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Residential Property Price Determination and Bubble Detection: Evidence from Seven Advanced Economies

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Abstract

This paper provides empirical evidence on the interrelation between residential property prices and business cycle relationship by combining panel data and time series methodologies to offer a contextual framework on the residential property prices for 7 advanced OECD economies. Initially, we apply a panel methodological framework using quarterly data over the period 2002-2015 that builds upon the interaction of economic fundamentals with financial variables. Additionally, novel evidence is provided on the detection of property price bubbles that have been manifested in each individual country of the sample through the use of time series methodologies developed by Phillips, Wu and Yu (2011) and Phillips, Shi and Yu (2015). The short-run dynamic panel framework provides a robust exploratory platform shedding light on the determinants of property prices (real gdp, bank credit growth, long-term bond yields and real effective exchange rate) whilst the bubble detection methodologies provide evidence on the impact of credit-driven economies on the propagation of housing booms and can serve as warning signals of potential formation of housing bubbles jointly with economic fundamentals, other factors and methodologies.

Key Words: House Price Determinants, Bubble Detection Tests, GMM.

JEL Codes: *C22; G12; R31*

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1. Introduction

Activity in the residential property market has been regarded as a potential indicator of economic performance. At the same time, the fact that housing booms and busts have been detrimental to both financial stability and real economic activity, have strengthened the perception that irrational exuberance as much as fundamentals to a great extent explain house price fluctuations (Shiller, 2009; Mikhed and Zemčík, 2009; Jordà *et al.*, 2016).

Over the course of past decades emerging evidence points towards a significant relationship between key macroeconomic indicators and fluctuations in the property market. Leamer (2007, 2015) provides evidence that residential investment has a larger impact on output that any other sector and is by far the best leading indicator of economic activity. By virtue of its prominence as the best early warning sign of an imminent recession, the housing market assumes a prominent role in the conduct of monetary policy. According to Leung (2004) the significant cyclical movements and volatility observed in the housing market are closely related to macroeconomic movements in the business cycles.

On the empirical front, various studies have been conducted in an attempt to shed additional light in the inherent relationship between macroeconomic indicators and house-price fluctuations. In this context, both cross-country and country-specific studies have generated strong evidence of dynamic interactions between house prices and bank lending (Davis and Zhu, 2011; Goodhart and Hofmann, 2008). Recently, a growing interest in the detection of bubbles in the housing market has spawned new empirical as well as theoretical research on the validity and further development of the current methodological approaches. (see for instance Yiu *et al*. 2013; Caspi, 2015; Engsted *et al*. 2016; Bourassa *et al*., 2016).

Motivated by Mayer's (2011) suggestion that without firm evidence about what causes bubbles, it is hard to develop policy, in this study, we initially explore the housing–business cycle relationship by looking at the determinants of residential property prices for a small panel of 7 advanced OECD economies (Australia, Belgium, Canada, Denmark, Great Britain, Norway and Sweden). A salient feature of the data on house prices is the presence of booms and busts (Burnside *et al*., 2011) that may be driven by fundamentals, but can be compounded by market expectations or speculation (Agnello and Schuknecht, 2011). For this reason, subsequently, we engage in the detection of potential property price bubbles that have been present in the respective property markets of the sample countries by utilizing times series methodologies. Recent reports indicate that in the sample countries housing prices have increased steadily after a brief correction during the Great Recession stressing the fears of

housing bubbles fuelled by record-low interest rates (FT, 2015; IMF, 2014). In our study, we employ the recently developed recursive procedures developed by Phillips *et al*. (2011, hereafter PWY) and Phillips *et al*. (2015, hereafter PSY) to identify and date residential house-price bubbles. These procedures have proved to be useful as warning signals in surveillance strategies developed by central banks with real-time data (Phillips *et al.*, 2015). We depart from the studies of Engsted *et al*. (2016) and Caspi (2015) by applying the bubble detection tests in the residential real housing price index and the ratio of credit to GDP. This is because the prospect of capital gains appears to remain a key driver for investors even in the face of declining rental yields. The declining affordability of housing and increasing investor presence have seen a downward trend in the share of households owning their own home in a number of OECD countries. For this reason, we consider as more relevant to apply the bubble detection tests on the housing index for each country.

The rest of the study is organized as follows: Section 2 provides an overview of the literature review and section 3 discusses the data and the methodology used. Section 4 presents as well as elaborates on the results of the panel data estimations whilst section 5 delineates and discusses the results of the detection of property bubbles. Section 6 provides some concluding remarks.

2. Literature Review

The interlinkages between housing prices, credit and real economic activity are well documented in both the theoretical and the empirical literature. Equally, a number of studies focused on financial instability risks inherent in the growing housing market imbalances. Especially, housing prices' busts can severely hurt economies. Analysing house prices in 14 countries during 1970-2011, IMF identified 20 examples of busts, when real prices fell by almost 30% on average, which led to a recession to all countries except one. America was the only country to avoid the boom and bust during that period. Subsequently, we focus on cross-country studies that analyse the determinants of housing prices.

In a sample of 15 countries, Adams and Füss (2010) find that house prices tend to increase in the long-run by 0.6% in response to a 1% increase in economic activity while the long-term interest rate show average long-term effects of approximately 0.6% and -0.3%, respectively. The evidence suggests that property price busts, even though found to be less frequent than equity price busts, they were twice as large in duration hence, resulting in significant output losses (Helbling and Terrones, 2003). At the same time, the time to full recovery or long-term

equilibrium may take up to 14 years, suggesting a slow adjustment process between macroeconomic variables on international housing prices (Adams and Füss, 2010).

Using a reduced-form theoretical model which relates bank lending to property prices, Davis and Zhu (2011) find that macroeconomic shocks (GDP, interest rates) cause changes in property prices and bank lending, in a sample of 17 developed economies. Goodhart and Hofmann (2008) provide evidence of a significant multidirectional link between house prices, credit and the macro-economy while the effects of shocks to money and credit are found to be stronger when house prices are booming. In a panel of 49 US states over the period 1975-2003, Holly *et al*. (2010) document a cointegrating relationship between house prices and real incomes and identify a small role for real interest rates. In a study for 14 OECD countries, Hott and Jokipii (2012) find that short-term interest rates that are set too low for too long have a significant impact on the creation of housing bubbles.

Recently, the respective literature has been enriched by studies that investigate the rapidly growing economies of the Asian region. More specifically, Jianhua and Huidian's (2013) evidence for the Chinese economy points towards a significant but nevertheless weak long-term equilibrium relationship as well as a bidirectional causality between the macroeconomic factors and the property markets. Additional evidence for the Turkish economy indicated that house prices are affected by innovations in CPI whereas the role of wages is insignificant (Ucal and Gőkkent, 2009). Beltratti and Morana (2010) find a bidirectional linkage between real housing prices and macroeconomic developments and that US are an important source of global fluctuations for real housing prices in the G-7 area.

Punzi (2016) finds that the correlations between real GDP per capita and real housing prices and between lending and real housing prices have increased over time, more evidently if we compare periods of the Great Recession with the Great Depression. In line with Igan *et al*. (2011), Punzi (2016) finds that asset prices tend to lead real activity. Igan *et al*. (2011) provide evidence that house price cycles lead credit and real activity in the long run, while in the short to medium run the relationship varies across countries. In contrast, Cerutti *et al*. (2015) find that the presence of a household-credit boom increases the probability of a real-estate boom to 57 percent from an unconditional probability of 29 percent suggesting that household-credit booms are better predictors of house-price booms than private credit booms. But, as Burnside et al. (2011) point out it remains difficult to find observable fundamentals that are correlated with price movements. In of booms and busts in housing prices for 18 industrialised countries over the period 1980–2007, Agnello and Schuknecht (2011) found that domestic credit and interest rates have a significant influence on the probability of booms

and busts. Moreover, global liquidity plays a significant role for the occurrence of housing booms and—in conjunction with banking crises—for busts. Empirical studies generally indicate that housing markets are influenced by the business cycle. The macroeconomy is typically proxied by fundamentals such as unemployment rate, inflation, industrial production and real GDP. Furthermore, there is a pronounced role for financial variables like monetary conditions (interest rates, money-credit supply) but also non-economic indicators such as the regulatory – institutional setting. Martin et al. (2007) claim that real and financial variables interact in boom-bust phases of asset prices. We aim to investigate this interaction using a panel data methodological framework.

3. Data and Panel Methodology

The choice of the countries in this study is determined by a) the fact that real house prices have increased by more than 50% in 2000-2015 (150% in the period 1985-2015) and b) the fact that the supply of housing, especially in the big cities of these countries is highly inelastic. The latter may not hold for Denmark which has been included in the sample because it has one of the highest household debt ratio in the world, reflecting little incentive to pay off the debt and build house equity (IMF, 2015). In determining whether houses in the sample countries are fairly valued we also looked at the ratios of house prices against rents or house prices against average income where a similar trajectory has been observed. In both cases, the ratios moved higher compared to their historical averages thus, indicating an overvaluation. Lastly, the choice of the sample was driven by the fact that these economies are considered to be 'stable and secure' environments by foreign investors according to surveys by the Association of Foreign Investors in Real Estate. A dominant feature of the housing market resurgence, recently, has been an increase in investor activity. The inherent homogeneity of these economies is arguably a valid reason why they might be experiencing a cyclical synchronization of house price fluctuations (Hirata *et al*., 2013).

In this context, we formulate and estimate a model for seven advanced OECD economies – Australia, Belgium,[1], Canada, Denmark, Great Britain, Norway and Sweden by using quarterly data spanning the period 2002q4-2015q2. In particular, the dataset consists of N cross sectional units, denoted $i = 1,\ldots, N$ observed at T time periods, denoted $t = 1,\ldots,T$.

[1] After the collective pre-crisis boom, European housing markets followed two paths: Denmark, Greece, Ireland, Portugal and Spain dropped sharply. Others including Belgium, Great Britain, Norway and Sweden only dipped before rebounding with worrying speed.

More specifically, y is a ($TN\times1$) vector of endogenous variables, x is a ($TN\times k$) matrix of exogenous variables, which does not include a column of units for the constant term. In this context, we collated data for a cross section of 7 OECD economies $(N=7)$ over a period of 51 quarters $(T=51)$. (See Table 1 for definitions of variables and data sources).

Table 1 Variables, definitions and sources.

Variables	**Definition**	**Source**
hp	Residential Property Price Index, Real, 2010=100	BIS
gdp	Real GDP.	National Bureaus of Statistics.
un	Unemployment as a percentage of total labour force.	National Bureaus of Statistics.
bcr	Credit to private non-financial sector by banks as a percentage of GDP.	BIS
hcr	Credit to households as a percentage of GDP.	BIS
ltby	Long-term bond yield (%)	IMF, OECD, ECB, Bank of Canada, Bank of England.
rer	Real Effective Exchange Rate	BIS

The empirical specification of the house price regression is a variant of the standard specifications encountered in the literature (see for instance Drake, 1993; Glindro *et al*. 2011, Alexiou *et al*., 2014). Given the dynamic dimension of our model we opted for the Generalised Method of Moments (GMM) introduced by Holtz-Eakin (1988) and further developed by Arellano and Bond (1991) and Arellano and Bover (1995). The GMM methodological framework is known to be very effective when dealing with estimation issues such as: bi-directional causality between variables; the possible endogeneity of explanatory variables, as well as omitted variable biases; time invariant country characteristics (fixed effects), that may be correlated with the explanatory variables; and the presence of autocorrelation (Anderson and Hsiao, 1981; Caselli, *et al.,* 1996; Bond, 2002).

In addition to the two-step system GMM, we also generate estimates using the standard OLS and fixed effects (or within) specifications.

We estimate the following regression specification:

$$hp_{it} = a_0 + a_1 hp_{it-1} + a_2 gdp_{it} + a_3 cr + a_4 rer_{it} + a_5 un_{it} + a_6 ltby_{it} + u_{it}$$

$$u_{it} = v_i + e_{it}$$

where *hp* is the residential real price index; *gdp* is the real GDP that has been used as a proxy to measure the state of the business cycle and household income; *cr* can be either bank credit to private sector (*bcr*) expressed as a percentage of GDP or credit to households (*hcr)*, and expected to positively affect demand for property thus exerting an upward pressure on property prices; *rer* is the real effective exchange rate which following an appreciation/depreciation is expected to positively/negatively affect property market prices, particularly in markets where there is substantial demand from non-residents for investment purposes; *un* stands for unemployment rate and *ltby* is the long-term bond yield, a proxy for long-term rates. This is a one-way error component regression model, where $v_i \sim$ IIN (0, σ^2) and independent of $e_{it} \sim$ IIN (0, σ^2).

Table 2 Estimation Results

Variables	**OLS**	**Fixed Effects**	**TSLS**	**GMM-SYS**
hp_{t-1}			0.961(4.68)***	0.512(7.96)***
gdp	0.325(2.54)**	0.261(3.15)***	0.352(2.34)**	0.241(2.78)***
bcr	0.001(0.10)	0.021(1.71)	0.010(2.19)**	0.252(4.05)**
rer	0.001(0.31)	0.062(1.24)	0.036(2.08)**	0.155(5.36)***
un	0.011(0.17)	0.573(1.01)	0.021(0.24)	0.48(0.81)
ltby	-0.163(2.21)**	0.124(1.33)	-0.180(-0.76)	-0.147(-2.08)***
R^2	0.45	0.47		
AR(1) [(1)]				0.032
AR(2) [(2)]				0.161
Sargan [(3)]				0.357

[(1)] Test for first order serial correlation (p-values); [(2)] Test for second order serial correlation (p-values);[(3)] Tests the null hypothesis of the appropriate set of instruments. A Hausman test between fixed effects and GMM-SYS indicates that GMM-SYS estimates are consistent (X^2) = 32.34 and p-value = 0.037. Robust (HAC) standard errors have been used in the estimation of OLS, Fixed Effects and TSLS models; Time dummies have been used in the estimation; (*), (**) and (***) denote significance at 10%, 5% and 1% level respectively; t-statistics are given in parentheses.

We apply the model specification in the first differences (growth rates) of the variables. The evidence from the panel unit root tests[2] indicated that almost all variables were *I(1)*. The focal point of the analysis that will follow pertains to the GMM-SYS specification,

[2] For economy of space the panel unit root tests are not reported in this paper but are available upon request.

the generated evidence of which yields more reliable estimates. It is worth noting that whenever there is considerable difference between the FE and the GMM estimates (mostly in terms of the significance of the coefficients), the Hausman test is applied to determine which model is the most consistent one. The robustness of our estimated coefficient for the GMM-SYS specification is confirmed by the AR(2) and Sargan tests on the basis of which the null hypothesis of no serial correlation and instrument validity could not be rejected. As robustness test for the validity of the chosen independent variables we also employed the ratio of credit to the household sector and the real interest rates as prolonged periods of low real rates tend to be associated with property hikes. As a robustness test for the results yielded by the GMM-SYS specification, we applied the two stage least square (TSLS) framework and obtained relatively consistent estimators. Also, the results remained robust in the presence of alternative proxies for credit, i.e. credit to households, and interest rates, i.e. money market rates.

4. Results and discussion of the panel framework

The results reported in Table 2 suggest that credit expansion is strongly associated with property price hikes hence, supporting the evidence of a strong housing price-credit nexus. In this context, the use of real estate as means of collateral might act as a conduit through which house price movements feed back into the credit market which in turn drives property prices (Davis and Zhu, 2011). The macroeconomic indicators that proxy real economic growth (*gdp*) and competitiveness of the economy (*rer*) are found to positively affect housing property prices. While the linkage between economic growth and housing prices is well-documented in the literature (Cerutti *et al*., 2015; Martin *et al*., 2007), the respective significant effect of *rer* in the case of developed economies constitutes a novel aspect in the time period of our study which captures both booms and bust for almost all countries in the sample. An appreciating *rer* might be the result of strong foreign inflows in the advanced economies of our sample countries where investment in housing properties is perceived to be a 'safe haven' in periods of uncertainty. Still, an appreciating rer which signals loss in competitiveness could well suggest risks of housing busts or at least, can help explain the occurrence of boom and busts (Martin *et al*., 2007).

We also find that in the short-run, house price-inflation is sensitive to the long-term government bond yields which is aligned with the evidence provided by Tsatsaronis and Zhu (2004) and Hirata *et al*. (2013). In an economic environment with unprecedented low interest rates, households' appetite for housing loans increases to a point where irrational behaviour is

likely to set in. The implication of the latter is of great significance for household mortgage repayment as a potential future increase in the interest rates or a house- price collapse may destabilize the financial sector. In general, low rates are perceived as a source of risk as they drive lending and risk-taking. Our results suggest that increasing long-term bond yields affect negatively housing prices in the sample countries. In the same spirit, Hott and Jokipii (2012) find that low interest rates drive housing prices higher while a number of studies document that an increase in domestic credit growth increase the probability of a housing boom. The effect of unemployment, although insignificant, is positive which is puzzling. This could be attributed to the time period of our study which encompasses both booms and busts for the sample countries implying possible sign switches (Agnello and Schuknecht, 2011).

Generally speaking, there is no widely accepted definition as to what constitutes housing or credit booms and busts. These episodes are generally defined as large and persistent deviations of these variables from some historical norm (Cerutti *et al*., 2015), or sharp increases in prices followed by collapsing ones (Lind, 2009). Strictly speaking, the term bubble may insinuate a predominant role of non-fundamentals which is not always the case for booms. In the following section, we use interchangeably both terms.

5. Detection of housing price bubbles

Property booms can be partly explained by fundamentals as bubble-like symptoms abound in the sample countries. This is because typically, the property bubble tends to replace a stock market bubble but also because of behavioural factors such as the deeply ingrained perception that property is by far the safest and most rewarding investment one can make in their lifetime. Still, housing prices are just as prone to irrational exuberance as is the stock markets. In detecting residential price bubbles, we employ three tests: a rolling window ADF test and the more recent tests developed by Phillips *et al*. (2011, hereafter PWY or SADF test) and Phillips *et al*. (2015, hereafter PSY or GSADF test) which constitute a sup augmented ADF test based on a sequence of forward recursive right-tailed ADF tests (PWY) and a more generalised version of it, which allows for flexible window widths in the recursive regressions on which the test procedure is based (PSY). Especially, the PSY test utilises a recursive flexible window method that is better suited for practical implementation with time series delivering a consistent real-time stamping strategy for the origination and termination of multiple bubbles. In all three tests applied the null hypothesis is of a unit root and the alternative hypothesis is of a mildly explosive process (Phillips and Madgalinos, 2007). In developing these tests we utilise longer time-series (individually for each country)

compared to the panel framework thanks to the data availability in the database of the Bank of International Settlements (BIS). Phillips *et al.* (2015) suggest that the use of these methods over long historical periods presents a serious econometric challenge due to the complexity of the nonlinear structure and break mechanisms that are inherent in multiple-bubble phenomena within the same sample period.

Table 3 Housing bubble detection tests

Australia (2003Q1-2015Q3)			
Period No.	Rolling ADF	PWY (2011)	PSY (2015)
1	2007Q2-2008Q3	2007Q1-2008Q4	2007Q2-2008Q4
2	2013Q1-2014Q4	2014Q1-2014Q4	2013Q1-2015Q1
Canada (1970Q1-2015Q3)			
Period No.	Rolling ADF	PWY (2011)	PSY (2015)
1	1987Q4-1989Q2	1988Q3-1989Q2	1988Q1-1989Q2
2	2001Q4-2008Q1	2006Q1-2008Q3	2002Q2-2008Q4
3		2009Q2-2015Q2	2009Q2-2015Q1
Denmark (2002Q4-2015Q3)			
Period No.	Rolling ADF	PWY (2011)	PSY (2015)
1	2015Q1	2005Q4-2007Q3	2005Q4-2007Q1
2			2009Q1-2009Q3
Great Britain (1968Q2-2015Q3)			
Period No.	Rolling ADF	PWY (2011)	PSY (2015)
1	1985Q4-1990Q1	1986Q4-1991Q2	1986Q2-1991Q2
2	1998Q3-2005Q2	1999Q2-2015Q2	1998Q4-2011Q3
3			2014Q1-2014Q2
Norway (1992Q1-2015Q3)			
Period No.	Rolling ADF	PWY (2011)	PSY (2015)
1	1999Q1-2000Q3	1996Q2-2002Q4	1996Q2-2002Q3
2	2005Q4-2007Q3	2004Q1-2008Q3	2005Q1-2008Q2
3		2010Q4-2013Q4	
Sweden (1986Q1-2015Q3)			
Period No.	Rolling ADF	PWY (2011)	PSY (2015)
1	1993Q1-1994Q2	2002Q2-2015Q2	1998Q1-2015Q2
2	1998 Q1-2001Q3		
3	2005Q1-2007Q4		
4	2014Q1-2015Q2		

Notes: (1) The table reports the estimated periods where the respective test statistics are above their corresponding 95% critical values (2) Critical values for all statistics are derived using Monte Carlo simulations with 1.000 replications where the underlying data are generated by a random walk with normal i.i.d. replications.

Notably, the tests were successful in identifying episodes of exuberance without necessary leading in collapses in the sample countries. Overall, the results presented in Table 3 and the respective plots as shown in the Appendix, broadly confirm existing empirical evidence

(Helbing and Terrones, 2003; Goodhart and Hofmann, 2008; Agnello and Schuknecht, 2011; Engsted *et al*., 2016) as well as anecdotal information such as real estate surveys or other market reports. For instance, the results for Canada, Great Britain, Norway and Sweden, i.e. these countries where longer time series were available are in line with Helbing and Terrones (2003). The same applies for the results for Canada, Norway and Great Britain which are broadly in line with Agnello and Schuknecht (2011). Equally, Denmark's results are in consensus with Dam *et al*. (2011) suggesting that the country has experienced a house-price cycle with a run-up in housing prices in 2005-2007. Dam *et al*. (2011) refer to a Danish housing bubble that begun to unfold in 2006-2007 and contributed strongly to the overheating of the economy. In the case of Belgium, the hypothesis of a mildly explosive process (housing bubble) cannot be accepted in all three tests performed – which is in line with IMF (2014) and Agnello and Schuknecht (2011) but in contrast to Engsted *et al*. (2016). A second observation from the results is that housing prices in the sample countries moved largely in tandem during 2000-2015. More importantly, the bust (bubble-bursting) occurred at around the same time in these countries. Firstly, house prices increased significantly prior to the Global Financial Crisis and then, with the exception of Great Britain, house prices collapsed over the period 2006-2008, and in 2014-2015 started to rebound in most of the countries in the sample. The finding of the synchronized fluctuations in the sample housing markets is in line with Hirata *et al*. (2013) suggesting co-movement of housing prices in the developed world as a result of a high degree of integration over the past two decades, and ultimately synchronized business cycles. Certainly, housing booms have different characteristics across (even within) countries and time periods. However, our tests reveal that most of the sample countries move in sync especially in the aftermath of the Global Financial Crisis. Noteworthy, a number of countries (Australia, Canada, Denmark and Sweden) are spotted as candidates for potential housing market 'exuberance' in 2015. Certainly, the tests applied in this paper serve merely as primary indicators of potential formation of housing bubbles that need to be co-estimated with other economic fundamentals and demand-supply factors. As Burnside *et al*. (2011) assert, not all booms in housing prices are followed by busts and the interpretation of booms and busts in housing markets requires a considerable degree of judgement, hence a subjective element as well as the stylised facts in the countries under analysis. Noteworthy, the bubble detection tests seem to be influenced by the length of time series, whereas the rule of 'the longer the better' is directly applicable. Especially, in the case of PSY (2015) the results are mildly sensitive to the choice of the minimal window size and the lag length.

According to Jordà *et al.* (2016) housing bubbles are fuelled by credit booms. Similarly, Davis and Zhu (2011) find strong links of credit to property prices in countries that experienced property-linked crises pointing to a positive long-run effect of credit on prices which is suggestive of possible bubbles. For this reason, we apply in the ratio of bank credit to GDP (*bcr*) the same bubble detection tests we applied in the residential real price index. Preliminary results suggest that credit booms broadly coincide with housing bubbles in most of the sample countries. Future work will enable us to ascertain whether credit booms can help predict house-price booms or the potential direction of the causality between bank credit to the private sector and housing prices.

6. Conclusions

Housing is a key sector in any economy but also a source of financial crises and vulnerabilities in the banking sector. For this reason, property price fluctuations and detection of housing price bubbles have been a focal point of contemporary macroeconomic research. The results generated in this study have important implications as they provide further insights in the understanding of the dynamics of housing prices as well as in the detection of deviations from fundamentals thresholds. Residential property prices and credit creation, long-term bond yields and the real effective exchange rate are intertwined. Therefore, it is important to include housing prices when studying business cycles; housing bubbles are broadly synchronized with excessive credit creation, coinciding or even leading the business cycle. In this respect, the bubble detection techniques can provide an early warning signal of an 'overheating' housing market that can assist regulators in the countries under analysis. Yet, country-specific demand and supply factors need to be accounted for in the study of housing cycles. For instance, it could be that housing demand from foreign inflows could bypass domestic credit. In this context, any design of macroprudential tools by central banks should be calibrated and adjusted according to the pace of economic growth and credit creation whilst taking into account the role of real effective exchange rates.

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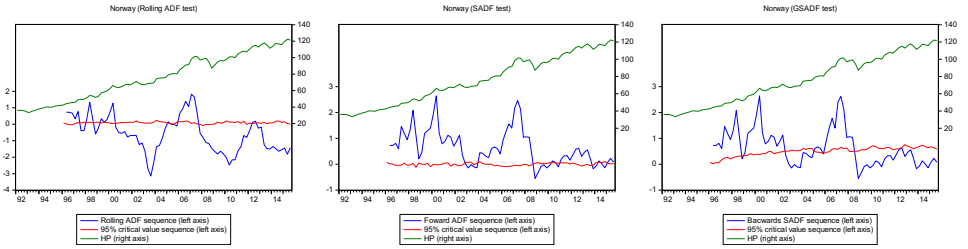
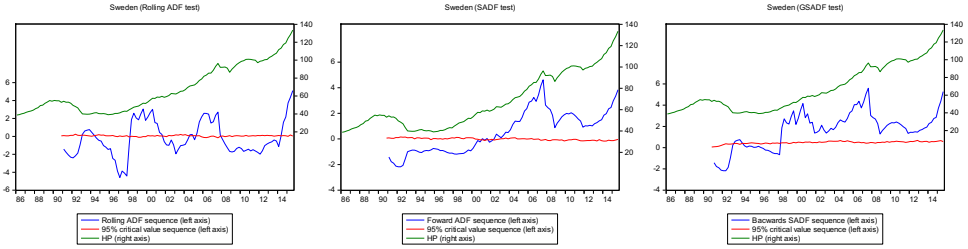
Appendix

Figure 1 Housing bubble detection plots


Norway (Rolling ADF test)
Rolling ADF sequence (left axis)
95% critical value sequence (left axis)
HP (right axis)
Norway (SADF test)
Foward ADF sequence (left axis)
95% critical value sequence (left axis)
HP (right axis)
Norway (GSADF test)
Bacwards SADF sequence (left axis)
95% critical value sequence (left axis)
HP (right axis)


Sweden (Rolling ADF test)
Rolling ADF sequence (left axis)
95% critical value sequence (left axis)
HP (right axis)
Sweden (SADF test)
Foward ADF sequence (left axis)
95% critical value sequence (left axis)
HP (right axis)
Sweden (GSADF test)
Bacwards SADF sequence (left axis)
95% critical value sequence (left axis)
HP (right axis)

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