statistically significant and do not influence nominal house prices in Portugal.

The outline of this dissertation is as follows: Section 2 briefly reviews the current literature regarding real estate markets and macroeconomic determinants that can lead to an abnormal behaviour of housing prices. Section 3 describes the importance of the real estate market developments in the economy; explains housing bubbles and the role of macro-prudential regulatory tools against such bubbles. Section 4 describes the selected data for the estimation of the multiple linear regression model – mainly, nominal house prices, gross domestic product and price-to-income ratio since 1988 first quarter up to 2018 last quarter; even more, the detail of the methodology used as well as the main econometric results are exhibited. Lastly, Section 5 presents the final remarks.

2. A Literature Survey

Housing is one of the most important markets in the industrialized economies and a source of guarantee for bank loans. As a manner of fact, banks and other financial institutions invest worryingly in residential real estate markets. Significant efforts are made to measure the level and volatility of housing values, building permits, housing starts and housing inventories (Carrillo, 2011). Further, Leung (2004) and Davis and Heathcote (2001), highlight the importance of the real estate sector. Their main findings are the following: (i) housing constitutes a substantial share of households' expenditure and total wealth; (ii) the annual market value of property investment is larger than that for business capital investment; (iii) Housing is not just "another" consumption good, and so, changes in housing prices would imply significant household wealth effects; (iv) the market value of residential property stock is approximately equal to the average GDP.

In a brief literature review, it is evident two main strands followed by researchers: the ones that investigates the determinants of housing prices and, second, the ones that make a bridge connection between asset prices, macroeconomic developments, and economic and regulatory policies. Kennedy and Andersen (1994) explore the interaction between household saving and the housing market, noting that saving behaviours as well as the misperceptions about the future clearly have an important role in the determination of house prices. Englund and Ioannides (1997) relate the dynamics of housing prices in fifteen OECD countries and they conclude that GDP growth and interest rates exhibit a significant power. Other authors are proponents that housing prices movements not only affect the business cycle dynamics but also the financial system. Hence, Central Banks' main goal passes through understanding this behaviour to maintain prices and financial stability. From a policy perspective, since almost all house purchases involve external financing, the cost of mortgage credit and the conditions are also noteworthy for house price dynamics. Tsatsaronis and Zhu (2004) conclude in their research that the dominance of inflation and nominal interest rates in real house prices are extraordinary. Lecat and Mésonnier (2005) research is about the relationship between house prices, financial variables and lending conditions. After an econometric analysis, the authors may conclude that short- and long-term interest rates and credit rationing impact the developments in the housing market.

Concerning the relationship between monetary policy and asset price oscillations a vast number of empirical studies has been developed in recent years, most of them under the label of boom-bust dynamics. Bordo and Jeanne (2002) conduct a study based on the relation between asset price movements and the potential cases for proactive and reactive monetary policy, considering that asset price reversals can have serious implications on real output. By the end of the research, they conclude that asset price booms and busts can be very costly in terms of declining output. Likewise, Borio and Lowe (2002) claim that a fast credit growth merged with an increase in asset prices and a low inflation environment leads to a period of financial instability. Detken and Smets (2004) analyse the development of monetary policy under asset price booms gathering data of 38 booms since the 1970s for 18 OECD countries. They split the sample of boom episodes into high- and low-cost booms, depending on the relative post-boom growth performance. Similarly, Detken and Alessi (2009) look at monetary policy developments and they predict high-cost asset price booms[5] for 18 OECD countries since the 1970s, concluding that is possible to identify early warning indicators for individual countries. Jaeger and Schuknecht (2007) emphasis the behaviour of fiscal policy during boom-bust phases in asset prices and find out that fiscal balances tend to recover during boom phases and to deteriorate in busts. That is, the response of fiscal revenue to asset price cycles leads to public expenditure in booms and public debt in busts. The finding suggests the adoption of fiscal policy rules that assure a medium-term orientation while leaving adequate short-term fiscal flexibility. Martin, Schuknecht and Vansteenkiste (2007) analyse boom-bust episodes in asset prices in industrialized countries, claiming that financial variables explain the emergence of such episodes and have a significant power for the role of exchange rate in adjustment. Finally, the major findings of these studies are coherent with the recent study of Reinhard and Rogoff (2008), where the authors offer a broadly panoramic analysis of historical financial crises.

Other researches analyse housing prices along with equity prices to examine the question of whether the underlying credit growth result in booms and busts. According to the econometric analysis of Borio and McGuire (2004), equity price peaks tend to be followed by housing price peaks already. Further, interest rates fluctuations appear to influence real estate price dynamics, which underlines the role of monetary policy (also

[5] The authors define a high-cost boom as "(…) a boom that is followed by a three-year period, in which overall real GDP growth was at least three percentage points lower than potential growth".

see e.g. Detken and Smets (2004)). Gerdesmeier, Reimers and Roffia (2009) evaluate the features of money and credit indicators for detecting asset price busts, by constructing an asset price composite indicator which is house and stock market-based. The empirical analysis is based on a pooled probit-type approach to predict the best indicators which help to forecast asset price misalignments. Hence, the statistical tests show that credit aggregates, nominal long-term interest rates and investment, together with house or stock price movements, prove to be the best indicators when assessing financial crises. Moreover, it is important for Central Banks to have a deep insight regarding early warning indicators to assess financial imbalances and large asset price dynamics. Dreger and Kholodilin (2013) conclude that early warning indicators are vital tools to be used by policymakers in their attempts to detect house price bubbles and weaken their disturbing effects on the world economy. Besides, there are some studies that investigate the effects of liquidity spillovers under asset price boom-bust cycles. Adalid and Detken (2007) show empirical evidence that liquidity shocks are a driving factor for housing prices during boom episodes. In fact, during the boom periods the development of real estate prices and money growth shocks may explain the depth of post-boom downturns. Similarly, Greiber and Setzer (2007) as well as Belke, Orth and Setzer (2008) find in their study that liquidity drives housing market progresses. The evidence is that not only do real estate prices influence monetary developments but also the inverted relationship is relevant as well – the so-called "asset inflation channel".[6] In principle, liquidity growth is seem as a suitable indicator of house price inflation.

Nevertheless, Carstensen et al. (2009) study the reaction of real house prices to a monetary policy shock. To evaluate the impact of housing and mortgage market heterogeneity across countries, they divide their panel into two distinctive groups: a strong reaction group and a weak reaction group. Their main findings suggest that macroeconomic variables co-move with housing prices after a monetary policy shock. For countries that belong to the strong reaction group, the reaction of macroeconomic variables is more noticeable than for countries of the weak reaction group (the group to which Portugal belongs to).

[6] As stated by Greiber and Setzer (2007), "house prices were more sensitive to an increase in aggregate demand caused by monetary expansion than consumer prices." That is, an expansive monetary policy which provides markets with abundant liquidity may influence house prices to increase.

In fact, the real estate market is influenced by a wide range of factors, and so, its evolution through time must be examined from a macroeconomic perspective. A proper appraisal of the real estate sector is a foremost step for a suitable decision making.

3. What is a Real Estate Bubble and How Can It Be Detected?

Real estate prices growth is evident in emerging markets and from the perspective of financial institutions and policymakers there is a doubt of the so called "Bubble or Correction?". It is often tough to define whether there exists a real estate bubble in the market until it eventually burst. However, there are some economic indicators and methods that may suggest symptoms of a bubble.

This chapter attempts to introduce the general notion of the term "bubble" within a real estate market and explains the commonly and lately indicators and methodologies used to detect it. A brief theoretical representation of rational bubbles is lastly explained.

3.1. Importance of Housing in Economics

The aspects of housing markets are different from most other markets (stock markets, for example), hence there are key features of housing markets that must be highlighted: the heterogeneity, once different properties have different characteristics and prices, and even for identical properties, the location will differ which leads houses to be priced differently; the purchase of such asset as housing evolves high transaction costs and a low turnover, which turns the assessment of price developments a difficult task; the conditions of sale easily fluctuate because prices mostly result from consensual negotiations within agreements on the price; the supply is considered plentiful rigid, as a result of shortage of buildable land and, even if land is available, the time needed to finish construction, obtain financing, and the time needed to assure building permits, leads the supply to be lagged; the wide variety of financing conditions which differ internationally and depends on the supervisory and regulatory framework for housing finance; last but not least, the taxation of, and financial incentives for homeownership can strongly affect settings in housing markets.

First and foremost, it is essential to define and understand the linkages between the real estate market and the macroeconomic sector. The main concern behind modelling

housing prices derives from the impact and severe consequences such price movements may have on the society and on the worldwide economy, and from the key evidence that a house fulfils the individuals' basic needs (Lu, 2016) and it represent one of the fundamentals of today's society. In fact, the housing sector contributes to the aggregate demand throughout residential investments. Private and public constructions comprise an essential portion of GDP in almost every country. This characteristic of universality gives the real estate sector a function of development indicator of a country or region.

The key point is that housing works as a multiplier driven in the economy. Housing transactions stimulate complementary industries (construction and furniture enterprises, real estate agencies and bankers). Capozza et al. (2002), for example, argued that lower construction costs have a significant role in dampening cycles. As a manner of fact, new construction is a market's response of the exponential increase of house prices. Moreover, owning a house means higher wealth, confidence and security for homeowners which leads to an increase in investments and income spending (NACCA, 2005). Housing prices substantially disturb private consumption through a housing wealth and a collateral effect (see Dreger and Reimers (2011)); and most of the consumption expenditure is allocated to housing (see Englund et al. (2002)), which indicates that the housing market is closely linked with consumer spending. According to a study upon a panel of 14 countries and a panel of US states developed by Case, Quigley and Shiller (2001), the authors conclude that discrepancies in real estate prices have had an impact on homeowners' consumption. In principle, the housing market seem to be more important than the stock market in prompting consumption (see also Rapach and Strauss (2006)). On the other hand, when house prices go down, houses may become worth less than their outstanding mortgage which becomes a major threat for homeowners leading to consumer spending reduction. As stated in the literature, outsized falls in asset prices could have substantial wealth effects on consumption. In line with Kahn (2008) and Chen (2012), a substantial portion of variation in housing prices can be explained by economic fundamental variables such as income, inflation, interest rates and construction costs. Although, there is also a collateral effect of house prices, once houses are most of the time used as a security for loans (see Muellbauer (2008)). In fact, when housing prices are rising, the value of the collateral is higher and higher. As of, the mortgage market turns out to be deregulated and it becomes easier and cheaper for households to borrow.

Last of all, housing has the strength for economic growth, employment and wealth but also has the capacity to dragging the economy down as noted in the beginning of 2007 with the Global Financial crisis and recession.

3.2. When Prices Go Over the Roof: Introduction to a Housing Bubble

The word bubble is nowadays widely used when designating the movements of housing prices but, in fact, a universally accepted method to identify boom-bust cycles does not exist. In 1988, a very well-known article regarding housing market inefficiency was published by Case and Shiller – "The Efficiency of the Market for Single Family Homes". The article displays house price movements in four cities (Atlanta, Chicago, Dallas and San Francisco), noting that "(…) increases in prices over any year tending to be followed by increases in the subsequent year", that is., house prices exhibited statistical significance in the short-run. Besides two decades of investigation on housing cycles, the authors never used the word bubble even once. In the succeeding year, in a *Journal of Economic Perspectives* symposium on bubbles, the author Shiller started introducing the word bubble while analysing the boom of housing prices in California. Later, Case and Shiller (2004) survey, in the article "Is There a Bubble in the Housing Market?", the question of whether a boom in housing prices indicates a bubble and whether it is expected to burst or deflate. The authors conclude that the exponential increase in house prices does not explain the existence of a bubble at all, and that changes in fundamentals may explain much of the increase. When analysing the origin of the term "housing bubble", the authors report the results of a Lexis-Nexis search for the usage of the term. Surprisingly, the usage of the term quickly died out after the stock market crash of 1987 and it just started being massively used in 2002. On the other hand, the term "housing boom" has appeared more often since the run-up in real estate prices in the 1980s. A brief explanation may be associated with the fact that the term "boom" designates that the upsurge in house prices may be a worthy opportunity for investors. Contrarily, the term "bubble" is usually used with a negative connotation, in a way that high price levels cannot be sustained.

Since the Great Depression, economists and policymakers are concerned about real estate bubbles, which were at the origin of the Subprime market collapse and is today considered as one of the deepest recessions ever and rapidly spread to other countries

worldwide. In fact, the period of the 1980s and the fall in house prices verified in many cities around the world in the early of the nineties are nowadays broadly looked back upon as an example, even a model, of a boom-bust cycle. The global house prices in the 2000s also taught us how housing market can work in the worst way. As declared by *The Economist*, in July 16th, 2005, "The worldwide rise in house prices is the biggest bubble in history (…) never before have real house prices risen so fast, for so long, in so many countries. Historical evidence shows that economic instability has been associated with boom-bust cycles in the housing market (see Bordo and Jeanne (2002); Reinhart and Rogoff (2008); Crowe et al. (2011))[7]. And the emergence of boom and bust episodes is related to the existence of housing bubbles (Case and Shiller (2004); Mayer (2011); Shiller (2014)). Besides Case and Shiller (2004), also Zhou and Sornette (2008) analysed the quarterly average sales of new houses sold in 22 states in the US, in a way to define whether house prices have grown faster-than exponential, which the authors take as the diagnostic of a bubble. They found out that mostly Northeast and West states exhibit explicit signals of a fast-growing bubble. Shiller (2005) showed that institutional bankruptcies and worldwide recession are due to a rapid surge in real house prices. Kemme (2012) presented evidence that the Global Financial crisis in 2008 could have been predicted pursuing just the real house prices.

Furthermore, since the XVII century that bubbles have been reported, and as developed by the author Garber (1990), the three most famous ones were: The Dutch Tulip mania (1634-37), considered as the first recorded speculative bubble, the collapse of the Mississippi Company in France (1719-20) and the South Sea bubble in England (1720). Besides these cases of speculative price movements, other well-known market bubble episodes occurred after that: The Great Stock Market Crash of 1929 – the "Black Thursday" in which stock prices had climbed to seemingly irrational peaks; the massive increase of births following World War II and the consequently increase of real estate and stock prices in the late 1980s, for which Mankiw and Weil (1989) claimed that the entry of the Baby Boom Generation in the residential market was the major cause of the increase in real housing prices and demand; the more recent US Subprime market collapse of 2008, which Shiller (2008) calls for an aggressive response from the financial system, aimed to grab back households' confidence to buy and sell homes and for greater

[7] For example, Reinhart and Rogoff (2008) state "housing price cycles in the advanced economies (...) have long been known to play a central role in financial crises"

prosperity of the American market – basically, the housing investments epidemic were driven by an irrational agents' enthusiasm that did not knew how to behave under speculative bubbles.

Nevertheless, fundamental questions have shown a lack of consensus among economists: What indeed causes the fluctuations in the price of speculative assets (properties, stocks, bonds, etc), especially real estate prices? How can one say that the real estate prices are in a bubble? Is there evidence to consider that a boost in house prices will be monitored by an analogous or even worse decline than the last time? Noticeably after the Great Recession, numerous of economic and financial researches develop and analyse this controversial issue. In fact, when asset prices may differ from their fundamental value and/ or when this misalignment persists over several periods of time, one may be in the presence of a bubble.

Even though there is not a clear and universal definition of real estate bubbles, we can argue that speculative bubbles refer to deviations of actual asset prices from their fundamental value because of investors' expectations of near future gains, followed by a price correction.[8] The price regime shifts in housing can be caused by various reasons, but often they are interrelated to speculation and high capital gain expectations.

Additionally, bubbles follow three distinctive phases. The first phase, known as the so-called "boom" period, refers to the former stage and starts when there is financial liberalization and lower lending standards. Such a behaviour from Central Banks and Governments lead to a credit expansion, consequently increasing real estate and stock prices. From a homebuyer perspective, during a housing price boom, homes which are normally considered expensive and unaffordable now are acceptable to be purchased because agents expect to be compensated in a near future by significant price increases. Furthermore, housing price booms cause pressure in the perceived risk associated with an investment in a home because first-time homebuyers believe that if they are not able to purchase now, they will not be capable to afford a home later. This phase of the bubble is characterised by an exponential rise in prices with the economy reaction positively. Until the point that the bubble inflates. However, prices cannot go up rapidly forever: the second phase starts, and it is characterised by the burst of the bubble, associated with a

[8] See, for example, Hott and Monnin (2008) that argued that to test whether there is a housing bubble, one should address the gap between real housing price and its fundamental prices; Fundamentals represent the main determinants such as personal income, mortgage rates, housing costs and similar factors that affect housing prices.

drastic fall in demand and prices which could last over a long period. In principle, this phase is swifter than the first one and causes severe negative effects. Finally, in the third phase the firms and agents of the market that have borrowed to buy assets at such exuberant price, now go bankrupt. As emphasized in the case study of Pavlidis et al. (2016), empirical evidence shows that house prices and house-price-to-fundamental ratios became explosive in the US and Ireland in the first phase, between the mid-1990s and the early 2000s. The second phase, in the first half of the 2000s, is depicted by a widespread propagation and synchronized episodes of exuberance across diverse housing markets. In the third and final phase, house prices suffered a non-sustainable run-up. The previous episode of global exuberance burst in a short-period of time, before the economic contraction of the 2008-09 global recession. Researches claim that the boom in house prices that originated in the US and propagated to international housing markets was driven by ripple effects from the drop-in world interest rates experienced during the 2000s and housing bubbles (see Case and Shiller (2004)).[9]

Most of the time, the last phase is followed by banking crises that can have major implications for the overall stability of the economy and can last for a long-period.[10] An example is the recent case of Spain in the early 2010s, where the housing bubble bursts and the consequences were felt for years on many macroeconomic indicators. Besides, historical economic episodes exhibit that the sharp increase in house prices is not itself conclusive of a bubble. It is relevant to also consider changes in fundamentals that may explain much of the increase.

By reviewing the literature, Stiglitz (1990) postulates that "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". It can be said that the mark of an asset bubble is irrational exuberance. In real estate market, when home prices begin rising at an appreciably high rate, optimistic investors and speculators jump in and bid the price up even more. Therefore, home prices are forced to further rise while not supported by market fundamentals and ending up at unsustainable levels. Case and Shiller (2004) defined the term bubble as "a situation in which excessive

[9] Case and Shiller (2004) state that "Clearly, interest rates have fallen substantially and have contributed to the run-up in prices since 1995, at least in cities where, in our regressions, the interest rate variable was significant."

[10] The authors Helbling and Terrones (2003) conclude that "Housing price busts were less frequent but lasted nearly twice as long and were associated with output losses that were twice as larger, reflecting greater effects on consumption and banking systems, which are typically heavily exposed to real estate."

public expectations of future price increases cause prices to be temporarily elevated." According to the authors, exponential rise in housing prices is sustained by the expectations of the public of future increases rather than fundamentals. For instance, Mayer (2011) presented two common definitions of bubble. One definition that better fits with some historical evidences of housing bubbles is that "bubbles represent extreme movements of house prices, during which housing prices rise rapidly, growing 20%, 30%, or even 40% per year for two or three years, and then falling just as rapidly in the following three years." Secondly, he stated that bubbles can be detected when house prices are volatile over the cycle – if raising more than its fundamentals, then it represents the boom phase; if falling faster than its fundamentals, it suggests the bust phase. Hence, by this definition, the literature suggests housing bubbles are common. Detken and Smets (2004) and Adalid and Detken (2007) defined that an asset is in a boom stage when its market price is at least 10% above their estimated trend.[11] Glaeser et al. (2008) present a model of housing bubbles with endogenous housing supply and conclude that regions with a more elastic housing supply will have fewer and shorter bubbles with smooth price increases. The data used by the authors reveal that the price climb in the 1980s occurred mostly in areas with inelastic supply. Mikhed and Zemcík (2007) combine price-rent ratios and panel data tests to construct a bubble indicator. The results show there were bubbles for the late 1980s and the early 1990s, as well as around the end of the 1990s. Nneji et al. (2013) focus their analysis on a long-run relationship between house prices and rents in the U.S. residential market from 1960 to 2009. Using a Markov regime switching model, they noticed evidence of an intrinsic bubble during the pre-1998 period only with individuals overreacting to changes in macroeconomic determinants. Additionally, Agnello and Schuknecht (2009), using a Random Effects Panel Probit model for 18 industrialized European countries and over the period 1980-2007, end up saying that the latest housing booms have been persistent and of significant magnitude. In fact, the model seems to be effective in identifying booms and busts early on. Granziera and Kozicky (2012) apply a Lucas tree model to the US housing market, where the stock price denotes to the house price and the rents equivalent to dividends that stock investors get from holding stocks, in a way to explore the contribution of expectations in the evolution of house prices and rent-price ratio.

[11] According to Adalid and Detken (2007), the trend is estimated using a very smooth adjusting Hodrick-Prescott filter (λ=100000) which is estimated recursively (that is, only with data available at that time).

Interestingly, in the economic literature there are a vast number of definitions over the bubble concept. Thornton (2009) define the three basic views of bubbles believed by economists and the general public. The dominant view among the modern mainstream economists and the proponents of supply-side economics, is to reject the hypothesis of the existence of bubbles and that what is thought to be a bubble is simply the result of real factors. The second view, which is espoused by proponents of Behavioural Finance, is that bubbles occur because of psychological factors, known as "irrational exuberance". According to Shiller (2007) findings, the speculative thinking among investors (denoted as "market psychology" by the author) plays an important role in determining house prices.[12] Else, Thao (2012) find out that a strong dynamic relationship between house prices and housing market sentiment. In fact, the psychological impact of homebuyers, builders and lenders is significative in driven house prices away from fundamentals. The third view is that bubbles derive from manipulation of monetary policy and, it consists of both real and psychological changes. This last view is forward looking and enables the identification of the economic cause of bubbles which, consequently, allows policymakers to the right policy choices that would avoid bubbles in the future.

Furthermore, Levitin and Wachter (2010) argue that there are two opposite competing theories regarding the factors causing housing bubbles: "Some explanations, based on macroeconomics, posit that the bubble was caused by excessively easy monetary policy. (…) Other explanations have been demand-side explanations, meaning that the bubble was caused by excessive consumer demand for housing. (…) a supply-side phenomenon, meaning that it was caused by excessive supply of housing finance. (…) it was the result of a fundamental shift in the structure of the mortgage finance market from regulated to unregulated securitization." As Levitin and Wachter conclude, the demand-side will contribute to assemble a bubble in real estate market, but the upward rising of house prices may also arise from large supply and effortless access to credit. That is, the proponents of demand-side theories support that bubbles are caused by increases in the consumer demand for housing; contrarily, the proponents of supply-side theories argue that bubbles are justified by increases in the supply of housing finance.

In a rational expectations' framework, rational bubbles appear in the market when market participants have expectations about future price growths (Flood and Hodrick

[12] As stated by the author, "(…) times and places with high home price increases show high expectations of future home price increases, and when the rate of price increases changes, so too do expectations of future price increases, in the same direction."

(1990)). In a stock market perspective, investors are willing to invest more in stocks than is justified by the discount stream of future dividends. Further, rational bubbles follow an explosive path, which leads to asset prices to rise abruptly and to diverge from their fundamental values, consequently inducing exuberance in housing markets.

Hence, it is assumed that the settings behind rational bubbles under symmetric information are that all the agents in the market have rational expectations and they are assigned with the same information. Tirole (1982) claim that the rational expectations equilibrium (REE) occur when the participants in the market have insights about the "statistical relationship between the market price and the realized value of their trade (the "forecast function") and use the information conveyed by the price as well as their private information to choose their demands". It is commonly known that in a market bubble, the seller of the "bubble asset" is better off than the buyer – Pareto Efficiency. Further, the author concludes by saying that "(…) a rational trader will not enter a market where a bubble has already grown, since some traders have already realized their gains and left a negative-sum game to the other traders". Thus, a bubble cannot exist if the initial allocation is Pareto Efficient.

The bubble process respects explosive paths, which prompts exuberance in housing markets and prices deviate from their fundamental values. Several authors have applied integration and co-integration tests to examine whether house price bubbles exist or not. For example, Hott and Monnin (2008) estimated fundamental prices on real estate markets through two alternative models. According to their findings, prices diverge significantly and for long periods from their fundamental values. In addition, in the long-run the actual prices tend to return gradually to their fundamental values.

However, the most intriguing fact about bubbles is that usually, one cannot perceive whether the price movements are due to pure speculation or not. And, of course, the literature review underlines that the optimal monetary policy is not necessarily easy to portray. As shown in Smets (1997), the optimal response will perform differently on whether asset prices are driven by improved productivity or over-optimistic expectations.

Summing up, in the real world we never know when a bubble is over. It is more accurate to designate bubbles as speculative epidemics.[13] Although regulatory policies

[13] As stated by Shiller's article (2013), "Bubbles Forever", "(…) a new speculative bubble can appear anywhere if a new story about the economy appears, and if it has enough narrative strength to spark a new contagion of investor thinking".

may diminish bubbles afterwards, it is challenging to control bubbles because of their social-psychological nature.

3.2.1. Theoretical Representation of Rational Bubbles

From a theoretical overview of rational bubbles, Cuthbertson (2004) is surveyed. The author analyzes the deviations of market stock prices from their fundamental values when agents are homogeneous, rational and equally informed. The study of explosive behaviour in housing markets is specified by the standard asset-pricing model, considering agents are risk neutral and have rational expectations, i.e., the price of a financial asset must be equal to the present value of discounted dividends in the future. Also, investors demand a constant (real) rate of return, r, on the asset, that is, $E_t R_t = r$. Concerning the authors Campbell et al. (1999), the asset-pricing model can be written as,

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

where P_t represents the real asset price at time t, D_{t+1} is the real dividend paid to asset's owner 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. Hence, the Euler equation in (1) denotes that the price today must be equal to the discounted present value of the expected fundamentals plus the resale price of housing tomorrow.

Under rational expectations and by recursively repeating forward substitution to yield, the Euler equation in (1) can be rewritten as

$$P_t = \sum_{i=1}^{\infty} \delta^i E_t D_{t+1} = P_t^f \quad (2)$$

where P_t^f is referred to as the fundamental price of housing due to the fact it is a function merely of economic fundamentals and the discount factor; the equation (2) is assumed that the transversality condition holds, that is, $\lim_{n\to\infty}(\delta^n E_t D_{t+n}) = 0$. In the deficiency of this condition, there exist infinite forward solutions. Hence, the transversality condition is essential as it ensures an unique solution given by (2), which corresponds to the

fundamental value of the asset, P_t^f. Also, the housing price relates to its fundamental-based price, i.e., $P_t = P_t^f$, and it is driven solely by economic fundamentals.

There is another expression behind a rational bubble which is another mathematical expression for the real asset price P_t that satisfies the Euler equation in (1), namely

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

where P_t^f is the fundamental-based price of housing determined in equation (2) and B_t represents a non-fundamental, the rational bubble. This equation implies that the market price, P_t, deviates from its fundamental value, P_t^f, by B_t, the amount of the rational bubble. In principle, the bubble is given by the difference between the actual price P_t, and the fundamental price P_t^f, as follows: $B_t = P_t - P_t^f$.

Since the discount factor is positive, $\delta > 0$, the bubble term, B_t is expected to be explosive. Moreover, the emergence of such a bubble designs exuberance in the housing market, that is, buyers have positive expectations and expect to be counteracted through future price increases and so, resulting in a substantial deviation of the actual prices from their fundamental value, P_t^f. As Phillips, Wu and Yu (2011) assume in their model, the behaviour of the bubble component B_t is explosive, reflecting the behaviour of the actual price P_t.

Nonetheless, in a way for (3) to satisfy (1), constraints need to be imposed on the dynamic behaviour of the bubble term, B_t. These constraints can be determined by supposing that equation (3) is a valid solution of (1), then restricting the dynamics of B_t. Consider equation (3) at time $t+1$ and take its expectations at time t,

$$E_t P_{t+1} = E_t[\delta E_{t+1} D_{t+2} + \delta^2 E_{t+1} D_{t+3} + \cdots + B_{t+1}] = \delta E_t D_{t+2} + \delta^2 E_t D_{t+3} + \cdots + E_t B_{t+1} \quad (4)$$

The second equality results from the law of iterated expectations, that is, $E_t\left(E_{t+1} D_{t+j}\right) = \left(E_t D_{t+j}\right)$. Henceforth, both equations (1) and (4) follows that

$$\delta(E_t D_{t+1} + E_t P_{t+1}) = \delta E_t D_{t+1} + (\delta^2 E_t D_{t+2} + \delta^3 E_t D_{t+3} + \cdots + \delta E_t B_{t+1}) \quad (5)$$

By substituting the definition of P_t^f in equation (2) in the right-hand side of equation (5), I have

$$\delta[E_t D_{t+1} + E_t P_{t+1}] = P_t^f + \delta E_t B_{t+1} \quad (6)$$

Therefore, equation (1) and (6) may jointly be written as

$$P_t = P_t^f + \delta E_t B_{t+1} \quad (7)$$

and for equation (3) to be a valid solution it is indispensable to assume that $\delta E_t B_{t+1} = B_t$ or consistently that

$$E_t B_{t+1} = B_t/\delta = (1+r)B_t \quad (8)$$

Moreover, the non-fundamental term B_t must behave as a martingale, in other words, the best forecast of all expected future values of the bubble depend only on its up-to-date value. Note that the bubble solution violates the transversality condition, when $B_t \neq 0$, and because B_t is arbitrary, the solution (house price) in equation (3) is non-unique. Equation (7) highlights that the bubble component must "grow" in expectations exactly at a rate of r.

Blanchard (1979) and Blanchard and Watson (1982) describe rational bubbles that burst almost surely in finite time. According to Blanchard and Watson (1982), a bubble will persist in each period with probability π or collapse with probability $1-\pi$. The authors believe that even all the agents have the same information, a speculative bubble may exist, consequently affecting the economy. Rational bubbles are likely to start, burst and restart repeatedly. If the bubble lasts, it has to grow in expectation by a factor of $(1+r)/\pi$. It is necessary in order to achieve an expected growth rate of r, as to compensate for the risk of a crash. Note also that the bubble component may be stochastic and that bubbles can only subsist in a world in which the required return is lower than or equal to the growth rate of the economy. Besides, Diba and Grossman (1988) shows that the impossibility of negative bubbles in stock prices suggests that a rational-bubbles component that burst could not restart later. However, among others, Evans (1991),

Taylor and Peel (1998) and Hall et al. (1999)[14] examine a class of rational bubbles that are always positive and periodically collapse, i.e., the authors define this type of bubble as,

$$B_{t+1} = \begin{cases} (1+r)B_t u_{t+1} & if\ B_t \leq \alpha \\ \{\delta + \pi^{-1}(1+r)\theta_{t+1}[B_t - (1+r)^{-1}\delta]\}u_{t+1} & if\ B_t > \alpha \end{cases} \quad (9)$$

where u_t is a sequence of non-negative 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 $P[\theta_{t+1} = 0] = 1 - \pi$, and subject to $0 \leq \pi \leq 1$, $\alpha > 0$. The following condition is also crucial $0 < \delta < (1+r)\alpha$ as rational bubbles cannot be negative (i.e. $B_t < 0$). The bubble has two different rates of growth: the first tranche of the equation says, where $B_t \leq \alpha$, says that the bubble grows at mean rate $(1+r)$; secondly, when $B_t > \alpha$ the bubble grows at a faster mean rate $(1+r)/\pi$, but a downfall is expected by a probability of $1 - \pi$ each period. Once the bubble has crashed it restarts and expands from the mean value of δ.

Furthermore, and as already stated, the parameter π refers to the probability of continuation of the bubble. Lastly, in the two rational bubble models described, the bubble component must grow exogenously at an expected rate of $(1+r)$ per period and it is "exogenous" to the "fundamental models".

Unlike the most popular examples of rational bubbles, some authors like Froot and Obstfeld (1989) proposed a new rational-bubble specification, the so-called intrinsic bubbles which depends entirely on dividends. Intrinsic bubbles are driven exclusively by the exogenous fundamental determinants of asset prices rather than by extraneous ones. Froot and Obstfeld simulate an intrinsic stock-price bubble,

$$d_t = \mu + d_{t-1} + \varepsilon_t \quad (10)$$

where μ is the dividends growth rate, d_t is the log of dividends at time t, and ξ_t is a random walk with zero mean and variance σ^2, that is, $\varepsilon_t \sim N(0, \sigma^2)$ white noise. They define the function of the intrinsic bubble as $B(D_t) = cD_t^{\lambda}$, with c being an arbitrary

[14] See also West (1986) that provides examples of strictly positive bubbles that periodically collapse.

constant and λ a positive root of the following quadratic equation $\lambda^2 \frac{\sigma^2}{2} + \lambda\mu - r = 0$. Further, the basic stock-price equation is given by

$$P(D_t) = P_t^{pv} + B(D_t) = P_t^{pv} + cD_t^{\lambda} \quad (11)$$

where for $c \neq o$ the equation contains a bubble and it is driven solely by fundamentals. As expressed, $P(D_t)$ is a function of dividends only and does not depend on time or any other extraneous variable. And it is assumed that $c > 0$ so that stock prices cannot be non-positive.

Since equation (10) only display characteristic bubble behaviour during their expansion phase, some authors propose a regime switching model of dividends such as,

$$\Delta d_t = \mu_0(1 - s_t) + \mu_1 s_t + [\sigma_0(1 - s_t) + \sigma_1 s_t]\varepsilon_t \quad (12)$$

where s_t is a state variable that follows a Markov process with the transition probability associated in each different state space; that is, it is assumed that the parameters of the ADF regression are time-varying, that is, they change with an unobserved indicator $s_t \in \{0,1\}$. The dividends' growth rates, 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. In practice, a Markov-switching procedure allows for the existence of two different regimes/ states consistent with the expanding and collapsing phases of the bubble. The MS-unit root test consists of testing the null hypothesis of non-stationarity $\sigma_0 = 0$ and $\sigma_1 = 0$ against the alternative $\sigma_0 < 0 (\sigma_1 > 0)$ or $\sigma_0 > 0 (\sigma_1 < 0)$ in equation (12). Accordingly, a positive estimate σ_s ($\sigma_0 > 0$ or $\sigma_1 > 0$) statistically significant in the regime $s_t = \{0,1\}$ suggests an explosive behaviour, and a negative one indicates a stationarity behaviour.

Furthermore, the real effects of bubbles do in turn affect market fundamentals and thus have the power to modify the behaviour of prices. Considering housing as an asset composed by two inputs, land and structures. Hence, the supply curve for land shows an upward sloping and the supply for structures is inelastic in the short-run and elastic in the long-run. When the market is in the steady-state, the housing prices are equal to the present value of housing services, "rents". In addition, new housing construction equals the depreciation on the existing stock. Suppose now that the agents of the market are willing to pay more than the market fundamentals, thus resulting in the start of a

deterministic bubble. Housing prices increase, implying higher returns to housing construction, a larger housing stock in the future and thus, a decline in the present discounted value of future rents – what happens is that the bubble has the force of immediately diminishing the market fundamental value. Further, as the bubble must grow exponentially, housing prices continue to rise, causing higher housing stock and lower rents. In fact, these lower rents reflect the lower fundamental value of housing over time, which is simply an indicator of overproduction of housing in the market. The story is identical even if the bubble is stochastic rather than deterministic. And when the bubble burst, the price falls intensely because of the vast housing stock. Further, a bubble on the price of any asset will typically distress the prices of other assets.

3.3. The Role of Easy Credit as an Early Warning Indicator

Since the nineties, house prices seem not to behave homogenously. As commonly believed, house prices tend to continuously rise if the participants of the market have positive expectations about a future price growth and if they expect a positive reaction of the whole economy. Additionally, prices tend to rise when the economy is surrounded by an environment of easy access to credit, that is, house prices increase if credit conditions are better off, allowing more households to borrow money to buy their own dwelling. The Banco de Portugal (BdP) also affects house prices through interest rate and macro-prudential measures imposed. Lower interest rates, lower cost of borrowing and the reduction of borrower-based regulatory policies, such as reduction in loan-to-value or debt-to-income limits, can be effective against booms in real estate markets. And the truth is that the recent Global Financial Crisis, triggered by the collapse of house prices in the United States, draw attention to the importance the housing market in the macro-prudential policy (Hartman, (2015)).

Economists and researchers denote that the financial accelerator[15] mechanism offers an explanation to the housing market fluctuations in that endogenous developments in credit markets work to strengthen and propagate shocks to the macroeconomic sector. Firstly, it is notable that the amount of credit needed to finance house purchase increases with a boom in housing prices. Consequently, higher property valuations are expected which creates an upward pressure in the demand for credit provided. Secondly,

[15] The term was conceived in Bernanke and Gertler (1999).

considering most housing loans are secured by the property itself, an increase in housing prices leads to greater net-worth for the housing sector as the value of housing capital raises jointly with house prices. At the same time, higher value of the collateral is connected to reduction of defaults on existing loans and it motivates the banks to expand their lending standards for households. Hence, swings in household borrowing are expected to affect housing prices as reinforced by Anundsen and Jansen (2013) in their findings. Throughout a structural vector equilibrium correction model (SVECM) over the period 1986-2008 in Norway, the authors find that an increase in housing prices lead to a credit expansion and, therefore, an upward pressure on prices is observed, showing there indeed is a financial accelerator in the real estate market. Interest rates influence housing prices in an indirect way through the credit channel.

The banking sector is highly wide-open to the housing market as real estate is commonly used as a collateral for loans, so changes in housing prices directly affect households' debt and their ability to repay loans. Arguably, the banking system plays an important role in the real estate market – an increase in the price of real estate consequently increase the supply of credit, which in turn, lead to further increases in the price of real estate. Or else, the banking system may have an important role in exacerbating the collapse of real estate prices. The decrease in housing prices directly will decrease bank capital as the value of the bank's own real estate assets will automatically suffer a reduction. Likewise, the cutback of the value of the collateralized loans may lead to defaults, which implies the devaluation of banking capital. In principle, the burst of a housing bubble often leads to a banking crisis. The linkage between the real estate market and bank behaviour can be used to analyse recent examples of real estate boom and bust cycles allied to banking crises in Japan[16] and other countries affected by the Asian Financial crisis. The risk shifting problem resultant from the incapability of lenders to notice how risky the investments of the borrowers are, is in fact in the origin of banking crisis (see Allen and Gale (2000)). In principle, real estate markets and systematic risks are closely associated.[17] The Great Recession is a case in this point. Also, the recent debt crisis in Greece have affected the world's most important economies.

[16] As stated by Vollmer and Bebenroth (2012), "swings in asset prices are due to monetary policy changes and that bank failures stem mainly from a less accommodative monetary policy, resulting in a collapse of the housing market and of the securitization market." and "(…) the third strand accuses the decrease in asset prices of bursting an asset bubble, i.e., to the sudden reversal of a speculative price increase."

[17] A systematic risk, also known as "market risk" relates to shifts in economic sectors that can affect the entire market and cannot be mitigated through diversification.

There is an extensive economic literature when assessing credit growth and real estate markets. Kiyotaki and Moore (1995) and Bernanke and Gertler (1986) developed models with the objective of understanding the dynamics between credit limits and asset prices. The authors conclude that changes in the borrowers' net-worth, through the credit market, provokes notable shocks in the real economy. Duca el al. (2011) analysed the role of credit through data on mortgage lending standards to model the demand for housing in US. The findings indicate that credit standards played a major role in driving the worldwide financial crisis. The authors Agnello and Schuknecht (2009) and Rousová and Van den Noord (2011) claim that credit growth and interest rates are among the most important predictors of boom and bust cycles in real estate markets, and further unemployment is suitable when predicting peaks and troughs. Lyons (2018) examines the housing price ratio in Ireland and conclude that credit conditions are central in determining equilibrium in the real estate market. There is a robust evidence of a change in the housing market regime in 2010 and again in 2014-15.

Several authors have related easy credit and subprime lending with the US housing bubble. Khandani et al. (2009) argue that when the three trends in the US housing market – rising home prices, declining interest rates, and near-frictionless refinancing opportunities- occur simultaneously, they hugely increase systematic risk in the financial system. Hence, these trends steer to increases in leverage during the market boom and swiftly rising defaults in bad times. Likewise, Favilukis et al. (2017) propose that housing booms can be explained by a relaxation of credit constraints and a cutback on housing transaction costs. Lastly, Mayer and Pence (2008) document that subprime loans tend to appear in over-valuated markets, that is, markets where the price-rent ratio is extremely high, and not just in markets with extraordinary house prices. Further, they show that fast-growing markets with substantial construction contributes to the subprime origination and house prices rise. Similarly, Mayer and Sinai (2009) examine the house price-rent ratio within US metropolitan areas and the empirical results show that higher price-rent ratios tend to appear in housing markets with a growing subprime lending. In principle, when housing is highly leveraged, it generates risks to both homeowners and their lenders. Asset price bubbles that are fuelled by credit booms, increase the vulnerability of the financial sector and the real economy (Jordà, Schularick and Taylor (2015)). Contrarily, Glaeser et al. (2012) find out that easy credit, such low real interest rates, high loan-to-value levels and lenient mortgage approvals, was not a sturdy explanatory feature of the great US housing market fluctuations. Of course, this

controversial theme is tough to prove and although not conclusive, the historical data seem to suggest that house prices rise because buyers entrust on unsustainable lending to buy a home, which contributes to the housing bubbles.

Based on numerous studies that have been developed over the years, my own opinion is that the rapid growth in real estate prices is boosted by the relaxation of lending criteria and by banks that had eased housing loan criteria. A good historical event was the boom in the American housing market that occurred mainly because of the lower lending standards, where most of the borrowers were younger and lower-credit-quality homeowners with weak financial capabilities and a higher repayment risk associated. The excessive lending in the US mortgage market started in earnest in the 1990s. Further, in 2006, there was even further easing of mortgage lending standards as well as a low interest rate policy imposed by the Federal Reserve. This boom period was characterized by a sharply increase in the overall debt-to-income levels for many US households (see Ligon (2013)).[18]

Lastly, it is evident that due to the strong relationship between housing markets and the financial and economic sectors of an economy, the detection of bubbles and the forecast of future house price fluctuations turn out a crucial point to be analysed – in fact, most of the worldwide financial crises could have been predicted using valuable real estate data. Furthermore, monetary policy must be considered to restrict private households' credit and asset price booms, in a way to prevent a credit crunch as happened in the Spanish market. In a research driven by Akin et al. (2014), the authors end up saying that the credit bubble in Spain was mainly due to the soft lending conditions and excessive risk-taking in the boom. This is a one more historical example that reinforces the idea that micro-prudential and macro-prudential policies are crucial to identify credit supply booms, preventing banks with corporate governance problems to moderate even more the lending standards.

[18] See Chambers et al. (2008) to better understand housing markets, mortgage decisions, and their linkage to the economy.

3.4. Macro-Prudential Regulatory Instruments Against Real Estate Bubbles

Since the Global Financial crisis in 2008-09, economists and policymakers start to prioritize the need to build financial resilience, contain credit growth and restrain house price increases, in both advanced and emerging economies. As already discussed, the ease of credit conditions inevitably pressures demand to go up continuously and implies housing prices to increase in both nominal and real terms. Nevertheless, policymakers must consider there are enough banking supervision and macro-prudential mechanisms to avoid non-performing loans (NPL).

The prime purposes of macro-prudential policies can be summarized as follows: to protect the financial sector from being over leveraged, preventing banks to suffer heavy losses during downturn periods; and to control financial imbalances and reduce the risk of large correction in house prices, thereby reducing the risk of asset price bubbles associated with credit booms (see Crowe et al. (2013); Mcdonald (2015)). In principle, such tools aimed to protect borrowers, strengthen banking system and slow down house price increases (for example, in the Norwegian and Swedish markets, macro-prudential policies were implemented especially with the purpose to tame the house price boom).

Several case studies show evidence that borrower-side channels, supported by lender-based channels, helped to build financial resilience and improve financial stability, limiting the share of riskier mortgages and house price increases, in countries with a still-accommodative monetary policy. In Europe, in response to the recent reacceleration in house prices, some countries have stepped up the implementation of macro-prudential policies (MaPPs). At the same time, the recent years' crisis experiences made evident that the macro-prudential aspects of financial supervision and regulation have been significantly strengthened.[19] Hence, in the beginning of 2011, the European Union agreed to establish the European Systemic Risk Board (ESRB), which the main purpose is to identify and assess emerging systemic risks, while making policy recommendations on how to contain them.

[19] See Hartman (2015), who after the Global Financial Crisis has pointed out the importance of housing market in macro-prudential policy.

By reviewing the literature, some studies have documented evidence of MaPP being effective in addressing systemic risks in the financial sector. For example, Elul et al. (2010) find that negative equity and illiquidity, as measured by high credit-card utilization, are closely associated with mortgage defaults. The effect of illiquidity on default intensifies with high combined loan-to-value ratios (CLTV).[20] Further, asking for a second mortgage implies a higher default risk, mainly for those borrowers who have a first-mortgage LTV (loan-to-value) approaching 100 percent. Lim et al. (2011) used cross-country regressions over 49 countries and conclude that MaPP seems to be effective in limiting the pro-cyclicality of credit and leverage growth. Instruments such caps on the LTV and DTI (debt-to-income), ceilings on credit growth, reserve requirements, and dynamic provisioning rules, are effective in mitigating the pro-cyclicality of credit. In related research, Calza et al. (2009) propose that countries with more flexible mortgage rates and high loan-to-value ratios[21], residential investment and house prices are more propitious to policy shocks. Crowe et al. (2011) argue macro-prudential measures appear to be the most effective in taming real estate prices and leverage. Also, the authors claim that mechanisms aimed at strengthening banks with an extra buffer of provision (such dynamic provisioning) may help to cope with busts, even when such tools fail to stop a boom. Vandenbussche, Vogel, and Detragiache (2012) explore for 16 countries in Central, Eastern and South-eastern Europe whether prudential instruments had an impact on housing price inflation or not. Their evidence suggests that capital ratio requirements and non-standard liquidity are efficient in slowing down housing price inflation. Claessens and Mihet (2013), using a panel data regression of 2800 banks in 48 countries over 2000-2010, find out that MaPPs such debt-to-income caps, loan-to-value ratios, and limits on credit growth foreign currency lending are the most effective in reducing financial cycles. Else, MaPPs are important regulatory instruments to mitigate overall systematic risk. Dell' Ariccia et al. (2012) prove that macro-prudential tools are effective in containing booms and in limiting the consequences of busts. Such tools reduce the occurrence of credit booms, episodes that coincide with periods of general overheating in the economy and which implies monetary policy to act first and foremost. These findings are in line with those in Lim et al. (2011), who reinforce the idea that macro-prudential

[20] The authors Elul et al. (2010) used a credit bureau data which permits to quantity total housing debt and then, the borrower's combined loan-to-value ratio (CLTV). They predict the current CLTV by "(…) dividing the sum of first and second mortgage balances (from the Lender Processing Services (LPS) and bureau data, respectively) by an estimate of the current house price".

[21] The loan-to-value (LTV) ratio is a ratio between the mortgage amount and the value of the property.

policies can mitigate the risk of a bust while simultaneously reducing the vulnerability of the rest of the economy to distresses in the financial system.

Besides cross-country analysis, some case studies focus on specific risks and markets/ economies. For example, the authors Jiménez et al. (2017) find that countercyclical macro-prudential policies, especially dynamic provisioning, smooth credit supply cycles. Moreover, dynamic provisioning is effective in assisting firm credit availability and performance during recessions. Igan and Kang (2011) analyses the Korean experience with macro-prudential measures and suggest that tighter limits on loan criteria, mainly on loan-to-value and debt-to-income, curb expectations and speculative incentives. That is, households were more likely to have reduced house price expectations and postponed house purchases in Korea after the introduction of macro-prudential limits on LTV and LTI ratios. Similarly, Jung and Lee (2017) suggest that, mainly, caps on debt-to-income ratios can be useful in shortening excessive household debt and subsequent house price bubbles. Kelly and O'Toole (2018), through an analysis of mortgage loans for the UK buy-to-let market[22], identify the existence of a "double trigger" interaction effect: loans with high originating loan-to-value (OLTV) and low originating debt service ratio (ODSR)[23] have the highest default rates, that is, borrowers with loose credit benchmarks are the most likely to be involved in ex-post default.

Limiting LTV and DTI ratios will rein in the purchase power of individual households, thus reducing the pressure on real estate prices. More precisely, a limit on LTV will attenuate the risk of a severe overhang. In addition, it will reduce the pool of households who resort to credit, hence reducing demand pressures in housing market and consequently contain the boom. These measures are mainly intended to restrict the extent of pro-cyclicality in the housing market and reduce injuries to the economy in the event of financial shocks. Moreover, Lament and Stein (1997) and Almeida et al. (2006) find evidence that countries where loan-to-value ratios are higher, and homeowners are more leveraged, house prices tend to be more sensitive to income shocks. Likewise, Kelly et al. (2018) claim that macro-prudential restrictions on loan-to-value (LTV), loan-to-income (LTI) and debt-service (DSR) ratios would have had significant impacts on credit

[22] Buy-to-Let (BTL) mortgages are for households who want to buy a property to rent it out. Such mortgages are defined as a mortgage secured against residential property but will instead be occupied based on a rental agreement.

[23] Debt-to-service ratio measures the amount of money required to repay debts/ loans over a period. Kelly et al. (2018) argue that "A one percentage point increase in originating DSR is reflected 1.5 times in the probability of a default transition." Also, the authors define the originating LTV ratio as "(…) a proxy for borrower wealth through the ability to provide greater down-payments (…)".

availability and house prices in Ireland from 2003 up to 2010 period.[24] According to the authors, MaPPs determine house price changes in two ways: "firstly through the direct impact of instantaneously lower credit volumes; secondly through the collateral channel, by scaling down the down-payment available to borrowers via weakened housing equity". In fact, the levels at which such limits are set are remarkably in determining the impact on house prices. Further, the timing of the introduction of a macro-prudential regime impacts house prices. In this regard, the ESRB of 2019 announces that the Banco de Portugal set an LTV limit of 90% for borrowers who buy a property for own use and permanent residence, 80% for those purchasing property for other purposes and 100% for those buying property held by the credit institutions themselves and for property leasing agreements. The maximum debt service-to-income (DSTI) limits is set considering a matrix of limits for different levels of income and interest rate, that is, it is associated with all of the borrower's loans (the sum of mortgages and consumer loans).[25] Banco de Portugal also specifies a maturity limit of 40 years for mortgage loans and of ten years for new consumer credit agreements.

The economic literature show evidence of three different viewpoints. The first view is the "Modified Jackson-Hole Consensus" which relates that the instruments and transmission mechanisms of monetary and macro-prudential policy can be separated, i.e., monetary authority should keep its mandate on price stability, whereas macro-prudential authorities should pursue financial stability.[26]

The second one is known as "Leaning against the wind vindicated", which defends that Central Bank's policy rate may be used jointly with macro-prudential policy when it comes to preventing financial imbalances such as credit, liquidity and risk-taking. At an early stage in the market dynamics, Central Banks are on the side of caution by driving a conduct that avoids feeding the bubble with an overly accommodative policy. In this way, financial institutions should let asset price bubbles to burst naturally, rather than acting to contain them.

[24] The Central Bank of Ireland proposed, in February 2015, macro-prudential measures for the Irish mortgage market, limiting new lending at high loan-to-value and loan-to-income ratios. For a deep understanding of the Irish regulations, see Cassidy and Hallissey (2016).
[25] See Dietsch and Welter-Nicol (2014) to better understand the effectiveness of macro-prudential tools such as loan-to-value and debt service-to-income caps to contribute to financial stability. The combination of both help to maintain the portfolio credit risk at feasible levels.
[26] See Gelain and Ilbas (2014) who defend the idea of keeping macro-prudential policy framework away from monetary policy decision.

Lastly, the third view is the "Financial Stability is Price Stability" and it goes even further. For proponents who support this viewpoint, it is not appropriate to separate monetary policy and macro-prudential policy (see Smets (2014) and Crowe et al. (2013)).[27]

The point that we wish to propose regarding financial and price stability is that the synchronisation of monetary policy and financial stability is crucial. Central Banks should consider monetary policy may have consequences for financial stability, rather than putting the two policies away and pretending the financial intermediators have no influence over it. The two domains need to be reinforced to increase resilience on the financial sector and reduce its pro-cyclicality. In fact, if both policies were aligned it will lead to a better outcome in terms of price and financial stability. Bernanke and Gertler (2000) find out, Central Banks should look at price stability and financial stability as highly complementary and both must be pursued within a merged policy framework. Monetary policy is not itself an enough tool to hold all the potential damaging effects of boom-bust cycles in asset prices. In fact, the European Central Bank's monetary policy combines some elements of the leaning against the wind approach within a broader stability-oriented framework (ECB (2010)).

Conclusively, there is an evidence that housing markets are affected by macroeconomic, prudential, and structural policies and the impact of such policies can be outsized and should be an issue in policy decisions. Firstly, the monetary policy affects short-term interest rates, which throughout their effect on longer-term rates and inflationary expectations will immensely impacts house price developments. Hence, the demand side of the real estate market is drastically affected and the supply side through the costs of borrowing. Along with, fiscal policy affects housing prices and their fundamentals due to taxes and subsidies. The tax deductibility and income taxation clearly impact households' disposable income. The subsidies assume an impact on the relative cost of renting versus owning a dwelling, together with the building activity (supply side). Next, supervisory and prudential policies have their impact on house prices predominantly through the cost and ease of financing house purchases. Mostly, these policies include capital requirements for lenders and loan limits on the borrower-side, and the legal context for the use of collateral. In addition, structural policies (such as, labour

[27] As Crowe el al. (2013) wrote "(...) monetary policy has to play a complimentary role and may have to be used to lean against the wind." See also, for example, Crowe el at. (2011).

market, competition, land and zoning policies), affect construction costs and thus the supply side of housing.

4. Analytical Framework and Discussion of Results

4.1. Data Description

Alongside with the economic literature, there are numerous of commonly used indicators and ratios which are suitable in understanding the real estate dynamics. As stated by the authors Girouard et al. (2006), Lind (2009) and Sjöling (2012), there is not a general rule for the list of indicators that predict future changes in property values. In principle, providing a proof for the split-up of prices from their fundamental values is not a simple task to do as there are no mutual arguments regarding the factors which truly establish the fundamental price in real estate markets. Else, the pricing process in real estate markets is a more complex process, where future expectations combined with real economic variables customize the final market price.

The foremost purpose of this section is to provide a preliminary analysis of the macroeconomic variables we found most relevant to characterize and understand the different evolution of housing market dynamics in the Portuguese marketplace, explicitly the nominal house price (NHP) index, as well as gross domestic product (GDP) and price-to-income ratio (PIR). The choice of such variables was because they came to be the most meaningful ones after a macroeconomic analysis, using the MatLab tool.[28] For that reason, seems plausible and interesting the study of the causes behind this atypical evolution of the variables.

Over recent years, housing prices have sharply risen to exceptional levels, but the disparities are more sizeable in a cross-country analysis. Hilbers et al. (2008) classified the European countries into three wide-ranging groups based on the real house prices appreciation. Countries, such as Spain, Ireland, United Kingdom and Belgium, were designated as the "fast lane" countries as their real house prices during 2005-07 more than double since 1988. The Nordic countries are within the "average performers" group and

[28] See Figure A.2.1. (Appendices) which plots the correlation between real house prices and fundamental economic variables selected from the OECD database.

it consists of countries with a considerable upturn in real house prices since the mid-1980s. Portugal is in the so-called "slow movers" group, where real house prices persisted mostly flat or even declined over the past decades.

Throughout the cross-country analysis, Spain and Ireland emerged to be interesting countries for a deep study and understanding. The real estate markets in these economies experienced one of the largest discrepancies in nominal and real house prices over time, and the latest boom has taken place over a relatively long period. Economic literature shows that Spain and Ireland suffered a robust period of economic growth from the mid-1990s to 2007.

Portugal and Spain joined the European Union in the 80s and since then, the housing market did not behave homogeneously, mainly afterwards the adoption of the single currency in 1999 and the boom of the financial crisis. At that time, house prices suffered an annual growth higher in the Spanish market than in the Portuguese one. Both economies recorded a remarkable increase in bank lending for housing purchase, similarly within a context of sustained growth in households' disposable income and low interest rates, and a substantial inflow of immigration, particularly in the Spanish case. When analysing real estate markets, Spain is in fact a very good case study to investigate as this country, known as a bank dominated economy, suffered periods of considerable upward and downward shifts in housing and credit markets that lasted during several years even after the worldwide economic recession in 2007-08. Although, besides the relevance and desirability of such economies, our econometric analysis will only emphasis the Portuguese market, which is the core country of this empirical study.

The main objective is to provide time series containing information on the long-term trend of nominal house prices, gross domestic product and price-to-income ratio to a further analysis of the macroeconomic developments and risks. To better compare and analyse the selected data, all the time series have been normalized to 100 index point for the year 1988. The dataset is seasonally adjusted with a quarterly frequency and from the OECD analytical database.

Furthermore, due to the non-homogeneous evolution of the real house price index (as depicted in Figure 4.1.), it is possible to divide the time range into three distinctive groups: Subperiod I, which represents the beginning of the data sample until 1996; Subperiod II, from 1996 to 2007; and lastly, Subperiod III from 2007 to the end of the sample (last quarter of 2018). Such an analysis allows to understand whether there were

in fact periods of an exuberant behaviour, which could mean the presence of a bubble in the housing market.

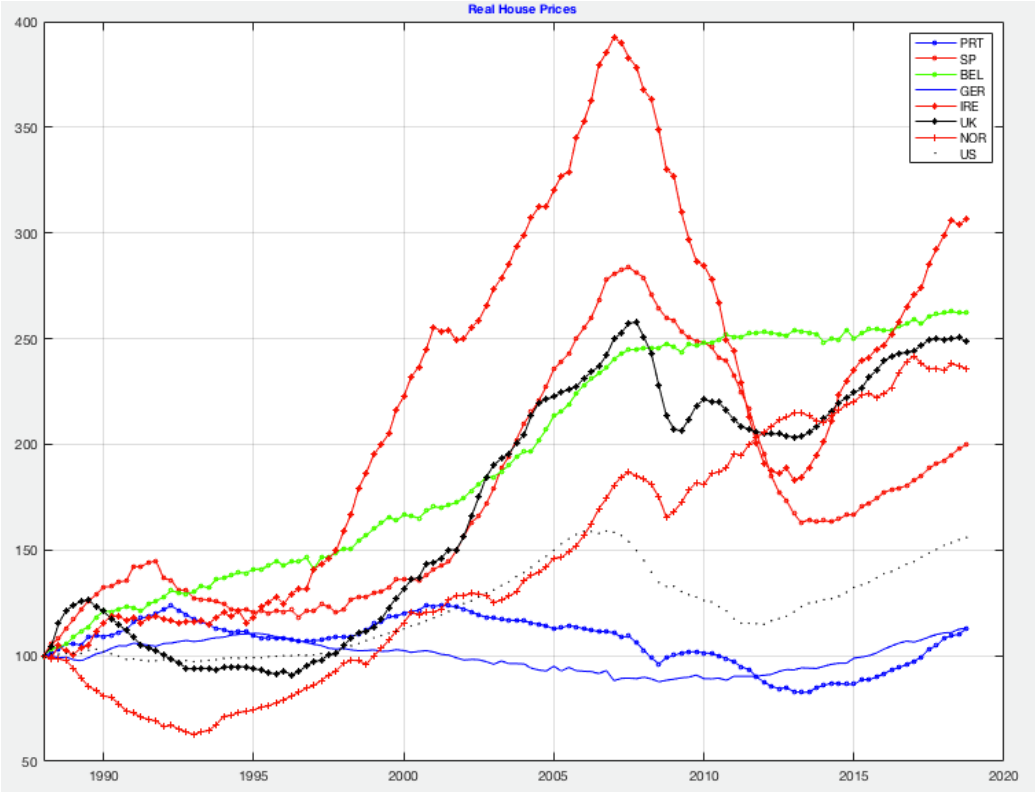

Figure 4.1. The Evolution of Real House Prices in OECD Countries (1988=100)

Subperiod I is represented by a steadiness in real house prices, with rare disruptive periods of growth, which may be linked with the "Baby Boom Generation" in real estate markets at late 1980s. Subperiod II is characterised by a deviation of house prices from the long-term averages, which may indicate the existence of overvaluation of house prices and the formation of speculative bubbles, especially in the Spanish case. The major disparity between the two economies was mainly from the late nineties onwards, a period in which residential investment increased suddenly in Spain in the context of low interest rates and significant immigration. Additionally, Ireland is the country where the boom and bust was particularly large. This abnormal behaviour was the cause of their massive banking crisis. Lastly, Subperiod III is symbolized by the sudden fall in the nominal house price, which is related with the global economic downturn that began in 2007 and most influenced the real estate environment in almost every European country. In fact, the Great Recession was due to a combination of rising house prices and easy credit without

adequate risk management that led to a proliferation of subprime mortgages. Later 2008, Ireland was the country where this downward movement was most marked: The Irish real estate market suffered a sharply decrease during Subperiod III. Nowadays, Ireland's housing market is stabilising after the decade-long house price boom (one of the longest and biggest in Europe), house price and rent inflation are decelerating since supply is catching up demand. Also, Central Banks had to restrict the loan-to-income limit, chocking off inflation. According to the results supported by the data gathered from the OECD database, the Portuguese real estate market is not in a tricky scenario regarding the unexpected increase in real house prices during the past years. As plotted in Figure 4.1., Portugal is the country with the lowest real house prices. And, surprisingly, it is the country with a non-abnormal evolution concerning housing prices.

Although, even now nominal house prices are well above their historical levels, except in Portugal (Figure 4.2.). Thereby, not unexpectedly, the countries that have been prone to the sharpest fluctuations in nominal house prices are those that historically have experienced the largest boom in housing prices.

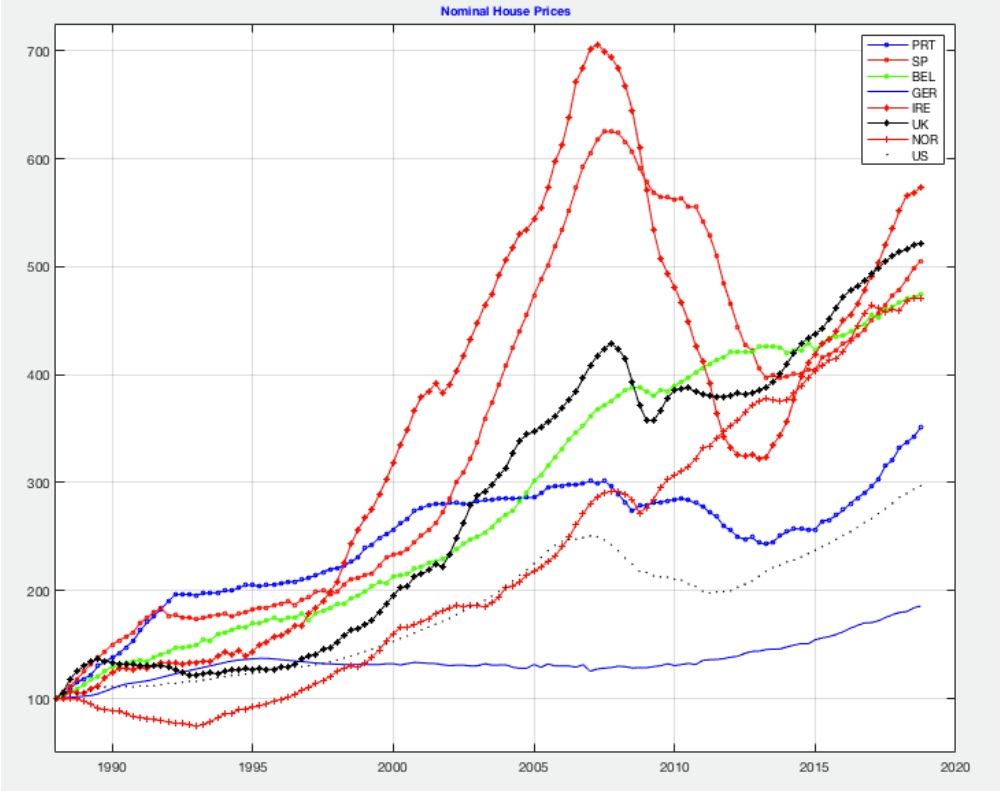

Figure 4.2. The Evolution of Nominal House Prices in OECD Countries (1988=100)

From 2011 to 2014, the Portuguese real estate market was marked by an abrupt fall in house prices and it began to recover after that time. Portugal's house prices are now much higher than the downward peak in 2009-10. Furthermore, it is clear the behaviour of the Portuguese economy as a "slow mover", as this country appear with the lowest level of nominal house prices. In fact, this is a surprise for those who argue that the Portuguese real estate market is suffering a boom-bust cycle. But the truth is that it is not. The Portuguese property is very inexpensive and in an astonishing good value from a foreign perspective. As presented by Lourenço and Rodrigues (2017), besides the enormous increase in house prices in Portugal, they are still below pre-crisis levels. In the last few years, demand increased because of the improvement of economic conditions, and fewer dwellings were being built leading supply to stay low. Basically, what is happening is that house prices in Portugal continuously rise as more households compete for fewer homes.

Nevertheless, despite not having considered the following variables in the econometric analysis, they are also relevant when assessing the evolution of real estate markets. For example, the consumer confidence is a key indicator that is helpful in drawing some conclusions in terms of the housing market. As commonly believed, consumer confidence and, therefore, consumer behaviour is affected by economic, political and social events. A positive feeling of confidence about the future may lead households to spend more money on real estate and invest. Hence, the main idea behind the usage of this variable is that the more likely households feel about the stability of their incomes, the more likely they are to major purchases and investments, hence indicating general trust in households' personal economic situation. During Subperiod II, households' confidence appears to be clearly higher to that verified in Portugal, probably reflecting a distress in the Portuguese economy (see Figure 4.3.).

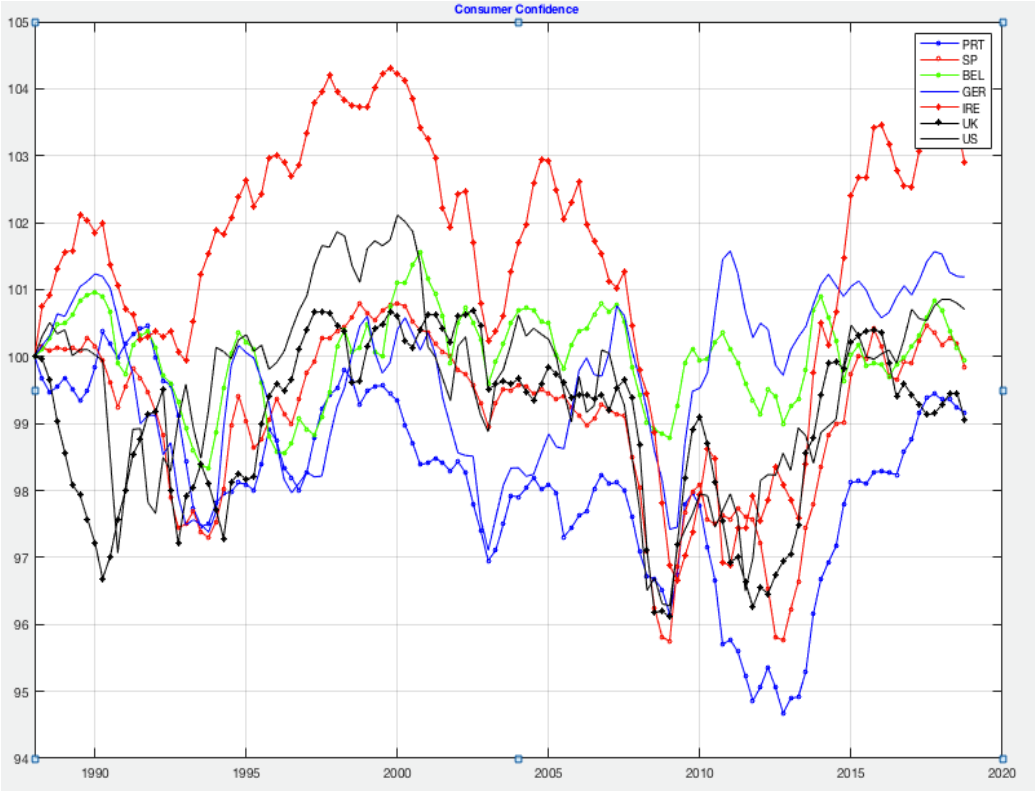

Figure 4.3. Consumer Confidence Evolution in OECD Countries (1988=100)

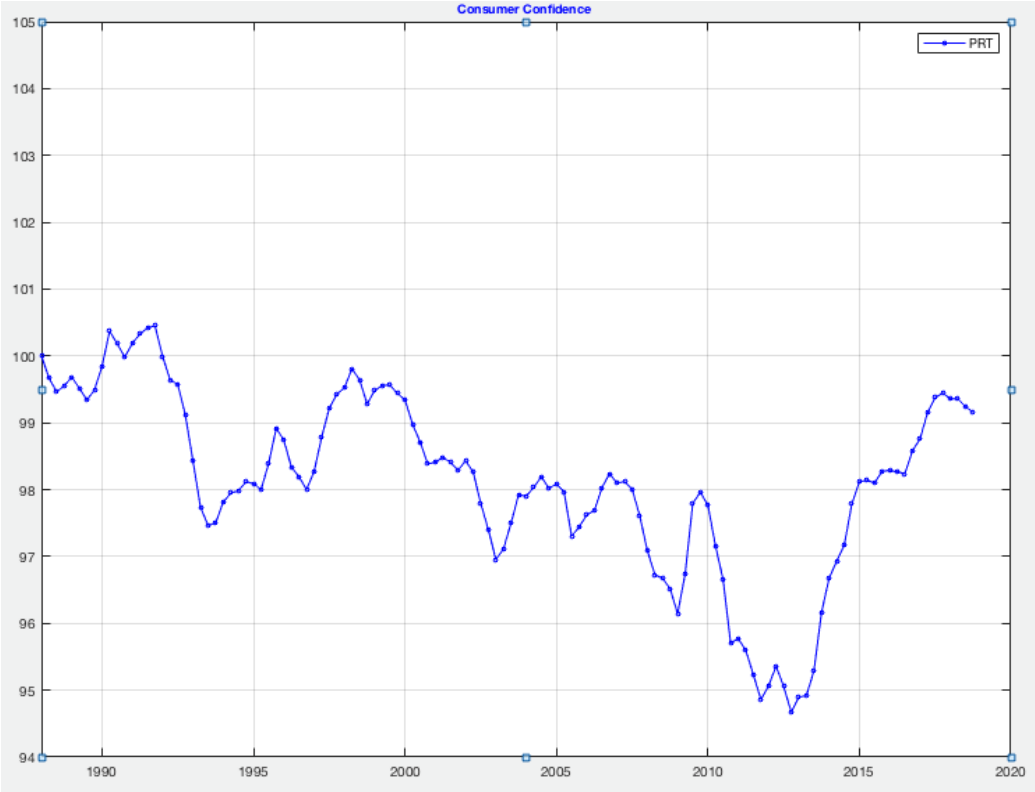

Figure 4.4. Consumer Confidence Evolution in Portugal

Consumer confidence suffered a greatest drop in the start of the subprime mortgage crisis in 2007 and the subsequent international impact on the real economy. From 2012 on, households' optimism has incredibly improved to reach progressive levels that had not been perceived since the end of 1999. In Portugal, the index has been on a moderate steady ascent since 2014 and from then on, immediate-spending intentions boosted. In reviewing the literature, Dees and Soares (2013) conclude that consumer confidence index can be a good predictor of household consumption. Also, confidence indicators can have an increasing predictive power in events of major changes in such indicator.

The unemployment rate is another important variable that may explain the real estate dynamics. It affects the size of the housing market as it operates as a financial constraint. As Gan and Zhang (2013) conclude in their research, high unemployment rates negatively influence housing market outcomes. From the demand side, when the unemployment rate increases, people will no longer be capable to afford their mortgage payments and it reduces the number of buyers from entering the housing market as they cannot get a mortgage. Consequently, demand goes down and the equilibrium price and transaction volume suffer an astonishing fall. From the supply side, as the unemployment rate increases, people will lower their expectations of job security and financial stability, which results in a decrease of sellers in the market. In fact, high unemployment rates weaken the homeowners' tendency to change houses. Over the years, financial and real estate crises had a remarkable effect on the economy, leading to high rates of unemployment among the population.

The evolution of unemployment in these countries seem very peculiar. Even before the crisis, while exhibiting a positive socio-economic environment, Spain has continuously maintained high unemployment rates. Also, Portugal has always reported abnormal unemployment rates. One of the reasons is because Portugal and Spain have a high rate of temporary contracts (fixed-term), which in fact lower the security of keeping the job. The gap between concluding the educational path and integrating the job market can also justify the high rates. During Subperiod II where unemployment is rising, fewer people were able to afford a house. This fear of unemployment led to discourage people from entering the real estate market, forcing housing prices to slow down.

Yet, consumer confidence and unemployment rate appear to be not statistically significant and for that reason, they have not been included in the estimation of the final

model. For rent prices and price-to-rent ratio the same statistical insignificance is verified, then such variables were also excluded for the final model.

Therefore, for the estimation of the final model, the nominal house price (NHP) index is defined as the dependent (resultant) variable, and the gross domestic price (GDP) index and the price-to-income ratio (PIR) are defined as the independent variables of the model. The time series data consists of quarterly observations from 1988-Q1 to 2018-Q4.[29] Figure 4.5. plots the time series during the chosen period of analysis.

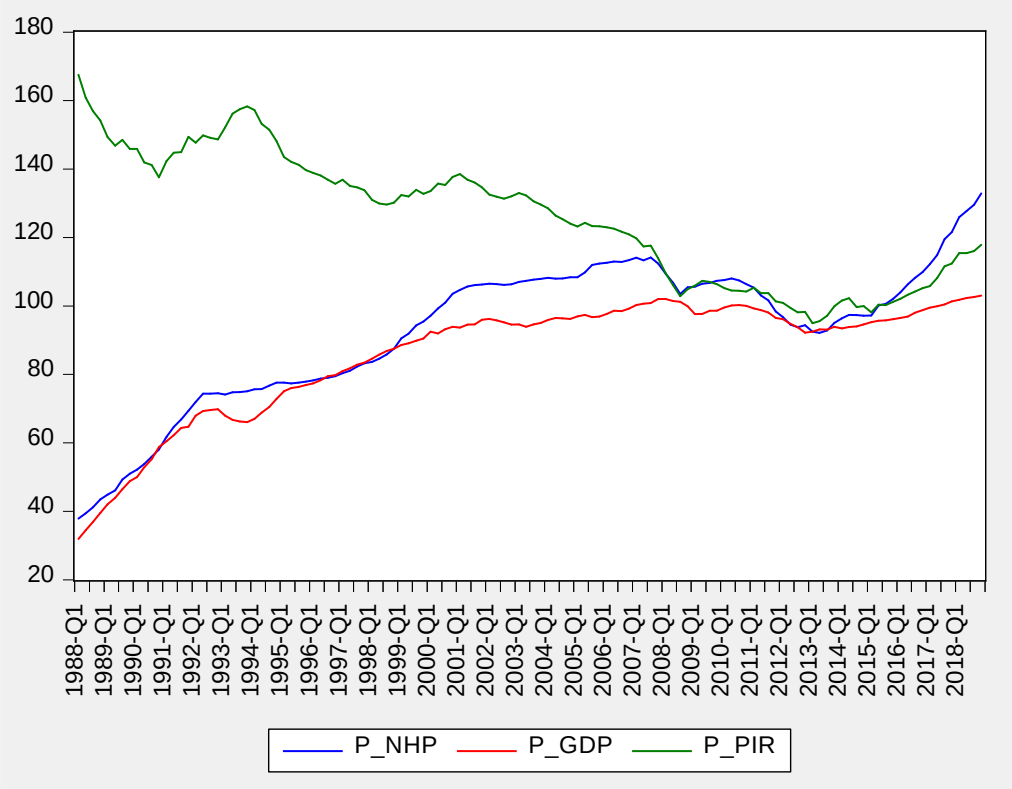

Figure 4.5. The Evolution of the Time Series of the Final Multiple Regression Model (Portugal)

As observed in the figure above, nominal house prices and gross domestic product have a parallel evolution. In fact, the economic activity is inseparable from the real estate sector and, of course, changes in the GDP of each country explain the variations on the profitability of real estate assets. Since mid-1990s, Portugal had a robust growth in GDP.

[29] The results were obtained through the EView 10 software.

But this growth has not been steady, and it was essentially explained by the unrestrained expansion of the building sector.

During Subperiod I, both nominal house prices and gross domestic product increased as price-to-income ratio decreased. In fact, as house prices fall relative to income, it is expected more people to be able to afford a house. Therefore, there would be an excessive demand and housing prices tend to rise. During the Global Financial Crisis in 2007-08, there was a severe reduction in the residential investment, which may represent the less evolution of GDP. From Subperiod II onwards, the evolution of the GDP has been steady, growing continuously. The increase in nominal house prices may be justified by the parallel increase in the price-to-income ratio, which may suggest the existence of overvaluation of house prices. Also, an increase in nominal house prices and in the price-to-income ratio may be accompanied by an increase in the annual household's income, which may indicate that households are more propitious to consume and invest in real estate.

In fact, when the recovery began, nominal house prices have risen and are now back at pre-crisis levels. Portugal and other worldwide economies went through a drastic situation. Real estate markets evolved until 2007-08, then entered an abysmal financial crisis and in 2014 there started a significant recovery. Hence, all these phenomena had a clear influence on nominal house prices that decreased and increased substantially within the sub-periods already mentioned. Nowadays, the housing prices will remain high in the Portuguese market. The favourable economic environment boosted households' disposable income and consumer confidence. The improvement of financial conditions driven by ECB's monetary policy also is considered a support for the housing demand recovery. Further, the good performance of the tourism sector in Portugal is a key factor for the real estate sector's recovery. The previsions indicate that foreign property ownership in Portugal will continue unlimited with low transaction costs, stimulating GDP to increase. Economic conditions will remain favourable and demand will continue to surge. Surprisingly, the idea of a housing bubble is left behind. It should be interpreted as a typical price adjustment rather than a deviation from their fundamentals.

4.2. Comparative Analysis of the Evolution of Price-to-Rent and Price-to-Income Ratios

Housing market conditions could be assessed and analysed through more formal measures such as the price-to-rent and price-to-income ratios. Within the extensive literature about the evolution of valuation ratios, André et al. (2014) analyse the price-to-income and price-to-rent ratios in a sample of 16 OECD countries over a 40-year period, concluding that both ratios are highly persistent with an upward trending. Besides the increase in prices slowed down, rents increased only slightly. The empirical results show that the integration order of the price-to-income and price-to-rent ratios is above one for most countries, suggesting that shocks are amplified. Further, if the great amplitude of these ratios has adverse social and economic consequences, policy intervention may be warranted. Gelain and Lansing (2014), throughout an empirical framework from 1960 to 2011, investigated the behaviour of the equilibrium price-rent ratio in US housing market and the influence of agents' expectations on the performance of house prices. According to their findings, rational agents tend to expect higher returns when prices are higher relative to their macroeconomic fundamentals. Further, Poterba (1984) argued that the cost of owning a house (its price) and the return on renting it out is captured by the price-to-rent ratio.[30] Price-to-rent ratio captures the long-term relation between the property prices in the real estate market and annual rent to proxy the earnings yield on owner-occupied housing, much like a price-earnings ratio in a stock market (Leamer (2002)) – it indicates the return on an investment in a house and whether housing markets are fairly-valued or in a bubble. Intuitively, when price-to-rent ratio is too high, house prices are very high compared to rents, and potential buyers will prefer to rent rather than buy a home, which implies demand for houses to fall as well as house prices, Girouard et al. (2006). Consequently, the price of houses is back in line with rents. The reasoning is the opposite when the price-to-rent ratio is low and in this case will be better to buy a house than to rent it. Gallin (2004) claim that the low level of the price-to-rent ratio in 2005 can be considered as sign of a bubble in the housing market. The author also states that the rent-price ratio is a good valuation indicator in the housing market. Moreover, a continuous upward price-to-rent ratio in the long-run reveals that prices are being

[30] "(...) evidence that the share of the population that owns a home is responsive to the relative prices of rental and owner-occupied accommodation."

supported by unrealistic expectations of future price gains rather than by the fundamental rental price. In this sense, there may be conditions in which there is a speculative bubble.

By analysing the evolution of the price-to-rent ratio it is evident that the ratio decreases and increases abruptly during long periods, mainly in Spain and Ireland, which indicates an abnormal scenario indeed (Figure 4.6.). It exposes that, over the past years, these countries were among the ones with the greatest risk of a housing bubble. Notwithstanding, Portugal is a country that does not belong to the list of the OECD countries with the highest risk for a housing bubble. This evidence supports the arguments presented and developed during the empirical study, that Portugal is not facing a crisis in the real estate market and, therefore, the hypothesis of a boom and bust in housing prices is rejected.

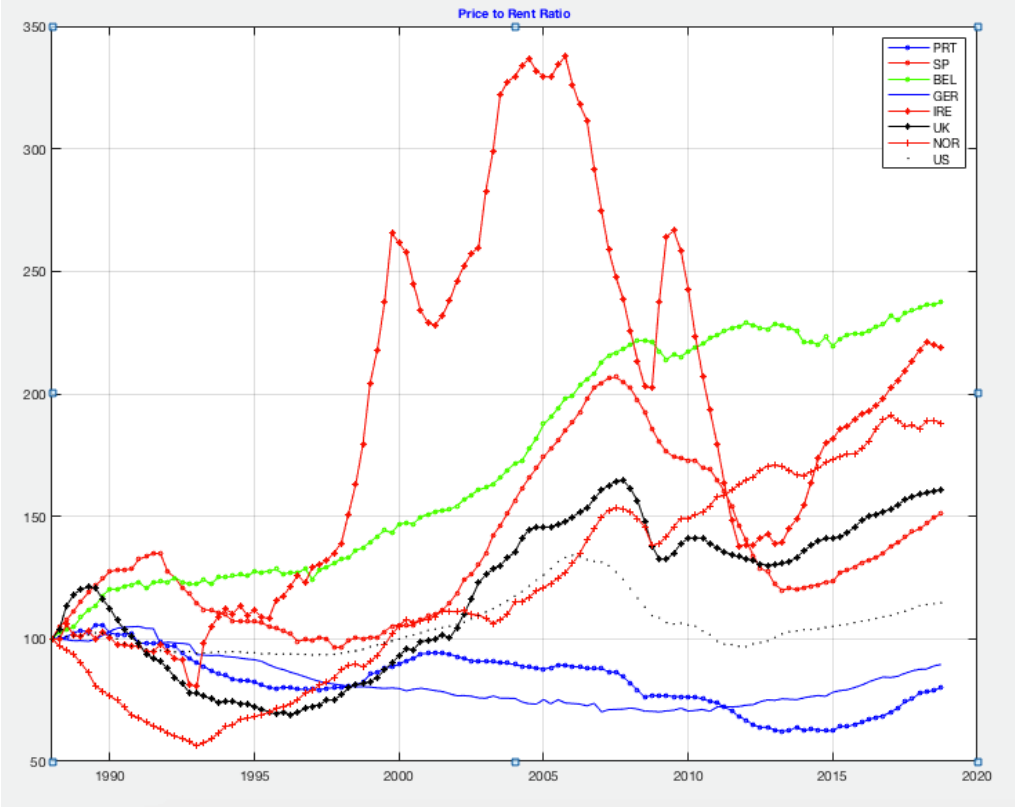

Figure 4.6. Price-to-Rent Ratio (PRR) Evolution in OECD Countries (1988=100)

The biggest marked fluctuation occurred between 1996 and 2008, particularly in Spain and Ireland. At that time, house prices deviate from the long-term averages, which may indicate the existence of overvaluation of house prices and the formation of real estate market bubbles, especially in the Spanish case. After 2008, the fall in house prices had dramatic consequences for the economy. By contrast, the deviations in Portugal were

more in line with long-term values and among the European's lowest ratio. The major disparity between the two economies was mainly from the late nineties onwards, a period in which residential investment increased suddenly in Spain in the context of low interest rates and significant influx of immigrants.

The price-to-income ratio is another conventional metric used when assessing house price dynamics and it indicates the affordability of a house.[31] It measures the ratio of the price of a median home to that of the median annual household income, that is, it measures whether housing is within range of average buyers. The ratio is known as a basic component of mortgage lending. A long-term increase in the ratio could be an indication that house prices are overvalued, leading households to rent a home instead of buying it. At some point, households will no longer be able to afford buying, bringing demand and prices down. In principle, this variable is of highly significance when analysing real estate developments in a country, as it provides an indication of whether households have a higher speculation of future housing price increases.

Looking at the evolution of the price-to-income ratio in OECD countries, the most evident signal is that housing prices in Portugal are undervalued, as suggested by the long-term decrease of the ratio (Figure 4.7.). Once again, this is considered an argument in favour of the non-existence of a real estate bubble in Portugal.

[31] The affordability of a house refers to houses that are priced so that households are also able to meet other basic living costs such as food, clothing, transport, medical care and education.

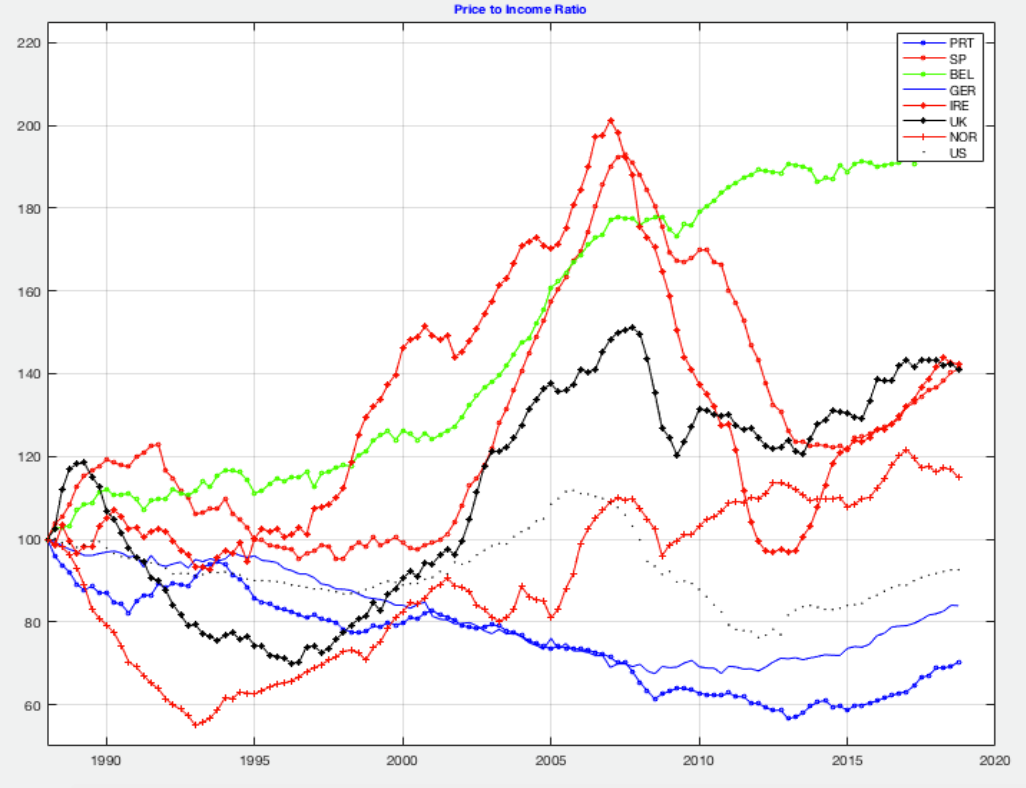

Figure 4.7. Price-to-Income Ratio (PIR) Evolution in OECD Countries (1988=100)

Notwithstanding it should be noted that price-to-rent and price-to-income ratios may, however, incur us in common fallacies about the costliness of housing market. According to Himmelberg et al. (2005), a growth in house prices does not necessarily denote that housing is overvalued and ownership is becoming more expensive, once the price of a house is not the same as the annual cost of owning. Also, different expected appreciation rates of houses and taxes influence the existence of considerable variability in the price-to-rent ratios across markets.[32] In fact, house price dynamics are a local phenomenon and a price-rent ratio that would be considered high for one city may be typical for another.[33] Finally, the research paper also emphasized that the sensitivity of house prices to fundamentals is higher at times when long-term interest rates are low, hence the acceleration in house prices growth is not inherently signal of a bubble.

[32] As Himmelberg, Mayer and Sinai (2005) denoted, "Without accounting for changes in real long-term interest rates, expected inflation, expected house price appreciation and taxes, one cannot accurately assess whether houses are reasonably prices."

[33] "(…) in cities where housing supply is relatively inelastic, prices will be higher relative to rents, and house prices will typically be more sensitive to changes in interest rates", said Himmelberg, Mayer and Sinai (2005).

In principle, price-to-rent and price-to-income ratios should be taken when assessing pricing in the housing market, but on the other hand, these ratios should fail to reflect accurately the state of housing cost and we must keep in mind when analysing and discussing the real estate market. However, the ratios may not be suitable indicators of the state of the housing market in the short-run, but they seem worthwhile when analysing long-term benchmarks.

4.3. Robustness Tests

The empirical tests are carried out in six stages: (1) The descriptive statistics of the selected time series, aiming to provide a brief summary of the series (2) The correlation analysis to evaluate the strength relationship between the chosen variables (3) The Augmented Dickey-Fuller (ADF) test to evaluate the integration level (the level of stationarity of the series), The Granger Causality test and The Engle-Granger Cointegration Test (4) The Final Model Estimation Output to assess the validity and the degree of desirability of the model and the statistical significance of the parameters included (5) The Breusch-Godfrey Serial Correlation LM Test to examine whether the time series are serially correlated and The Breusch-Pagan-Godfrey to evaluate the presence of heteroscedasticity in the model. Lastly, (6) A brief forecast analysis based on the final model estimation outcome.

4.3.1. Descriptive Statistics and Correlation for The Set of Data

The descriptive statistics shows exclusive features of the data used. Table 4.1.[34] exhibits the mean value of the price-to-income variable, PIR (125.8165), which is the highest among all the chosen variables. Instead, the median of (NHP, GDP, PIR) is 97.87900, 93.970999, 129.8070, respectively. The table also indicates that the maximum is 167.5640 for price-to-income ratio and the minimum is 31.85814 for GDP. The dependent variable is the one with the highest standard deviation. Skewness and Kurtosis values were also calculated for the 124 observations. NHP and GDP has a negative Skewness, which means that the time series distribution has a long-left tail. The Kurtosis

[34] See the Descriptive Statistics of the Series of the Model (Portugal) in Appendices, Figure A.3.1.; See the detailed histograms of GDP, PIR and NHP Series in Appendices (Figure A.3.2., A.3.3., and A.3.4., respectively).

indicates that distribution of these time series is peaked (leptokurtic) relative to the normal. However, PIR distribution has a long right tail. The Kurtosis is much lower than 3, meaning that the distribution is flat (platkurtic) relative to the normal. Under the null hypothesis of a normal distribution, the Jarque-Bera statistic reject the null hypothesis at a 5% significance level, for all the three variables. Although, PIR does not reject the null hypothesis at 1% significance level, meaning that at this point PIR time series assumes a normal distribution.

Table 4.1. Descriptive Statistics for All the Variables

Descriptive Statistics								
Variables	**Mean**	**St. Dev.**	**Min.**	**Max.**	**Skewness**	**Kurtosis**	**Jarque-Bera**	**p-value**
GDP	85.84905	17.46081	31.85814	102.9923	-1.380905	3.997817	44.55336***	0.000000
NHP	92.76731	20.89933	37.86800	132.8840	-0.801336	3.055783	13.28697***	0.001302
PIR	125.8165	18.77652	94.90500	167.5640	0.024255	1.848480	6.863155**	0.032336

Source: Author's computation and EView 10 Output.

Notes: ***, ** and * denote statistical significance levels at 1%, 5% and 10% level, respectively. Number of observations: 124.

Moreover, Table 4.2. exhibits the correlation coefficients between the dependent variable and the independent variables. It confirms that there exists a linear relationship between the chosen variables for the model. As seen in the table, the gross domestic product is positively correlated with nominal house prices denoted by the correlation of 0.963933.[35] This correlation coefficient demonstrates that as gross domestic product increases in Portugal, nominal house prices increase as well. On the other hand, price-to-income ratio is negatively correlated with nominal house prices in Portugal indicated by the correlation of -0.680765.[36] This means that as nominal house prices increase in Portugal, the price-to-income ratio evolves in the opposite direction.

[35] See the scatter plot of the positive correlation between the variables (Figure A.4.3 in Appendices).
[36] See the scatter plot of the negative correlation between the variables (Figure A.4.2 in Appendices).

Table 4.2. Correlation Matrix on Nominal House Prices and the Explanatory Variables

	GDP	NHP	PIR
GDP	1.000000	0.963933	-0.773803
NHP	0.963933	1.000000	-0.680765
PIR	-0.773803	-0.680765	1.000000

Source: Author's computation and EView 10 Output.

Concluding, it can be said that the correlation (dependence) assumption of multiple linear regression is fulfilled. The relationship between the independent and dependent variables is strong and can be modelled by a linear relationship.

4.3.2. Unit Root, Granger Causality and Cointegration Tests

Regarding time series analysis, a question that frequently arises is whether one economic variable can help forecast another economic variable. In an attempt to answer this question, Granger (1969) suggested a time series data-based approach in order to determine the "casual relationships" between variables in econometric models.[37] This proposed method was latter one popularized by Sims (1972). Hence, a multivariate Granger-causality procedure is employed to examine causality between nominal house prices and its determinants, GDP and price-to-income ratio, in the selected time series.

In principle, Granger-causality entails the series to be stationary and cointegrated. The series are tested whether they are stationary at level I(0) or at their first or second differences. Hence, the first stage in this analysis involves testing that both GDP and PIR time series demonstrate the same order of stationarity.

The Augmented Dickey-Fuller (ADF) test is employed to verify the null hypothesis $H_0: \alpha = \rho - 1 = 0$, against the alternative hypothesis $H_1: \alpha < 0$. This is a common and very strong unit root test used in the literature.[38] As table 4.3.[39] shows, the null hypothesis is not rejected since the p-value is higher than the critical values for a

[37] Econometricians and economists classify "casual relationships" as asymmetrical relationships. Policymakers use this kind of test as they need to understand the consequences of the various actions which they are pondering to take.
[38] See, for example, the study developed by Joseph and Sze-Teck (2004).
[39] For further details see Figures A.5.1., A.5.2., A.5.3., A.5.4., A.5.5., and A.5.6. in Appendices.

significance level of 5%. Therefore, GDP is non-stationary in level terms, which means the variable has a unit root.

Table 4.3. Augmented Dickey-Fuller Test Statistics

	Variables	t-Statistics	p-value	Critical Values 5%	Critical Values 10%
GDP	At Level	-2.956845	0.1489	-3.448021	-3.149135
	At First Difference	-4.417697***	0.0030	-3.448021	-3.149135
NHP	At Level	-1.197347	0.6742	-2.885450	-2.579598
	At First Difference	-2.938440**	0.0439**	-2.885450	-2.579598
PIR	At Level	-1.430690	0.5650	-2.886290	-2.580046
	At First Difference	-2.077243**	0.0368	-1.943768	-1.614801

Source: Author's computation and EView 10 Output.

Notes: ***, ** and * denote statistical significance levels at 1%, 5% and 10% level, respectively. H_0: Has a unit root.

Then, the first difference of the GDP variable was calculated in order to examine if stationarity can be induced by first differencing the time series. The results can be observed in table above. Since the computed p-value (0.0030) is lower than the 5% level of significance, the null hypothesis is rejected. We conclude that the GDP time series is integrated of order one, I(1), meaning that the series is non-stationarity in level but stationary in first difference.

Regarding nominal house price (NHP) and price-to-income (PIR) time series, the results are quite similar. In ADF test in levels for NHP and PIR series, the p-values (0.6742 and 0.5650, respectively) are higher than the 5% significance level, which implies the null hypotheses to be not rejected. Once again, the first difference operator is applied and the ADF test is performed afterwards. At this stage, the differenced time series become stationary, that is, NHP and PIR are I(1). Since the null hypothesis is rejected, the corresponding p-values (0.0439 and 0.0368 for NHP and PIR, respectively) are lower than the level of significance of 5%. In summing up, the empirical results illustrate that the three-time series are non-stationary and not of order 1, I(1).

Testing causality by the Granger method involves using F-statistics to test whether lagged information on a variable Y postulates any statistically significant information about a variable X in the presence of lagged X. If not, then "Y does not Granger-cause X. Table 4.4.[40] reports the Granger causality test results for the selected variables. By analysing the presented results, it can be concluded that NHP does Granger-

[40] For further details see Figure A.7.1. in Appendices.

cause GDP because the p-value of 0.0085 is lower than 5% significance level. It can be contended that the coefficients of GDP in the model, with NHP being the dependent variable, are not equal to zero and so they affect the future performance of NHP. In fact, the development of nominal house prices in Portugal cause fluctuations in the real economy. Hence, past values of NHP contribute to the prediction of the present value of GDP.

Table 4.4. The Granger Causality Test

Null Hypothesis	Obs.	F-statistics	Prob.
GDP does not Granger Cause NHP	122	1.27139	0.2843
NHP does not Granger Cause GDP		4.96829***	0.0085
PIR does not Granger Cause NHP	122	1.25582	0.2887
NHP does not Granger Cause PIR		0.72222	0.4878
PIR does not Granger Cause GDP	122	0.49338	0.6118
GDP does not Granger Cause PIR		0.46473	0.6295

Source: Author's computation and EView 10 Output.

Notes: ***, ** and * denote statistical significance levels at 1%, 5% and 10% level, respectively.

Further, through the Engle-Granger methodology which assumes the null hypothesis that the series are not cointegrated, the cointegration of time series were tested. The results show that the null hypothesis is not rejected at a 5% significance level, that is, there is no cointegration relation between the variables we consider in the final regression model.[41]

4.3.3. Final Model Estimation Output

A regression analysis is used when the main aim is to estimate the statistical relationship among variables which have a result relation. The analysis of nominal house prices evolution throughout a simple linear regression model would be insufficient, since economic situations in which correlations implicate only two variables are very rare. In fact, in the presented empirical study we have a dependent variable, y, that depends on at least two series of independent variables. In such case, where there is a dependent variable and more than one independent variable, the so-called multiple linear regression is

[41] For further details see Figure A.6.1 in Appendices.

applied. Anghelache et al. (2014) emphasize the role and consistency of multiple regression tools in analyses approaching macroeconomic indicators and forecasts.

Hence, multivariate regression analysis model is formulated as in the following,

$$y_i = \beta_0 + \beta_1 x_{1(i)} + \beta_2 x_{2(i)} + \cdots + \beta_k x_{k(i)} + \varepsilon_i, \;\; i = 1, \dots, n \tag{13}$$

where, y_i, $x_{1(i)}$, $x_{2(i)}$,…, $x_{k(i)}$ represent the ith observations of each of the variables y_i, x_1, x_2, …, x_k respectively, β_0 is a constant (intercept), β_1, β_2,…, β_k are the parameters of the regression slope and ε_i is the residual term for the ith observations, normally distributed and with zero mean and a constant variance defined as σ_ε^2. Several assumptions[42] were imposed on the variables x_i and ε_i and they are as follows:

- The explanatory variables x_1, x_2,…, x_k are assumed to be either fixed numbers (measured without error), or they are random but uncorrelated with the error terms ε_i, $Cov(\varepsilon_i, x_k) = 0$. In either case, the values of such variables must not be all the same.
- The error terms ε_i are uncorrelated, i.e., linearly independents $Cov(\varepsilon_i, \varepsilon_j) = 0$.
- The error terms ε_i all have a zero mean and constant and finite variance, $E(\varepsilon_t) = 0$ and $Var(\varepsilon_t) = \sigma^2$ respectively.
- The errors are assumed to be normally distributed, $\varepsilon_i \sim N(0, \sigma^2)$.

In examining the macroeconomic determinants of nominal house prices in Portugal, the multiple linear regression model in consideration is expressed under the following form:

$$Dlog(NHP) = C(1) + C(2) \times Dlog(GDP) + C(3) \times Dlog(PIR) + C(4) \times LDNHP(-1) \tag{14}$$

The equivalent substituted coefficients for the model are shown below:

$$Dlog(NHP) = 0.003343 + 0.657664 \times Dlog(GDP) + 0.694087 \times Dlog(PIR) + 0.246481 \times LDNHP(-1) \tag{15}$$

[42] To a further understanding of the residuals' assumptions, see Figure A.9.1 in appendices.

where we denote by C_i the coefficients and by $Dlog$ the logarithmic difference of each of the variables. Note that the $LDNHP(-1)$ is the order one lagged value of nominal house prices.

The model parameters were estimated using the ordinary least square method[43], and then we confirmed the validity of the model, its degree of reliability and statistical significance of the parameters included. Log transformations of the variables were carried out to improve linearity. The output model is presented in Table 4.5.[44]:

Table 4.5. The Results of the Regression Model Parameter Estimates

Dependent Variable Dlog (NHP)				
Variable	**Coefficient**	**Std. Error**	**t-statistic**	**Prob.**
C	0.003343	0.000645	5.180908	0.0000
Dlog (GDP)	0.657664	0.046983	13.99791	0.0000
Dlog (PIR)	0.694087	0.041513	16.71985	0.0000
LDNHP (-1)	0.246481	0.045206	5.452365	0.0000
R-squared	0.883802			
Adjusted R-Squared	0.880848			
F-statistic	299.1707***			
Prob (F-statistic)	0.000000			
Durbin-Watson stat	1.918722			

Source: Author's computation and EView 10 Output.

Notes: ***, ** and * denote statistical significance levels at 1%, 5% and 10% level, respectively.

From the point of view of statistical tests that verify the accuracy of the econometric model considered, it can be observed that the coefficients of determination, R-squared and adjusted R-squared, are sufficiently high (88.3% and 88.1%, respectively), letting to the conclusion that the model is suitable and with a minimum risk for the economic analysis. In fact, all the three chosen variables have the predicted sign and are statistically significant. The empirical results show that 88.3% of the variation of the nominal house prices is explained by the simultaneous fluctuation of gross domestic product and price-to-income ratio in Portugal from first quarter of 1988 until last quarter of 2018. It suggests a robust link between endogenous variable and the two exogenous

[43] As stated by Jonathan (2018), the ordinary least square method "(…) chooses the parameters of a linear function of a set of explanatory variables by minimizing the sum of the squares of the differences between the observed dependent variable in the given dataset and those predicted by the linear function."

[44] For further details see Figures A.8.1. and A.8.2. in Appendices which represent the Final Model Estimation Output Result without logs and with logs, respectively.

variables, as established by the adjusted R-squared value. Lastly, the R-squared value demonstrates that the estimated regression model approximates the observation data very well, with high reliability.

We can also claim that the model is statistically significant and acceptable after applying the F-statistic test, as it has a close to zero-significance level Prob (F-statistic), much lower than 5%.

Moreover, for each independent variable and constant, E-views software stated the standard error of the coefficient, the t-statistic test and the related p-value. Considering a level of 5% of significance, the probability associated with the statistical t-test is below that level for all the exogenous variables. Also, the free term coefficient is significant because the probability ascribed to the statistical t-test is below the significance level, then concluding that all the variables are statistically significative. Nevertheless, the Durbin-Watson statistic is approximately 2 (1.918722), which means that there is no first-order linear auto-correlation between the residuals.

In summing up, it can be esteemed that the chosen model, the multiple linear regression, is representative to designate the impact that gross domestic product and price-to-income ratio have on nominal house price fluctuations. In fact, the relationship between the studied variables is strongly pertinent.

4.3.4. Serial Correlation, Heteroscedasticity and Normality Tests

The Breusch-Godfrey Serial Correlation LM test (see Breusch (1978) and Godfrey (1978)) is the most appropriate one for detecting auto-correlation in model residuals. By analysing the results, can be argued that a high probability of the LM statistic signifies that residuals are not correlated. Table 4.6.[45] illustrates the output of the auto-correlation test.

Table 4.6. Breusch-Godfrey Serial Correlation LM Test

Null Hypothesis: No serial correlation			
F-statistic	0.088912	**Prob.F (2,116)**	0.9150
Obs*R-Squared	0.186737	**Prob. Chi-Square (2)**	0.9109

Source: Author's computation and EView 10 Output.

[45] For further details see Figure A.9.2. in Appendices.

This test is settled under the null hypothesis H_0: No serial correlation, against the alternative, H_1: Serial correlation. The results suggest that the residuals of the model are not serially correlated as the p-value of the test statistics is higher than 0.05 percent. The null hypothesis is not rejected which seems desirable.

Table 4.7.[46] exhibits the results of the Breusch-Pagan-Godfrey test (see Breusch-Pagan (1979) and Godfrey (1978)). This is a Lagrange multiplier test with the null hypothesis of no heteroscedasticity (and so, homoscedasticity exists) against the alternative one of heteroscedasticity. Since the p-value of the test statistics is higher than 0.05, the null hypothesis is not rejected which denotes that residuals are homoscedastic, meaning that the residuals variance is constant. Hence, the assumption of homoscedasticity is satisfied.

Table 4.7. Heteroscedasticity Test: Breusch-Pagan-Godfrey

Null Hypothesis: **No heteroscedasticity/ Residuals are homoscedastic**			
F-statistic	2.169316	**Prob. F (3,118)**	0.0953
Obs*R-Squared	6.376858	**Prob. Chi-Square (3)**	0.0946
Scaled explained SS	9.816349	**Prob. Chi-Square (3)**	0.0202**

Source: Author's computation and EView 10 Output.

Notes: ***, ** and * denote statistical significance levels at 1%, 5% and 10% level, respectively.

Moreover, residuals should be normally distributed $\varepsilon_t \sim N(0, \sigma^2)$. It can be tested through the Jarque-Bera test.[47] Under the null hypothesis of normal distribution (the residual follows a normal distribution), the Jarque-Bera p-value is much lower than 5% relevance. Thus, the H_0 is rejected and we conclude that the residuals are not normally distributed. Note that in a regression, the problem of non-normal distribution could be lessened by adding up dummy variables when an outlier is detected in the residuals. These dummies will improve the standard errors as well as the R-squared, leading to a more appropriate final model.

Therefore, the mean of the residuals is null, and so it can be argued that the forecasts are non-biased. Hence, the regression model is valid, and it is desirable for the proposed analysis.

[46] For further details see Figure A.9.3. in Appendices.
[47] For further details see Figure A.9.4. in Appendices, which illustrates the histogram and the descriptive statistic of the residuals.

4.3.5. Forecasting

This sub-section relates to the forecasting performance and it aims to measure how accurate the forecast was. Generally, for a time period *t*, the forecast error equals the actual value minus the forecast value. Forecasting is used for estimates of values at certain specific future times. In fact, quantitative forecasting ensures it is reasonable to assume that trends of the past patterns will continue in the future. That is, it attempts to estimate future outcomes based on historical data. Figure 4.8. plots the evolution of the forecasted and real values of the dependent variable of the model, nominal house prices.

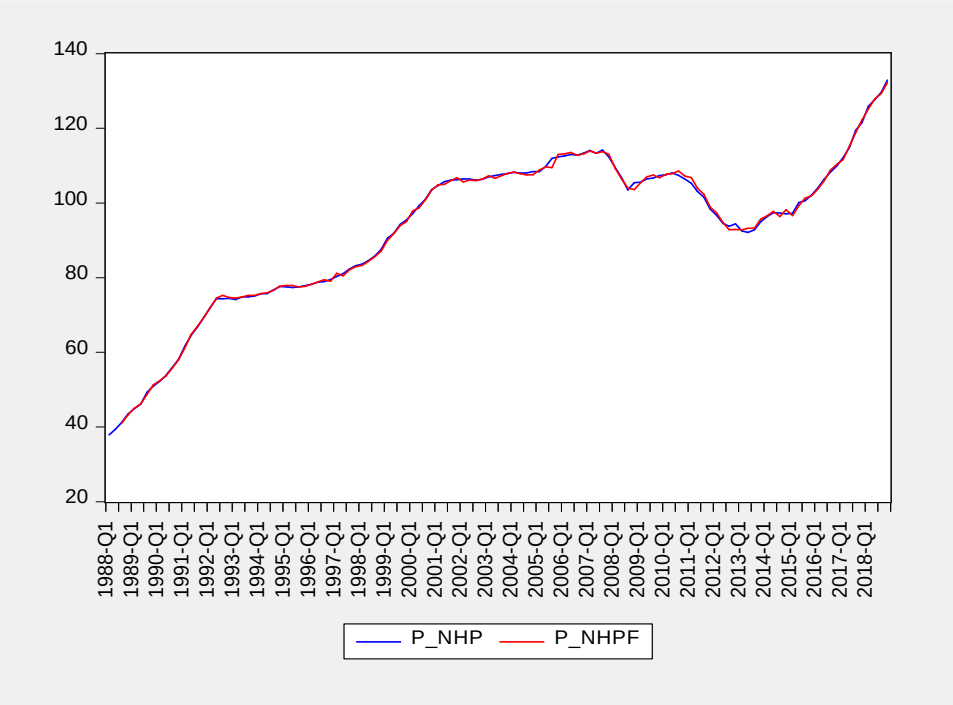

Figure 4.8. Comparison of Forecasted and Real Values of the Dependent Variable (Portugal)

Considering the last quarter of 2018-year, the forecast error is 0.6339 and it is given by the following equation, $F_e = A_t(132.884) - F_t\ (132.2501)$.[48] The difference between the predicted and the real value is not substantial indeed. Surprisingly and opposing to people's beliefs, there is not an evidence of an economic bubble in the

[48] See annex A.10.3. for further detail.

Portuguese housing market and the country is, in fact, far away from a critical scenario. Hence, it can be argued that a drop in the Portuguese nominal house prices will take place in a near future, although such a decrease is not of major significance for households and the economy. In fact, the exponential increase in house prices is, instead, interpreted as a typical price adjustment of the real estate prices. The result of the atrocious economic conditions that settled in Portugal and the drastic collapse in housing prices in the aftermath of the Subprime crisis, is, in fact, an astonishing increase in the housing prices that have been distressing the whole country. The projections for a real estate price growth are now in a neutral territory, hinting that the recent period of such housing price increases is now losing pace. For now, on it is expected a slightly stagnation in the housing market.

5. Concluding Remarks

The recent robust growth in house prices in Portugal has boosted concerns that a real estate bubble may be inflating, resulting in an unfavourable impact both on financial stability and economic activity. In fact, the Portuguese real estate market is under a high speculative thinking among investors over the last years. It can be argued that the recent exponential increase in house prices is due to a general perception that houses are a great investment and to the psychological boom that helped extent such thinking that one may have to buy now or miss out the opportunity to buy at all, which generates a feeling of anxiety about personal safety. Of course, monetary policy plays an important role in driving house prices since it has a potential power to alter the level of interest rates and, hence, the discount rate. But, even beyond monetary policy, there are many other factors that drive decisions on purchasing long-term assets such as housing. For most of the households, the purchase of a house is considered as one of the major life decisions, and since this decision can be postponed, anything that draws attention to or away from housing can have a meaningful impact on real estate markets. In fact, policymakers, economic and financial institutions must provide some reliance on the emerging field of behavioural economics in order to fully understand the intrinsic functioning of such an important sector as the housing market.

This study investigates the macroeconomic determinants that influence and explicate nominal house prices in Portugal, using time series data from period 1988-Q1 to 2018-Q4, gathered from OECD database. The choice of this time range is based on its relevance as during this period a vast number of housing bubbles occurred worldwide in major economies. We collected a vast database with variables evidently related to the housing market, such real gross domestic product, short- and long-term interest rates, real house price index, price-to-rent and price-to-income ratios, consumer confidence index, unemployment rate. Then, we decided to concentrate on the elaboration of an econometric work adequate on the explanation of the evolution of nominal house prices in Portugal. After a careful explanatory analysis of the data, the variables chosen for this empirical analysis were the nominal house price (NHP) index as dependent variable, while real gross domestic product (GDP) and the price-to-income ratio (PIR) as independent variables.

The output of the multiple linear regression model seems to be relevant from a statistical point of view, coming up with a very high ratio of determination, a R-Squared of 0.883802 (88%), meaning that 88% of the dynamics in nominal house prices in Portugal are explained by the independent variables integrated in the model (real GDP and price-to-income ratio).

The truth is that housing bubbles feed on the illusion of optimism. And more important than being sure that a real estate bubble accurately exists in the Portuguese market, it is crucial to recognize the market is facing robust imbalances nowadays. A dangerous coincidence of factors drives demand to be excessive: domestic demand, foreign demand, tourism, economic recovery and low interest rates. All these combined with a limited supply of dwellings, within a slow response to shocks in demand. It is recommended that financial policies and real estate measures are designed in line with both demand and supply sides – and of course, follow a medium to long term thought.

Surprisingly, the results of this empirical work suggest that the hypothesis of an emerging housing bubble in Portugal is easily rejected. Furthermore, the data provided by the OECD displays Portugal as the country with the lowest housing prices. As a matter of fact, and regardless of what people believe, there is no significant statistical or economic evidence of a bubble in the Portuguese real estate market. The country is far away from a critical scenario and the rising in house prices is seen as a typical price adjustment. Further, the forecast error suggests that the decrease in nominal house prices that is going to occur in a near future is not of major significance.

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APPENDICES

A. Model Details

A.1. Data Details

Frequency: Quarterly

Range: 1988Q1-2018Q4, 124 observations

Source: OECD Database

Individual Series Details:

RHP: Real House Price, seasonally adjusted. OECD's definition: "The real house price is given by the ratio of nominal price to the consumers' expenditure deflator in each country, both seasonally adjusted, from the OECD national accounts database."

NHP: Nominal House Price, seasonally adjusted. OECD's definition: "The nominal house price covers the sale of newly-built and existing dwellings, following the recommendations from RPPI (Residential Property Prices Indices) manual".

PRR: Price-to-rent ratio**,** seasonally adjusted. OECD's definition: "The price to rent ratio is the nominal house price divided by the rent price and can be considered as a measure of the profitability of house ownership".

PIR: Price-to-income ratio**,** quarterly data from Q1-1988 to Q4-2018 (except for Portugal Q1-1995), seasonally adjusted. OECD's definition: "The price to income ratio is the nominal house price divided by the nominal disposable income per head and can be considered as a measure of affordability".

GDP: Gross Domestic Product. OECD's definition: "Gross domestic product (GDP) is the standard measure of the value added created through the production of goods and services in a country during a certain period. As such, it also measures the income earned from that production, or the total amount spent on final goods and services (less imports). While GDP is the single most important indicator to capture economic activity, it falls short of providing a suitable measure of people's material well-being for which alternative indicators may be more appropriate. This indicator is based on real GDP (also called GDP at constant prices or GDP in volume), i.e. the developments over time are adjusted for price changes. The numbers are also adjusted for seasonal influences. The indicator is available in different measures: percentage change from the previous quarter, percentage change from the same quarter of the previous year and volume index. All

OECD countries compile their data according to the 2008 System of National Accounts (SNA)".

CONF: Consumer Confidence Index. OECD's definition: "This consumer confidence indicator provides an indication of future developments of households' consumption and saving, based upon answers regarding their expected financial situation, their sentiment about the general economic situation, unemployment and capability of savings". Moreover, an indicator above 100 signals a boost in the consumers' confidence towards the future economic situation. Hence, households are less prone to save and, consequently, more prompt to spend money on major purchases in the succeeding months. Conversely, an indicator below 100 suggests a pessimistic attitude towards future developments in the economy, thus resulting in a tendency to save more and consume less.

i: Short-Term Interest Rate. OECD's definition: "Short-term interest rates are the rates at which short-term borrowings are effected between financial institutions or the rate at which short-term government paper is issued or traded in the market. Short-term interest rates are generally an averaging of daily rates, measured as a percentage. Short-term interest rates are based on three-month money market rates where available. Typical standardised names are "money market rate" and "treasury bill rate".

LTIR: Long-Term Interest Rate. Quarterly data from Q1-1988 to Q4-2018 (except for Portugal Q1-1994; a proxy is used in the data for Portugal, since Portugal and Spain had a similar behaviour over years, and so we assume that the variation is the same and fits for previous years). Definition: Long-term interest rates refer to government bonds maturing in ten years. Rates are mainly determined by the price charged by the lender, the risk from the borrower and the fall in the capital value. Long-term interest rates are generally an averaging of daily rates, measured as a percentage. These interest rates are implied by the prices at which the government bonds are traded on financial markets, not the interest rates at which the loans were issued. In all cases, they refer to bonds whose capital repayment is guaranteed by governments. Long-term interest rates are one of the determinants of business investment. Low long-term interest rates encourage investment in new equipment and high interest rates discourage it. Investment is, in turn, a major source of economic growth".

u: Harmonised Unemployment Rate. OECD's definition: "Harmonised unemployment rates define the unemployed as people of working age who are without work, are available for work, and have taken specific steps to find work. The uniform

application of this definition results in estimates of unemployment rates that are more internationally comparable than estimates based on national definitions of unemployment. This indicator is measured in numbers of unemployed people as a percentage of the labour force and it is seasonally adjusted. The labour force is defined as the total number of unemployed people plus those in civilian employment".

A.2. Graphical Representation of the Series

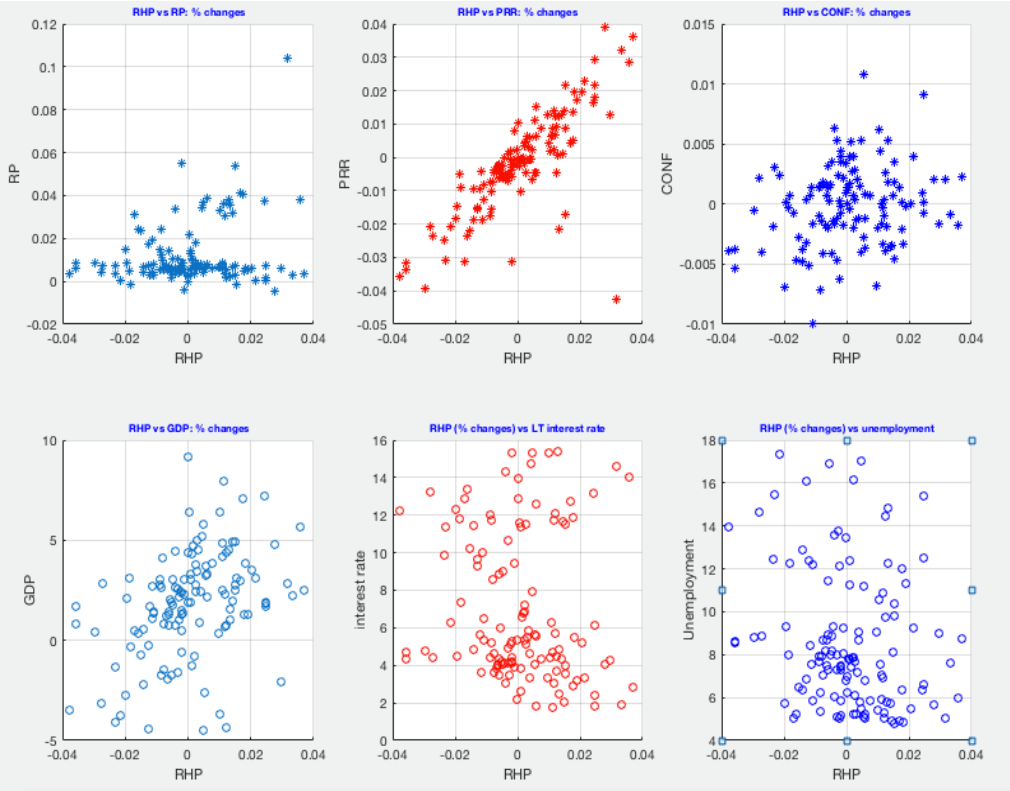


Figure A.2.1. Correlation Between Real House Prices and Fundamental Economic Variables selected from the OECD Database (Portuguese Marketplace)

A.3. Descriptive Statistics of the Time Series

	P_NHP	P_PIR	P_GDP
Mean	92.76731	125.8165	85.84905
Median	97.87900	129.8070	93.97099
Maximum	132.8840	167.5640	102.9923
Minimum	37.86800	94.90500	31.85814
Std. Dev.	20.89933	18.77652	17.46081
Skewness	-0.801336	0.024255	-1.380905
Kurtosis	3.055783	1.848480	3.997817
Jarque-Bera	13.28697	6.863155	44.55336
Probability	0.001302	0.032336	0.000000
Sum	11503.15	15601.25	10645.28
Sum Sq. Dev.	53724.19	43364.62	37500.21
Observations	124	124	124

Figure A.3.1. Descriptive Statistics of the Series of the Model (Portugal)

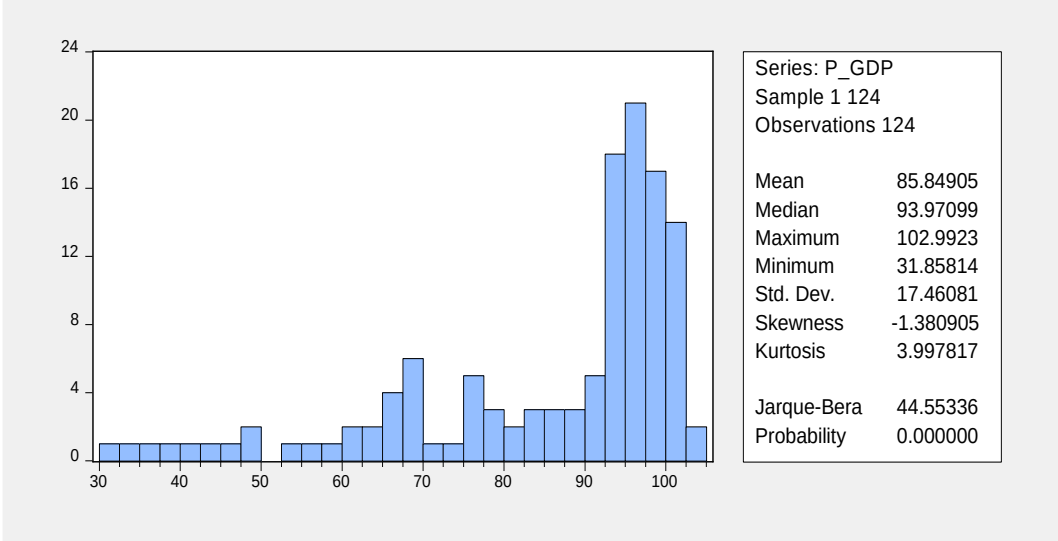


Figure A.3.2. Descriptive Statistics of GDP Series (Portugal)

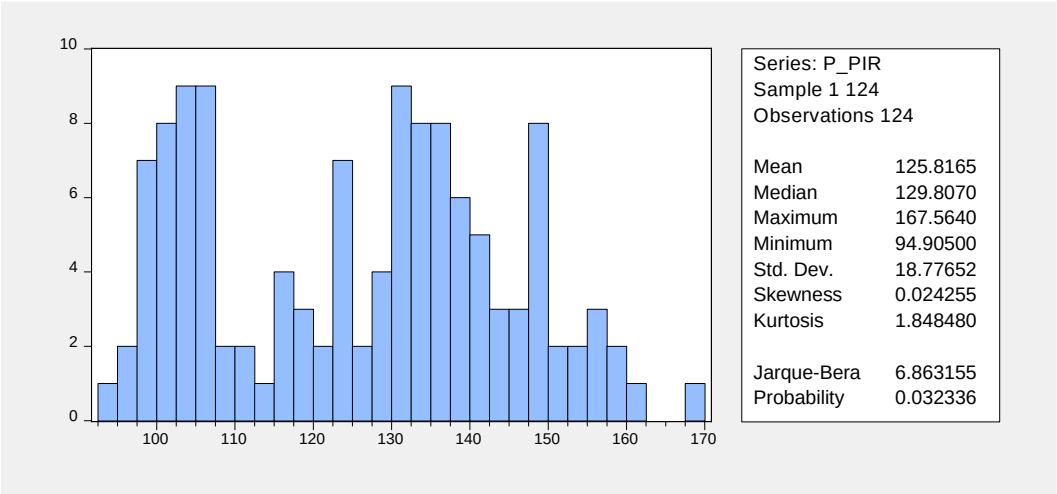


Figure A.3.3. Descriptive Statistics of PIR Series (Portugal)

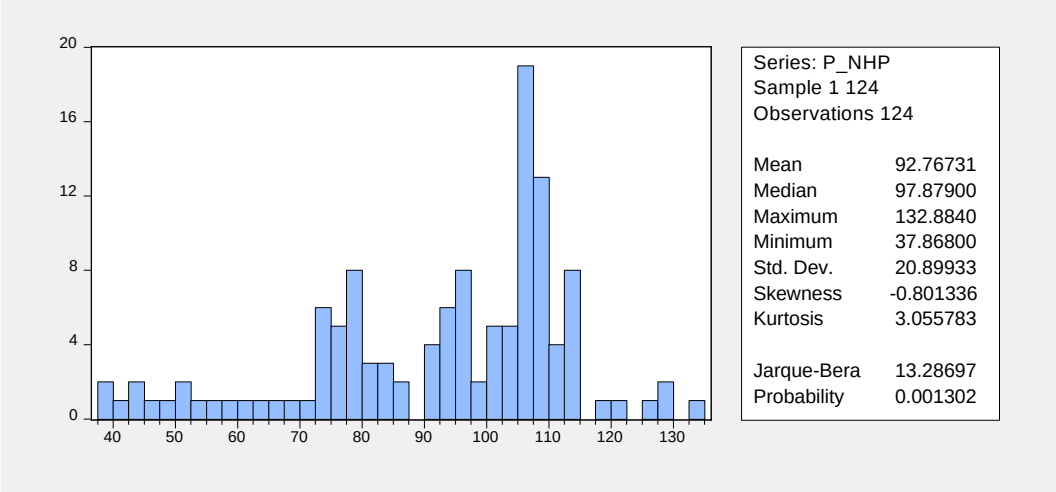


Figure A.3.4. Descriptive Statistics of NHP Series (Portugal)

A.4. Correlation Analysis

	P_NHP	P_PIR	P_GDP
P_NHP	1.000000	-0.680765	0.963933
P_PIR	-0.680765	1.000000	-0.773803
P_GDP	0.963933	-0.773803	1.000000

Figure A.4.1. Correlation Matrix on Nominal House Prices and the Explanatory Variables (Portugal)

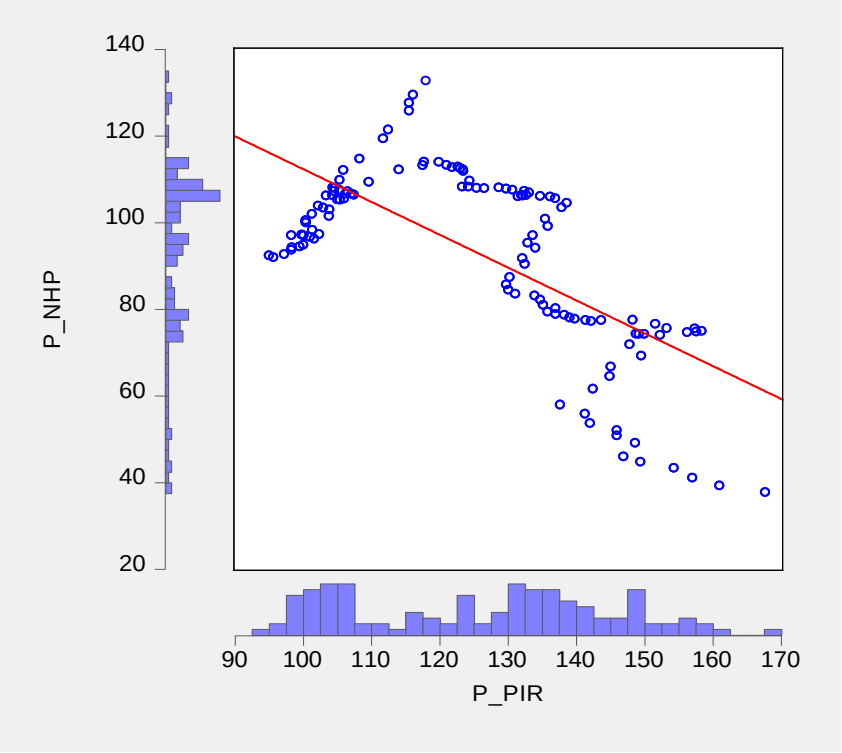


Figure A.4.2. Scatter Plot of Correlation on Nominal House Prices and Price-to-Income Ratio (Portugal)

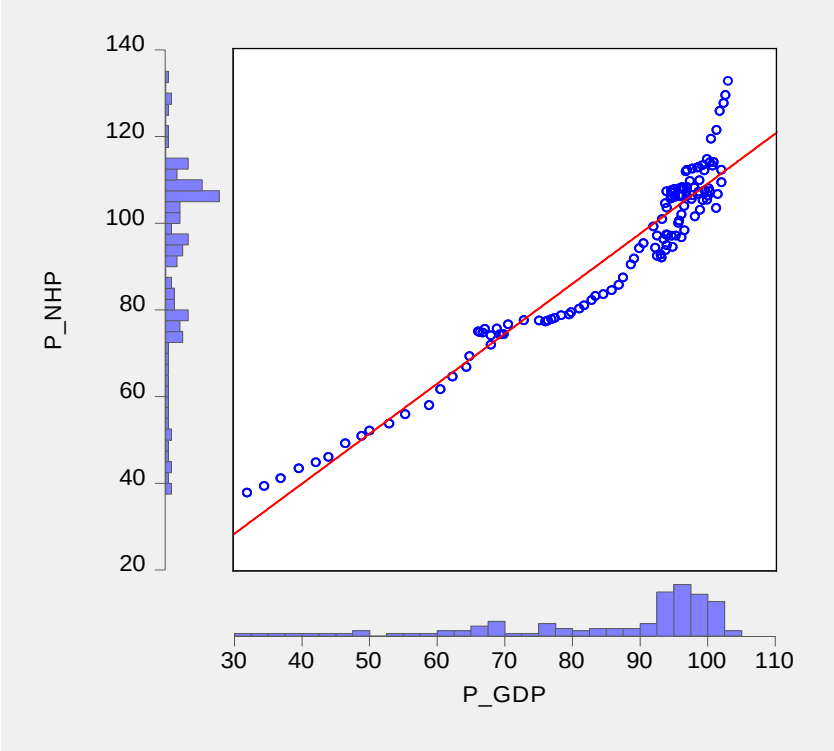


Figure A.4.3. Scatter Plot of Correlation on Nominal House Prices and Gross Domestic Product (Portugal)

A.5. Unit Root Test in Levels and First Differences

Null Hypothesis: P_NHP has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.197347	0.6742
Test critical values:	1% level	-3.485115	
	5% level	-2.885450	
	10% level	-2.579598	

*MacKinnon (1996) one-sided p-values.

Figure A.5.1. The Augmented Dickey-Fuller Test Result at Levels for NHP (Portugal)

Null Hypothesis: D(P_NHP) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.938440	0.0439
Test critical values:	1% level	-3.485115	
	5% level	-2.885450	
	10% level	-2.579598	

*MacKinnon (1996) one-sided p-values.

Figure A.5.2. The Augmented Dickey-Fuller Test Result at First Difference for NHP (Portugal)

Null Hypothesis: P_GDP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 4 (Automatic - based on AIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.956845	0.1489
Test critical values:	1% level	-4.036983	
	5% level	-3.448021	
	10% level	-3.149135	

*MacKinnon (1996) one-sided p-values.

Figure A.5.3. The Augmented Dickey-Fuller Test Result at Levels for GDP (Portugal)

Null Hypothesis: D(P_GDP) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 3 (Automatic - based on AIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.417697	0.0030
Test critical values:	1% level	-4.036983	
	5% level	-3.448021	
	10% level	-3.149135	

*MacKinnon (1996) one-sided p-values.

Figure A.5.4. The Augmented Dickey-Fuller Test Result at First Difference for GDP (Portugal)

Null Hypothesis: P_PIR has a unit root
Exogenous: Constant
Lag Length: 6 (Automatic - based on AIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.430690	0.5650
Test critical values:	1% level	-3.487046	
	5% level	-2.886290	
	10% level	-2.580046	

*MacKinnon (1996) one-sided p-values.

Figure A.5.5. The Augmented Dickey-Fuller Test Result at Levels for PIR (Portugal)

Null Hypothesis: D(P_PIR) has a unit root
Exogenous: None
Lag Length: 12 (Automatic - based on AIC, maxlag=12)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.077243	0.0368
Test critical values:	1% level	-2.586154	
	5% level	-1.943768	
	10% level	-1.614801	

*MacKinnon (1996) one-sided p-values.

Figure A.5.6. The Augmented Dickey-Fuller Test Result at First Difference for PIR (Portugal)

A.6. Cointegration Test

Series: P_GDP P_NHP P_PIR
Sample: 1 124
Included observations: 124
Null hypothesis: Series are not cointegrated
Cointegrating equation deterministics: C
Automatic lags specification based on Schwarz criterion (maxlag=12)

Dependent	tau-statistic	Prob.*	z-statistic	Prob.*
P_GDP	-0.638456	0.9846	-2.309542	0.9767
P_NHP	-0.046293	0.9965	-0.199407	0.9961
P_PIR	-1.433700	0.9103	-3.477503	0.9508

*MacKinnon (1996) p-values.

Figure A.6.1. Engle-Granger Cointegration Test Result (Portugal)

A.7. Granger Causality Test

Sample: 1 124
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
P_NHP does not Granger Cause P_GDP	122	4.96829	0.0085
P_GDP does not Granger Cause P_NHP		1.27139	0.2843
P_PIR does not Granger Cause P_GDP	122	0.49338	0.6118
P_GDP does not Granger Cause P_PIR		0.46473	0.6295
P_PIR does not Granger Cause P_NHP	122	1.25582	0.2887
P_NHP does not Granger Cause P_PIR		0.72222	0.4878

Figure A.7.1. The Granger Causality Test Results (Portugal)

A.8. Final Model Estimation Output

Dependent Variable: P_NHP
Method: Least Squares

Sample: 1 124
Included observations: 124

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-41.92042	8.081323	-5.187322	0.0000
P_GDP	1.304100	0.042170	30.92505	0.0000
P_PIR	0.180675	0.039215	4.607333	0.0000

R-squared	0.939738	Mean dependent var	92.76731
Adjusted R-squared	0.938742	S.D. dependent var	20.89933
S.E. of regression	5.172652	Akaike info criterion	6.148544
Sum squared resid	3237.516	Schwarz criterion	6.216777
Log likelihood	-378.2097	Hannan-Quinn criter.	6.176262
F-statistic	943.4530	Durbin-Watson stat	0.054363
Prob(F-statistic)	0.000000		

Figure A.8.1. Final Model Estimation Output Result Without Logs, from 1988-Q1 until 2018-Q4 (Portugal)

Dependent Variable: DLOG(P_NHP)
Method: Least Squares

Sample (adjusted): 3 124
Included observations: 122 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003343	0.000645	5.180908	0.0000
DLOG(P_GDP)	0.657664	0.046983	13.99791	0.0000
DLOG(P_PIR)	0.694087	0.041513	16.71985	0.0000
DLNHP(-1)	0.246481	0.045206	5.452365	0.0000

R-squared	0.883802	Mean dependent var	0.009973
Adjusted R-squared	0.880848	S.D. dependent var	0.017494
S.E. of regression	0.006038	Akaike info criterion	-7.349091
Sum squared resid	0.004303	Schwarz criterion	-7.257156
Log likelihood	452.2945	Hannan-Quinn criter.	-7.311749
F-statistic	299.1707	Durbin-Watson stat	1.918722
Prob(F-statistic)	0.000000		

Figure A.8.2. Final Model Estimation Output Result Within Logs, from 1988-Q3 until 2018-Q4 (Portugal)

A.9. Serial Correlation, Heteroscedasticity and Normality Tests

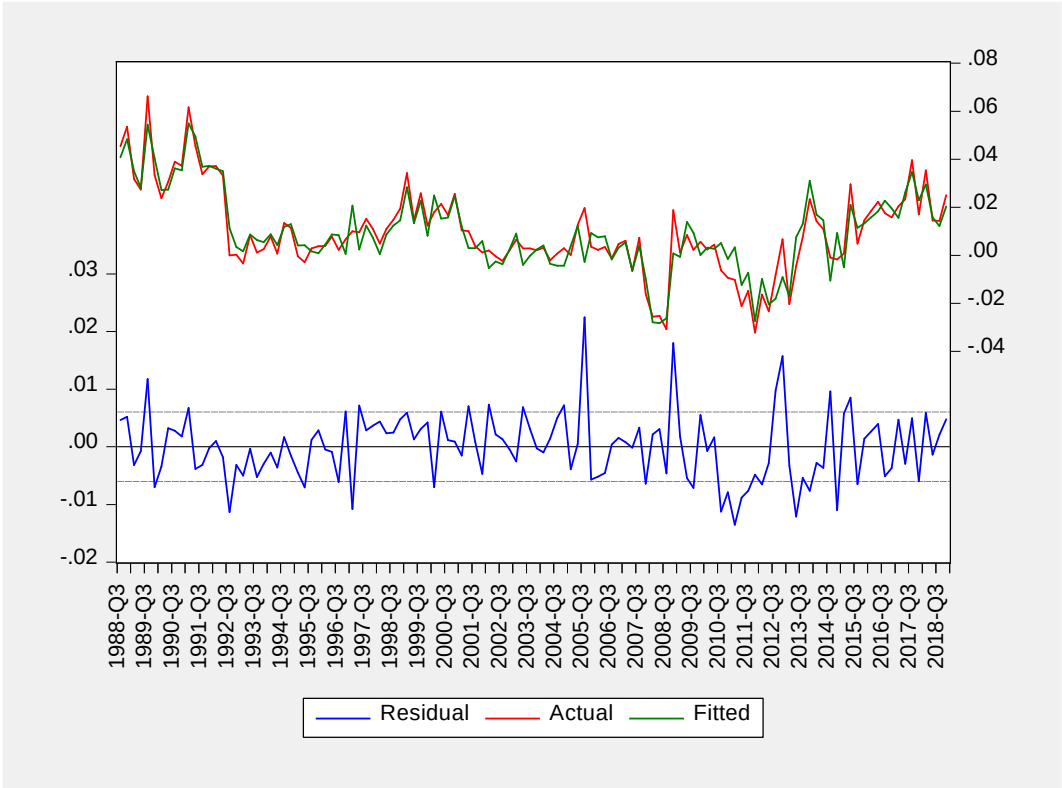


Figure A.9.1. Comparison of Actual and the Fitted Values

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.088912	Prob. F(2,116)	0.9150
Obs*R-squared	0.186737	Prob. Chi-Square(2)	0.9109

Figure A.9.2. Breusch-Godfrey Serial Correlation LM Test Result

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	2.169316	Prob. F(3,118)	0.0953
Obs*R-squared	6.376858	Prob. Chi-Square(3)	0.0946
Scaled explained SS	9.816349	Prob. Chi-Square(3)	0.0202

Figure A.9.3. Breusch-Pagan-Godfrey Heteroscedasticity Test Result

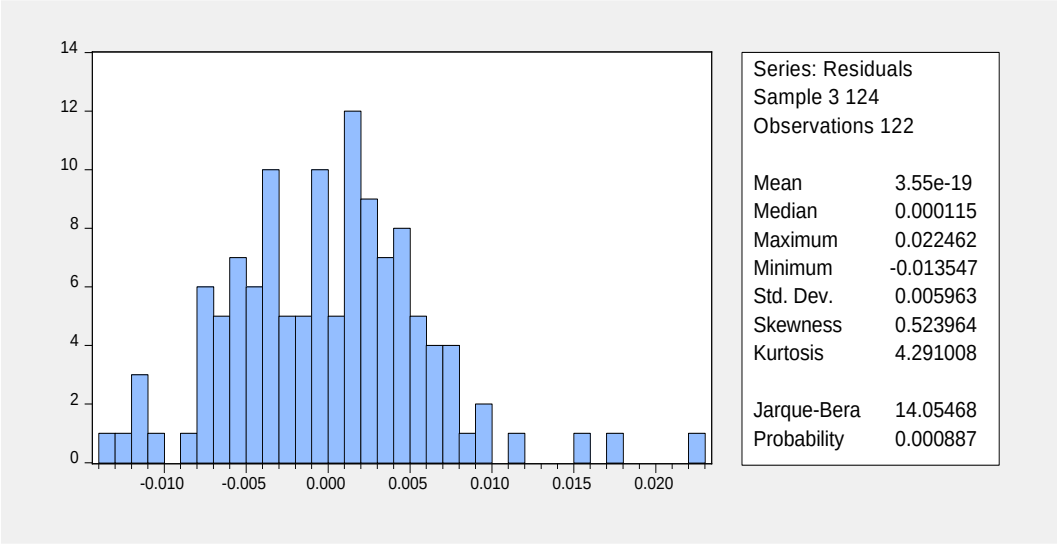
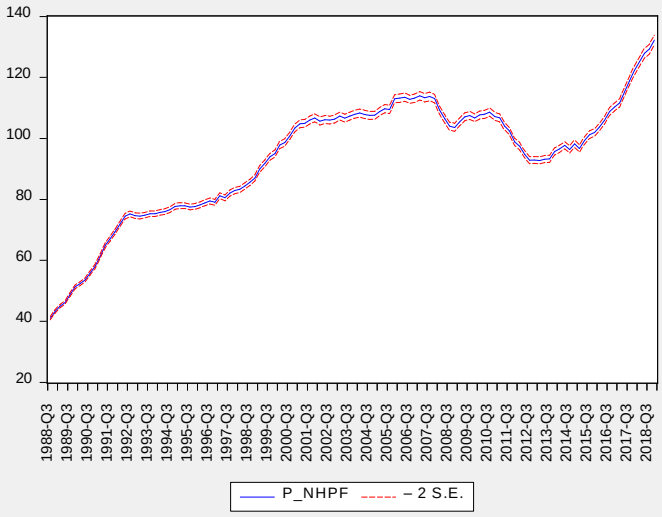


Figure A.9.4. Histogram and Normality Test Result of Residuals (1988Q3 – 2018Q4)

A.10. Forecasting from the Estimated Equation



Forecast: P_NHPF	
Actual: P_NHP	
Forecast sample: 1 124	
Adjusted sample: 3 124	
Included observations: 122	
Root Mean Squared Error	0.579491
Mean Absolute Error	0.437600
Mean Abs. Percent Error	0.463591
Theil Inequality Coef.	0.003027
Bias Proportion	0.000010
Variance Proportion	0.001547
Covariance Proportion	0.998443
Theil U2 Coefficient	0.299437
Symmetric MAPE	0.463744

Figure A.10.1. The Forecasts and Statistics Evaluating the Quality of the Fit of the Actual Data (Portugal)

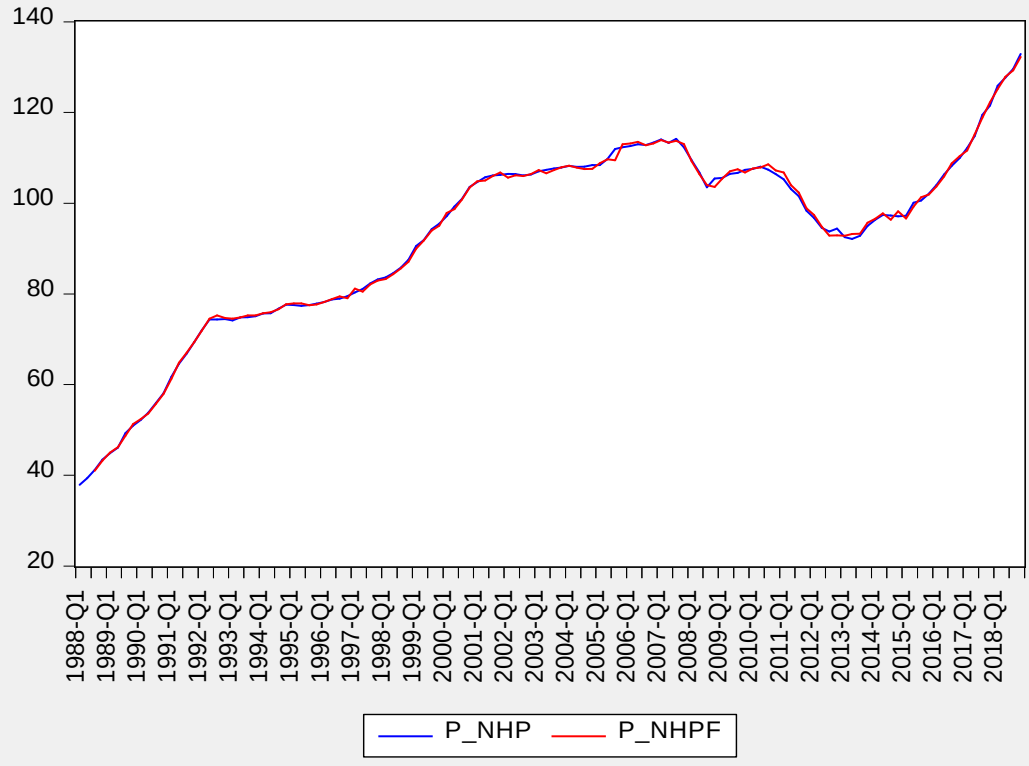


Figure A.10.2. Comparison of Real and Forecasted Values of the Dependent Variable, Nominal House Price (Portugal)

	P_NHP	P_NHPF
1988-Q1	37.868	NA
1988-Q2	39.363	NA
1988-Q3	41.192	41.00092
1988-Q4	43.458	43.23162
1989-Q1	44.865	45.00665
1989-Q2	46.109	46.14396
1989-Q3	49.266	48.69022
1989-Q4	50.938	51.29477
1990-Q1	52.163	52.34247
1990-Q2	53.784	53.60846
1990-Q3	55.920	55.76416
1990-Q4	58.040	57.93617
1991-Q1	61.730	61.31650
1991-Q2	64.612	64.86110
1991-Q3	66.827	67.03518
1991-Q4	69.344	69.36062
1992-Q1	71.964	71.89139
1992-Q2	74.390	74.52605
1992-Q3	74.389	75.23574
1992-Q4	74.414	74.64599
1993-Q1	74.165	74.53641
1993-Q2	74.784	74.80731
1993-Q3	74.874	75.26817
1993-Q4	75.067	75.28788
1994-Q1	75.654	75.73075
1994-Q2	75.707	75.97893
1994-Q3	76.734	76.60628
1994-Q4	77.614	77.73039
1995-Q1	77.582	77.93154
1995-Q2	77.362	77.90981
1995-Q3	77.579	77.48660
1995-Q4	77.872	77.64909
1996-Q1	78.184	78.21867
1996-Q2	78.793	78.86121
1996-Q3	78.972	79.45492
1996-Q4	79.506	79.01853
1997-Q1	80.300	81.16955
1997-Q2	81.075	80.49533
1997-Q3	82.314	82.07983
1997-Q4	83.215	82.91013
1998-Q1	83.624	83.25671
1998-Q2	84.551	84.35186
1998-Q3	85.811	85.59841
1998-Q4	87.488	87.07078
1999-Q1	90.540	90.00451
1999-Q2	91.872	91.75389
1999-Q3	94.273	93.98083
1999-Q4	95.446	95.04552
2000-Q1	97.170	97.85302
2000-Q2	99.270	98.66619
2000-Q3	100.953	100.8368
2000-Q4	103.569	103.4734
2001-Q1	104.649	104.8062
2001-Q2	105.705	104.9658
2001-Q3	106.104	106.0147
2001-Q4	106.234	106.7329
2002-Q1	106.444	105.6669
2002-Q2	106.397	106.1692
2002-Q3	106.141	106.0015
2002-Q4	106.342	106.3858
2003-Q1	107.039	107.3126
2003-Q2	107.347	106.6139
2003-Q3	107.653	107.3181
2003-Q4	107.879	107.9113

	P_NHP	P_NHPF
2004-Q1	108.217	108.3212
2004-Q2	107.991	107.8335
2004-Q3	108.070	107.5327
2004-Q4	108.387	107.6072
2005-Q1	108.391	108.8144
2005-Q2	109.780	109.7235
2005-Q3	111.960	109.4732
2005-Q4	112.360	112.9993
2006-Q1	112.607	113.1926
2006-Q2	112.997	113.5102
2006-Q3	112.840	112.7946
2006-Q4	113.373	113.1957
2007-Q1	114.067	113.9714
2007-Q2	113.323	113.3426
2007-Q3	114.152	113.7723
2007-Q4	112.330	113.0520
2008-Q1	109.483	109.2475
2008-Q2	106.759	106.4288
2008-Q3	103.516	103.9969
2008-Q4	105.475	103.5935
2009-Q1	105.599	105.4072
2009-Q2	106.495	107.0719
2009-Q3	106.729	107.4929
2009-Q4	107.326	106.7327
2010-Q1	107.591	107.6684
2010-Q2	108.060	107.8845
2010-Q3	107.392	108.6086
2010-Q4	106.387	107.2289
2011-Q1	105.309	106.7453
2011-Q2	103.105	104.0167
2011-Q3	101.586	102.3629
2011-Q4	98.369	98.84421
2012-Q1	96.777	97.41086
2012-Q2	94.550	94.81790
2012-Q3	93.766	92.86048
2012-Q4	94.398	92.92151
2013-Q1	92.498	92.79929
2013-Q2	92.078	93.19794
2013-Q3	92.785	93.28548
2013-Q4	94.979	95.70663
2014-Q1	96.334	96.60252
2014-Q2	97.389	97.74361
2014-Q3	97.298	96.36645
2014-Q4	97.129	98.20363
2015-Q1	97.199	96.64293
2015-Q2	100.115	99.26368
2015-Q3	100.604	101.2591
2015-Q4	102.082	101.9433
2016-Q1	103.979	103.7055
2016-Q2	106.328	105.9077
2016-Q3	108.212	108.7697
2016-Q4	109.940	110.3456
2017-Q1	112.199	111.6724
2017-Q2	114.844	115.1827
2017-Q3	119.485	118.8969
2017-Q4	121.532	122.2556
2018-Q1	125.909	125.1686
2018-Q2	127.745	127.9171
2018-Q3	129.592	129.3185
2018-Q4	132.884	132.2501

Figure A.10.3. Detailed Real and Forecasted Values of the Dependent Variable, Nominal House Price (Portugal)