Received 15 March 2018
Revised 7 June 2018
10 August 2018
18 September 2018
30 October 2018
31 October 2018
Accepted 31 October 2018

Is there a bubble in the Swedish housing market?

Maher Asal
School of Business, Economics and IT, University West, Trollhättan, Sweden

Abstract

Purpose – This paper aims to investigate the presence of a housing bubble using Swedish data from 1986Q1-2016Q4 by using various methods.

Design/methodology/approach – First, the authors use affordability indicators and asset-pricing approaches, including the price-to-income ratio, price-to-rent ratio and user cost, supplemented by a qualitative discussion of other factors affecting house prices. Second, the authors use cointegration techniques to compute the fundamental (or long-run) price, which is then compared with the actual price to test the degree of Sweden's housing price bubble during the studied period. Third, they apply the univariate right-tailed unit root test procedure to capture bursting bubbles and to date-stamp bubbles.

Findings – The authors find evidence for rational housing bubbles with explosive behavioral components beginning in 2004. These bubbles do not continuously diverge but instead periodically revert to their fundamental value. However, the deviation is persistent, and without any policy correction, it takes decades for real house prices to return to equilibrium.

Originality/value – The policy implication is that monetary policy designed to contain mortgage demand and thereby prevent burst episodes in the housing market must address external imbalances, as revealed in real exchange rate undervaluation. It is unlikely that current policies will stop the rise of house prices, as the growth of mortgage credit, improvement in Sweden's international competitiveness and the path of interest rates are much more important factors.

Keywords VECM, Rational, Bubbles, Cointegration, Explosive, Fundamental

Paper type Research paper

1. Introduction

Housing bubbles have long puzzled economists and have led to several strands of definitions, models and empirical tests. Although there is no firm consensus regarding the definition of a housing price bubble, the term is most commonly understood to mean that house prices exceed their fundamental values because homebuyers believe that they can resell the house at an even higher price in the future (Brunnermeier and Julliard, 2008; Stiglitz, 1990). According to this definition, changes in house prices must be attributable to one of two causes (or a combination thereof): changing fundamentals or a speculative bubble. This definition raises questions about the appropriate means of measuring

The research for this paper was financially supported by the University West, without which the present study could not have been completed. The author also thanks the anonymous reviewers for their feedback.

equilibrium house values based on fundamentals. Certain empirical studies assess whether a bubble is present by examining various ratios that compare house prices with rents, incomes or user costs (Himmelberg *et al.*, 2005; McCarthy and Peach, 2004). A bubble is typically identified if the current ratio is much greater than the historical average. Alternatively, a housing bubble arises when homeowners have excessively high expectations about future capital gains, which causes them to perceive their user cost to be lower than it actually is and thus pay too much to purchase a house. Other studies (Yiu *et al.*, 2013) examine whether there is a long-run stationary relationship in the ratio; a failure to reject a unit root is considered evidence of a bubble. These measures have been criticized because rents and incomes are not the only fundamentals that explain housing consumption and because the calculation of the user cost is extremely sensitive to the assumptions made regarding the measurement of expected capital gains.

One commonly used alternative approach to detect housing bubbles is the application of cointegration techniques to compute the fundamental (or long-run) price based on one or several fundamental factors. The long-run relationship is then inserted into an error correction model (ECM) to detect bubbles (Holly *et al.*, 2010). The ECM is subject to criticism, also, for the following reasons:

- The model is inadequate for measuring housing bubbles because the estimation of ECM is based on the entire sample period considered, and thus a correction of house prices toward a long-run equilibrium does not exclude the presence of a housing bubble at a given point in time.
- The choice of variables that define house price fundamentals is relatively ad hoc and does not account for the heterogeneity of housing markets across countries.

A more novel and still rarely used approach drawn from physics focuses on the rate of growth in prices. Lind (2009) and (Mayer, 2011) define a housing bubble as dramatic increases in prices followed by rapid decreases in prices. Zhou and Sornette (2006) define a housing bubble as a situation in which housing prices increase faster than exponentially. This approach raises other questions regarding how fast and by how much housing prices must increase and decrease to constitute a bubble.

Therefore, the existence of house price "bubbles" remains a controversial topic, and the empirical findings to date are inconclusive. Several studies based on supply and demand fundamentals find no evidence of overvaluation and conclude that the price movement follows fundamentals. Examples of such studies include Claussen (2013), Dermani *et al.* (2016), Claussen *et al.* (2011), Englund (2011), and Bergman and Sørensen (2013) for Sweden; McCarthy and Peach (2004), Himmelberg *et al.* (2005) and Gallin (2008) for the USA; and Fox and Tulip (2014) for Australia. In contrast, other empirical studies have found evidence of bubbles, e.g. Turk (2015), the European Commission Report (2016), the IMF (2016) and UBS (2016) for Sweden; Case and Shiller (2003), Wheaton and Nechayev (2008), Bourassa *et al.* (2016) and Nneji *et al.* (2013) for the USA; Oikarinen (2009) for Helsinki, Black *et al.* (2006) for the UK; and Ambrose *et al.* (2013) for Amsterdam.

To resolve this controversy, this paper uses different methods to identify housing bubbles using quarterly Swedish data from 1986 to 2016. First, we use affordability indicators and asset-pricing approaches, including the price-to-income ratio, price-to-rent ratio and user cost, which are supplemented by a qualitative discussion of other factors that affect Swedish housing prices, such as expectations. Second, we use a cointegration technique to compute the "fundamental" price, which is determined either by a single fundamental factor (income or rent) or by a broader set of supply and demand factors against which current prices can be evaluated. The cointegration results are then embedded into a vector ECM to detect bubbles and determine the speed of the adjustment of actual real housing prices to their long-run equilibrium. Third, we use the univariate right-tailed unit root test procedure of Phillips and Yu (2011), which is explicitly designed both to capture bursting bubbles and to date-stamp a bubble's beginning and end. Not only is this procedure a powerful method for detecting explosive or mildly explosive alternatives, it also allows for a sample period that contains both bubble and non-bubble periods (Engsted *et al.*, 2016).

Unlike previous housing studies, this study also explores the role of real exchange rate depreciation in real housing price surges. In standard small open economy models, in which foreign investment plays an important role, such as Sweden, real exchange rate depreciation has an expansionary effect on aggregate demand and housing prices. Despite the central role played by the real exchange rate, we are unaware of any studies that examine its impact on housing markets in a small open economy such as Sweden. Our analysis has been subjected to various robustness checks, both to support the findings of housing bubbles and to quantify the role played by real exchange rate undervaluation in the creation of housing bubbles.

The remainder of this paper is organized as follows. Section 2 offers a review of earlier studies. Section 3 describes the methods used to detect housing bubbles in this study. Section 4 presents an overview of the drivers that presumably affect Swedish real house prices. Section 5 presents the empirical findings of this study. Section 6 presents the robustness check. Section 7 concludes the paper.

2. Review of the literature on housing bubbles

There are two approaches that have been used in the literature to identify housing bubbles, and the empirical findings are inconclusive. The first approach defines a housing bubble as a situation in which house prices exceed their fundamental value because the current owners believe that they can resell their houses at even higher prices in the future (Brunnermeier and Julliard, 2008; Stiglitz, 1990). Researchers who present international evidence for the presence of housing bubbles include Case and Shiller (2003), who compare US house price growth with income growth since 1985 and conclude that income growth can explain nearly all house price increases for more than 40 states. However, their analysis indicates that elements of a speculative bubble exist in some cities. Wheaton and Nechayev (2008) examine the increase in housing prices between 1998 and 2005 for 59 metropolitan statistical areas in the USA and find that changes in income, employment and interest rates do not explain the movement in prices. Oikarinen (2009) estimates a cointegration relationship for Helsinki, finding substantial overvaluation in the late 1980s. Regarding Sweden, measuring overvaluation in terms of deviations from long-term average price-to-rent and price-to-income ratios and using a fundamental model, the European Commission Report (2016) indicates overvaluation in Swedish housing prices by more than 20 per cent and argues that the current level of house prices cannot be fully explained by fundamentals. Similarly, the Swiss investment bank UBS (2016) indicates that Stockholm has the third most overvalued property market in the world, behind London (in second place) and Vancouver (in first place). In a similar vein, the IMF (2016) concludes that Swedish house prices are overvalued by 30 per cent in relation to rent and by 20 per cent in relation to income.

In contrast, other studies find no evidence of overvaluation. For example, McCarthy and Peach (2004) use a structural model of the housing market and find that aggregate prices are not inconsistent with long-run demand fundamentals. Consequently, they conclude that market fundamentals are sufficiently strong to explain the recent path of home prices and that no bubble exists. Himmelberg *et al.* (2005) use supply and demand fundamentals– including house price growth rates, the price-to-income ratio, and the rent-to-price ratio–to assess the state of house prices in terms of both the existence of bubbles and the underlying factors that support housing demand in more than 100 metropolitan areas in the USA for the 1980-2004 period. Their main conclusion is that the cost of home ownership rose moderately relative to the cost of renting, although larger deviations from fundamentals (e.g. bubbles) occurred in certain markets. Fox and Tulip (2014) examine the relationship between housing prices and rents to assess housing overvaluation using data from Australia for the 1955-2014 period. To detect housing bubbles, they decompose house prices into contributions from rents, interest rates and expected capital gains and find no signs of a bubble.

Focusing on Sweden, Claussen *et al.* (2011) analyze the development of Swedish housing prices and evaluate the presence of bubbles in Sweden during the 1986-2010 period. They use an econometric supply and demand model, a Bayesian VAR model and a dynamic stochastic general equilibrium model. The recent rapid rise in house prices can be explained for the most part by higher household income, lower real interest rates and increased preferences for housing consumption compared to other types of consumption. The conclusions with respect to overvaluation depend on the definition, method and period considered. Englund (2011) finds no evidence of overvaluation for the 2005-2010 period and concludes that much of the price increase can be explained by a decrease in after-tax capital costs caused by falling real interest rates and a reduction in Swedish taxation on returns to owner-occupied housing. Dermani *et al.* (2016) use panel data to compare the development of housing prices in Sweden with developments in Denmark, Finland, Norway, the UK, Germany and the USA for the 1995-2015 period. They find no evidence of overvaluation in Sweden and suggest that the primary factors underlying the recent increase in prices are increases in disposable income and financial net wealth, the low level of housing investment, substantial population growth and low real interest rates. Bergman and Sørensen (2013) examine whether Swedish house prices were over- or undervalued in the 1986-2012 period and obtain results that vary depending on the methodology used. Using the ratios of imputed rents to rents and incomes, they find no evidence of overvalued prices in 2012. However, using the VECM, they find evidence that house prices in 2012 were approximately 15 per cent greater than their fundamental level. Claussen (2013) estimates an ECM to examine whether Swedish housing prices are overvalued between 1986Q1 and 2011Q3. He finds that increasing household disposable income and falling mortgage rates are the most important factors in the upswing in prices and that there is no evidence of overvaluation. Turk (2015) uses a three-equation model to examine the interactions between housing prices and household debt in Sweden for the 1980-2015 period. She finds overvaluation in the housing market of up to 12 per cent in 2015.

Other studies focus on the relationship between discounted expected rents and current prices to examine the presence of housing bubbles. Black *et al.* (2006) analyze house prices relative to fundamentals using UK data and a time-varying present value approach for the 1973-2004 period. They note that intrinsic bubbles play an important role in determining actual house prices and that price dynamics are driven by momentum behavior. Ambrose *et al.* (2013) apply a present value model to the Amsterdam rent-price ratio series, finding several bubble periods from 1650 through 2005. They estimate the deviation of house prices based on fundamentals and find that these deviations can be both persistent and long lasting. However, the correction back toward equilibrium can take decades. More recently, Bourassa *et al.* (2016) use the present value approach together with six other methods to identify housing bubbles in six metropolitan areas in three countries: Helsinki (Finland); Geneva and Zurich (Switzerland); and Chicago, Miami and San Francisco (USA) for the period from 1975 to 2012. They conclude that Helsinki experienced bubbles in the late 1970s and mid-to-late 1980s, whereas Miami had a bubble in the mid to late 2000s, and that the price-rent ratio is the best overall method to identify bubbles.

The second approach typically uses the unit root test method, which is based on the time series properties of the data only, to identify bubbles. Phillips *et al.* (2011) develop a method that involves the recursive implementation of a right-side unit root test and a supplementary test to examine explosive behavior and to date-stamp the origination and collapse of a bubble. Applying this methodology to the Nasdaq stock price index in the 1990s, they find evidence of explosiveness and date-stamp the origination of financial exuberance in mid-1995. Yiu *et al.* (2013) apply unit root tests to Hong Kong, identifying ten short-lived "bubbles" during an 18-year period. In recent applications of this technique to national housing markets, Engsted *et al.* (2016) test for housing bubbles using OECD data for 18 countries from 1970 to 2013 and find evidence of explosiveness in many countries, including Sweden. Finally, Nneji *et al.* (2013) examine the dynamics of the residential property market in the USA between 1960 and 2011. They find evidence of an intrinsic bubble in the market pre-2000 and evidence of periodically collapsing rational bubbles in the post-2000 market.

3. Assessing housing bubbles: a theoretical framework

3.1 Ratio analysis

A commonly used measure of possible overvaluation in the housing market in comparison to fundamental value is the price-to-income ratio. A high and prolonged price-to-income ratio can indicate the presence of unrealistic expectations of future housing price increases. Econometric techniques can also be used to test the assumption that real house prices and real disposable income are nonstationary but cointegrated. Evidence of the cointegration of prices and income has been argued as indicative of the absence of explosive rational bubbles in asset prices (Gallin, 2006).

Another measure that is widely used in empirical studies (Case and Shiller, 1989; Gallin, 2008) to assess housing price valuation is the price-to-rent ratio, which measures the relative cost of owning and renting and resembles the price-to-earnings ratio commonly used in equity evaluation. The price of a house should equal the expected benefits of ownership, either as rental income for an investor or as the rent saved by an owner-occupier. One common argument is that when price-to-rent ratios remain high for a prolonged period, prices are being sustained by unrealistic expectations of future price gains rather than the fundamental rental value of houses, and therefore the prices contain a "bubble." Econometrically, one may test for a bubble by examining whether the housing price series is cointegrated with rent. There is a bubble if either:

- the price level is nonstationary but the rent level is stationary; or
- both series are of a first order of integration but are not cointegrated.

In both cases, the relationship between the two variables breaks down, and there is said to be a bubble in the housing market.

The main drawback of these two popular measures is that they do not consider other components of the total cost of housing, which leads us to the concept of the user cost of owner-occupied housing.

3.2 The user cost of owner-occupied housing

A comparison of the costs of home ownership with the costs of the nearest alternative investment seems central to a measure of overvaluation. Following Himmelberg *et al.* (2005), one may express the annual cost of the housing obtained by investing one krona in a home (e.g. the user cost) as follows:

$$\mu_t = r^f{}_t + \omega_t - \tau_t\,(i_t^m + \omega_t) + \delta_t + \theta_t - g_{t+1} + \gamma_t \tag{1}$$

where $r^{rf}{}_t$ is the risk-free interest rate (*i.e.* the cost of foregone interest that the home owner could have earned by investing in something other than a house); ω_t is the property tax rate; τ_t is the effective tax rate on income subject to the tax deductibility of mortgage nominal interest, i_t^m, and property taxes for filers who itemize their income tax deductions; δ_t is maintenance and other carrying costs, such as repairs and insurance; g_{t+1} is the expected capital gain (or loss); θ_t is the yearly depreciation; and γ_t represents a risk premium to compensate home owners for the higher risk of owning versus renting. Multiplying the user cost by the price of the property, P_t, one obtains the annual cost of home ownership in SEK (e.g. imputed rent) as $P_t\,\mu_t$:

$$P_t\,\mu_t = P_t\left[r^f{}_t + \omega_t - \tau_t\,(i_t^m + \omega_t) + \delta_t + \theta_t - g_{t+1} + \gamma_t\right] \tag{2}$$

$P_t\,\mu_t$ should not exceed the yearly cost of renting, R_t. In equilibrium, a household will be indifferent between owning and renting if $R_t = P_t\,\mu_t$. After rearranging, we have the following equation:

$$\frac{P_t}{R_t} = \frac{1}{\mu_t} \tag{3}$$

Equation (3) states that the equilibrium price-to-rent ratio should equal the inverse of the user cost. Thus, a decline in the user cost leads to a corresponding increase in the price-to-rent ratio that reflects fundamentals. Equation (3) also implicitly defines an equilibrium value for housing: $P^* = \frac{R_t}{\mu_t}$. This relation resembles the Gordon growth model (DDM), which is used to determine the value of a stock based on a future series of dividends that grow at a constant rate. The main problem with using user cost to assess housing bubbles is that the forecast housing inflation rates in the user cost formula may not be consistent with the long-run equilibrium.

3.3 The structural housing model

Following the literature, the model presented below provides rigorous properties of housing prices over the long run, including a correction mechanism to capture price adjustment to their long-run relationship. In the long run, the demand for housing (D) determines the equilibrium price that will clear the stock of housing (S), as given by the following equation:

$$D(X, P) = \oint_0^T DS \tag{4}$$

Stating the variables in logs and adding an error term, ε_t, the observed price, p_t, can be expressed as a function of the equilibrium price, p_t^*, which is determined by the housing stock and demand factors:

$$\mathrm{p}_t = \alpha_0 - s_t + X + \varepsilon_t = p_t^* + \varepsilon_t \tag{5}$$

Thus, housing markets can clear rapidly only if prices react to demand, X, and housing stocks, s_t. New housing supply relative to a given level of demand will lower house prices. On the demand side, theory suggests that an increase in households' real disposable income fuels demand for housing, X, and spurs an increase in housing price appreciation in the short run at a fixed supply. Theory also suggests that an increase in the after-tax real interest rate increases the yield of other fixed-income assets, such as bonds, relative to that of real estate, which shifts demand, X, from real estate to other assets. Additionally, a higher real interest rate is reflected in higher mortgage rates, which will decrease demand and further reduce house prices, making renting more appealing than buying. Demographic factors, which describe the composition of a population (e.g. population growth, age and migration patterns), can also affect not only overall housing prices but also which types of properties are in demand. A positive population shock, i.e. a population increase caused by natural population growth or inflows of immigrants, fuels demand for housing because it increases the share of potential purchasers who need to consume real estate assets.

Unlike previous housing studies, we argue that another important determinant of housing demand and prices is the real effective exchange rate. In standard small open economy models in which foreign investment plays an important role, such as in Sweden, real exchange rate depreciation (i.e. an improvement in international competitiveness) has an expansionary effect on aggregate demand, improves the current account position and can drive up housing prices. Real depreciation not only makes exports more competitive but also makes them appear less expensive to foreigners. Such expenditure-switching effects are familiar from the well-known Mundell–Flemming–Dornbusch models and remain valid in the new open economy macro model. Improvement in competitiveness prompts the sale of houses and other assets in a given country, and only buyers who can pay in the stronger foreign currency can pay the sale price. Evidence that foreign buyers push up housing prices and rents can be found in OECD countries (Sá *et al.*, 2014) and in other nations with weak currencies (e.g. the UK following the devaluation of the British pound in 1992, 2009 and 2016).

In summary, the observed real housing price, p_t, can be expressed as a function of the long-run equilibrium real housing price for one- and two-family dwellings, p^*, which is determined by aggregate household real disposable income, $rdisp_t$; the real after-tax deductibility mortgage rate, $atmr_t$ (which is a simple measure of the user cost); the demographic variable, pop_t (which captures the share of the 25-44 age cohort in the population, i.e. those who are most likely to buy housing); the real effective exchange rate, $reer_t$; unemployment, $unemp_t$; and the housing stock, $stocks_t$. Thus, the empirical version of the inverted demand model is expressed as follows:

$$p_t = \alpha_0 + \alpha_1 rdisp_t - \alpha_2 atmr_t + \alpha_3 pop_t - \alpha_4 reer_t - \alpha_5 unemp_t - \alpha_6 stocks_t + \varepsilon_t = p^* + \varepsilon_t \quad (6)$$

Equation (6) reflects the equilibrium of supply and demand for housing stock and implies that a surge in real house prices could be the result of changes in the factors that determine housing supply and demand (i.e. fundamentals) rather than evidence of overvaluation or a bubble. The coefficients of income and demographics are expected to be positive, whereas the real after-tax mortgage rate, the real effective exchange rate and housing stocks should have negative signs.

Building on the previous literature (Ambrose *et al.*, 2013; Dermani *et al.*, 2016; McCarthy and Peach, 2004; Turk, 2015), we incorporate the growth of rent, Δ rent and the growth of real household mortgage debt, Δ rhd, as two additional determinants of housing prices in the short run:

$$\Delta p_t = \alpha_0 + \varepsilon_{t-1} + \sum_{i=1}^{n} \gamma_1 \Delta p_{t-i} + \sum_{i=0}^{n} \gamma_2 \Delta rdisp_{t-i} - \sum_{i=0}^{n} \gamma_3 \Delta atmr_{t-i} - \sum_{i=0}^{n} \gamma_4 \Delta reer_{t-i} + \sum_{i=0}^{n} \gamma_5 \Delta pop_{t-i} - \sum_{i=0}^{n} \gamma_6 \Delta unemp_{t-i} - \sum_{i=0}^{n} \gamma_7 \Delta stocks_{t-i} + \sum_{i=0}^{n} \gamma_8 \Delta rhd_{t-i} + \sum_{i=0}^{n} \gamma_9 \Delta rent_{t-i} + \mu_t \quad (7)$$

Equation (7) represents the specification of housing price dynamics for the purpose of econometric analysis. In the above equation, ε_{t-1} is the error correction term, i.e. the residual from the long-run equation, lagged one period and measures the (quarterly) speed of adjustment to the long-term equilibrium. It is expected to be negative, given that disequilibrium in prices in previous periods will adjust back to equilibrium over the following periods. Once the variables are cointegrated, the long-run relationship is then embedded into a VECM, as described in equation (7), to infer the short-run dynamics and the speed of adjustment of real house prices to their long-run relationship.

4. Development of the fundamentals of Swedish house prices

Sweden's housing market developments reflect the intersection of evolving supply and demand factors. On the demand side, Sweden has experienced a prolonged period of strong increases in disposable income fueled by increasing wages and tax cuts. The indebtedness of Swedish households has steadily climbed in recent years to a record high level. The aggregate ratio of household debt to personal disposable income (after taxes and interest payments) currently stands at more than 180 per cent. The abolition of taxes on property, wealth, inheritances and gifts – together with a 30 per cent mortgage interest deduction – has led to a reduction in user cost for home owners and created a debt preference among households. Combined with a very low, even negative, inflation environment in certain years and an expansionary monetary policy, this trend has led to a significant decrease in mortgage interest rates, which reached an all-time low of 1.65 per cent in 2016. The Swedish population has increased rapidly since 2000, and this increase accelerated in 2006 due to increased net migration. A record high immigration rate of 160,000 people in 2015 alone increased demand for housing, particularly in the country's three largest cities: Stockholm, Gothenburg and Malmo. Supported by monetary policy, the high growth of the Swedish economy has contributed to the continuous decrease in the unemployment rate since 2013, from 8.30 per cent in October 2013 to 6.9 per cent in December 2016. Moreover, the employment rate has risen continually since 2010, reaching 67 per cent in July 2016, which is almost as high as it was before the financial crisis.

Exchange rate developments may also have contributed to the surge in housing prices. Real depreciation, together with several favorable tax reforms, has encouraged foreign homebuyers, particularly those from neighboring Scandinavian countries and Germany. Foreign ownership of vacation homes in Sweden amounted to 6.5 per cent of the vacation housing stock in the country.

Figure 1 shows that the exchange rate depreciated by 18 per cent in real terms, while real house prices increased by 70 per cent in the period 2004-2016, with the accumulated current account surplus reaching 2725.4bn krona in 2016. Lower imported energy prices and restrained nominal wage growth, in addition to strong productivity gains, have reduced cost pressure and are considered the main factors driving the improvement of Swedish competitiveness in recent years. Meanwhile, Sweden's high and persistent current account surplus suggests that the krona is moderately undervalued, a hypothesis that will be examined in Section 6.2.

On the supply side, despite rapidly growing demand for housing, residential housing construction in Sweden has recently been low from a historical perspective. For example, approximately 40,000 dwellings were built annually from 1986 to 1996, compared to approximately 23,000 dwellings built annually from 1997 to 2016. Indeed, neither construction costs nor housing investment profitability (i.e. Tobin's Q) can explain the lack of response of the housing supply to the dramatic increase in demand (Figure 2). The large-scale conversion of rental apartments into tenant-owned housing between 1991 and 2011 resulted in long queues for new tenants in urban areas and encouraged many households to buy rather than rent. Several factors appear to have restrained construction in recent years, including high land prices, regulations in the rental market, and limited access to land in attractive locations (Emanuelsson, 2015).

5. Empirical results: Is there evidence of a housing bubble in Sweden?

As there is no firm consensus on what constitutes the fundamentals of housing prices, we start by examining the development of the price-to-income ratio, the price-to-rent ratio and

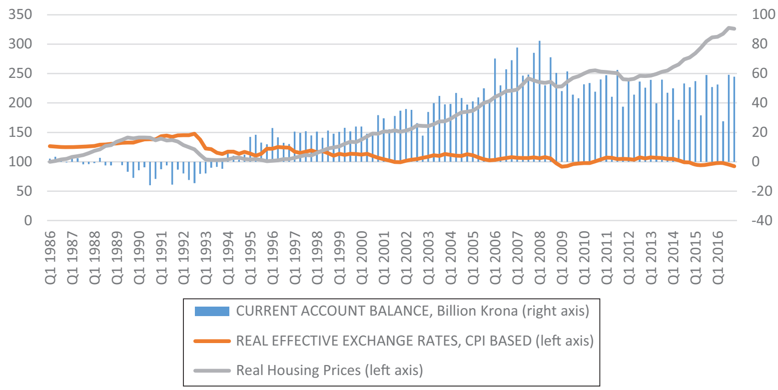

Figure 1.
Sweden's real effective exchange rate, current account balance and real house prices, 1986-2016.

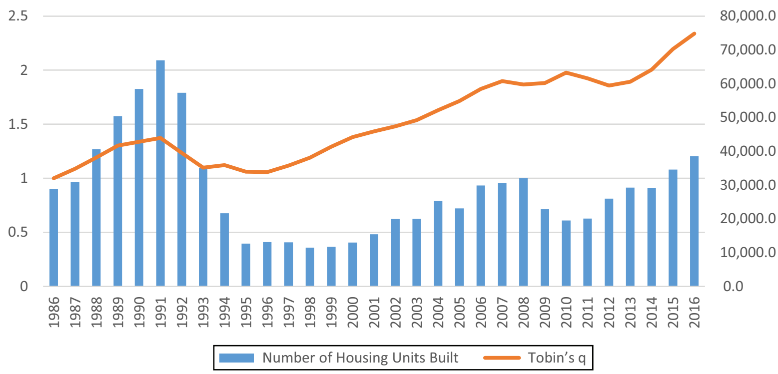

Figure 2.
Tobin's Q and number of housing units built in Sweden, 1986-2016

the user cost over time to detect bubbles in the Swedish housing market for the period from 1986Q1 to 2016Q4. This qualitative analysis is followed by an econometric analysis to determine whether house prices are cointegrated with one or several fundamentals, as described in Section 3.3. Then, we proceed to the VECM to estimate the short-run dynamics and the speed of adjustment of real house prices to their long-run relationship.

5.1 House prices and their long-run average and trend

Figure 3 shows the development of real prices for one- and two-dwelling buildings for the 1986Q1-2016Q4 period. The figure shows that except for a temporary dip following the introduction of the mortgage cap in October 2010, real house prices in Sweden have grown almost without interruption for the past 20 years. Between 1986 and 1995, real single-family house prices increased an average of 0.42 per cent per year, or 4.2 per cent over the course of 10 years. In contrast, from 2004 to 2016, national real house prices increased 6 per cent per year, amounting to an almost 78 per cent increase in 13 years. This growth has accelerated since late 2014. However, the pace of growth decelerated in 2016, reflecting the high level of prices reached in the fall of 2015 and the introduction of an amortization requirement for new mortgages in June 2016. Nonetheless, housing prices currently stand at approximately 80 per cent above their 20-year average, and expensive housing has resulted in an increasing portion of new borrowers taking on high debt relative to their income. Although national house prices have increased all over the country, there are significant regional differences. The metropolitan areas of Stockholm and Gothenburg have exhibited the greatest price increase since 2004, with increases of 100 and 83 per cent, respectively.

Figure 3 seems to suggest that Swedish real house prices have been above their long-run average since 2004 and above their long-run trend since 2006, which indicates that the Swedish housing market might be overvalued. Nonetheless, the estimated long-run trend in real house prices depends on the period considered; therefore, high and prolonged house price growth above its long-run average or trend is only an indication of overvaluation.

5.2 Price-to-income ratio

Figure 4 shows the price-to-income ratio compared to its long-run average and trend. As seen from the figure, the price-to-income ratio began to decline in 1991 and continued to decline for three successive years, bottoming out in 1993 at 42 per cent

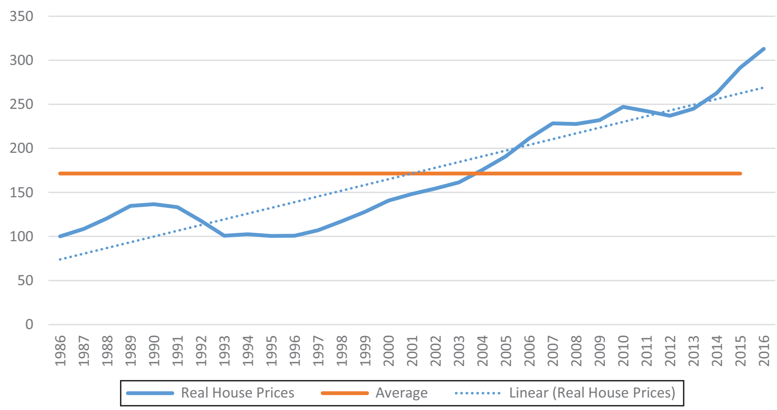

Figure 3.
Real Swedish house prices vs their long-run average and trend, 1986-2016

below its 1990 level. After 1996, the price-to-income ratio began to increase, and by 2004, it had exceeded its 1990 peak. Most striking is the fact that the price-to-income ratio in 2016 exceeded its long-term average and surpassed the prior peak in 1990 – when there was arguably a bubble in the housing market – by 52 per cent. Notably, the 2004-2016 development suggests that the Swedish housing market is currently overvalued at 152.8 per cent of the historic price-to-income ratio. On these grounds, the IMF and the Swiss investment bank UBS (2016) conclude that Swedish house prices are overvalued by approximately 30 per cent.

5.3 House price-to-Rent ratio

Figure 5 shows the price-to-rent ratio compared to its long-run average and trend. The figure shows that beginning in the mid-1980s, there was an increasing trend in the price-to-rent ratio. After 1990, the price-to-rent ratio started to decrease, reaching an all-time low of approximately 59 points in 1996. Between 1991 and 1996, the price-to-rent ratio decreased by 30 per cent, leaving the ratio 27 per cent less than its 1990 value. More remarkable is the fact that the price-to-rent ratio increased by more than 24 per cent (8 per cent annually) between 2014 and 2016. Whereas rent per m^2 increased by 47 per cent (2.25 per cent per annum) from 1996 to 2016, house prices increased by 210 per cent (10 per cent per annum). If one were to focus on the evolution of the house price-to-rent ratio since 2004, one might conclude that the Swedish housing market is currently extremely overvalued at 170 per cent of its historic price-to-rent ratio.

As noted, neither the price-to-income ratio nor the price-to-rent ratio reflects the cost of owning a home. Additionally, rents in Sweden are not determined in free markets but rather established through negotiations in which central organizations representing landlords and tenants agree on a fair price (Englund, 2011). For these reasons, we need to calculate the cost of owning a house (i.e. the user cost), which can then be compared to rental costs to judge whether the cost of owning is out of line with the cost of renting.

5.4 User cost and imputed rent

One way to judge whether housing prices are overpriced is to calculate the imputed-to-actual-rent ratio and compare it to its 25-year average. In addition to providing an alternative measure of housing valuation, this measure allows us to assess whether the imputed cost of owning a house relative to renting the same unit has changed over time. In a

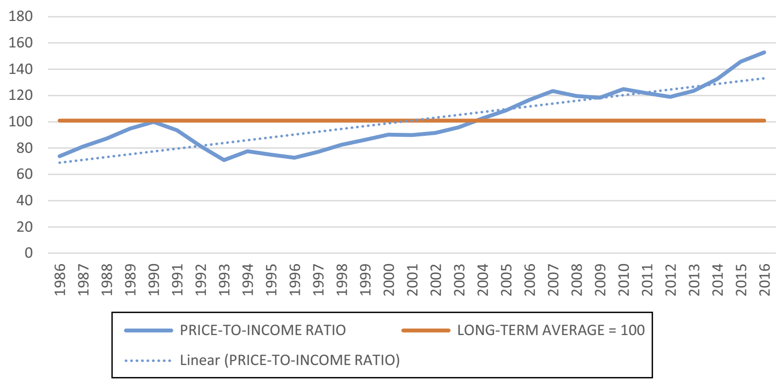

Figure 4.
Price-to-income vs its long-run average and trend, 1986-2016

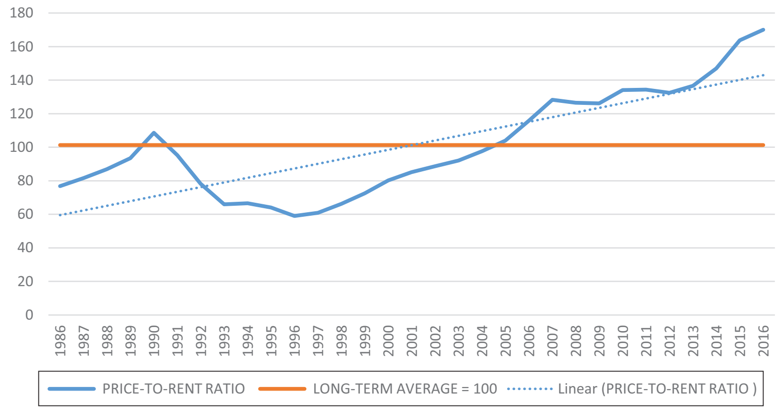

Figure 5.
Price-to-rent vs its long-run average and trend, 1986-2016

bubble market, we would expect the user cost to increase faster than rents, thus raising the imputed rent-to-actual-rent to unjustifiable levels (Himmelberg *et al.*, 2005).

The development of the imputed-to-actual-rent ratio along with its 25-year average is depicted in Figure 6 (for measurements of the variables and parameters included in the imputed rent formula, see Table AI in the Appendix)[1]. The figure identifies two periods in which the imputed-to-actual-rent ratio is above its 25-year average. The first occurs between 1994 and 2000, when the user cost peaks more dramatically following the sharp decline of the mortgage interest rate and capital gains. The second overvaluation extends from 2013 to the present, a period in which the user cost temporarily increased following the temporary decline in capital gains, leading to a period of overvaluation[2].

By these measures, houses were underpriced relative to income and regulated rents from 2001 to 2013, and they have been overpriced since 2013. To explore what motivates purchases, we must explore the components of the user cost, particularly the interest rate and expectations.

5.4.1 The role of the mortgage rate. The downward trend in nominal mortgage interest rates over the past two decades (from 9.1 per cent in 1996 to 1.65 per cent in 2016), and the resulting decrease in user cost have significant implications for home ownership affordability (the home price-to-income ratio) and for return on housing (the price-to-rent ratio). Despite a record high household indebtedness of greater than 180 per cent of disposable income in 2016, the household debt-service ratio (DSR), as percentage of

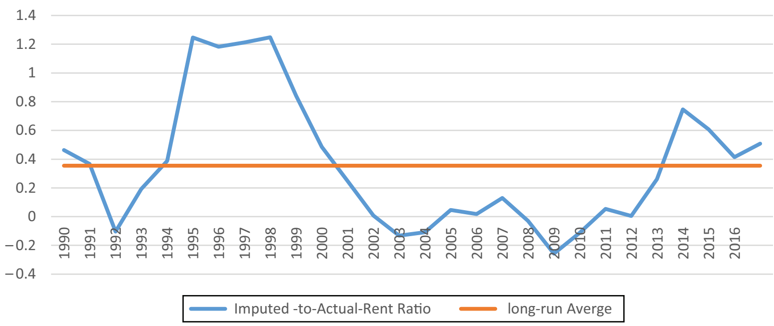

Figure 6.
Imputed-to-actual-rent ratio vs its long-run average

disposable income, has decreased steadily in recent years (Figure 7). Hence, the increase in household indebtedness has been offset by the decline in the borrowing rates, such that on average, households have not devoted a greater share of their income to debt service than they have in the past[1].

5.4.2 The role of expectations. The calculation of the user cost shown in Figure 7 is extremely sensitive to the assumptions regarding the measurement of expected capital gains. One may assume that home buyers expect house prices to rise at the same rate as consumer prices. However, this assumption is inconsistent with a rational view of the housing market, given the negative inflation and accelerated increase in house prices in Sweden in recent years. Alternatively, one may assume that home buyers form their expectations rationally. It is often argued that the recent house price boom is explained by excessively optimistic expectations. Homebuyers may believe that a home that they would normally perceive as too costly is an acceptable purchase because they will be rewarded by a substantial price upsurge. Case and Shiller (2003) report survey evidence indicating that homebuyers tend to extrapolate past price increases during booms, which contributes to further price increases.

Consistent with rationality, we measure expected capital gains (g) in the user cost formula by moving average changes in real housing prices in the previous period adjusted for a risk premium, γ_t, measured by the standard deviation of housing price changes in previous periods (up to three years). Similar to the previous Swedish literature (Englund, 2011), we added an additional risk premium of 5 per cent to reflect current and future borrowing constraints and any other expected risk of owning a house that could result from a probable increase in the lending rate, the implementation of the proposed debt-to-income (DTI) ratio, or the phasing out of tax deductibility. Incorporating expectations in this manner, assuming constant maintenance, depreciation and house quality, the predicted user cost for 2016 is 1.967 per cent; that is, for every hundred krona in price, the owner pays 1.967 krona per year in cost. On these grounds, people should be willing to pay as much as 51 times (1/0.01967) the market rent to purchase a house. For example, a two-bedroom apartment that rents for SEK 6,000/month (SEK 72,000/year) should sell for a value of SEK 3,672,000, which is close to the market price. Note that with an autocorrelation of the real house price of 88 per cent, embedding such expectations of capital gains and generously

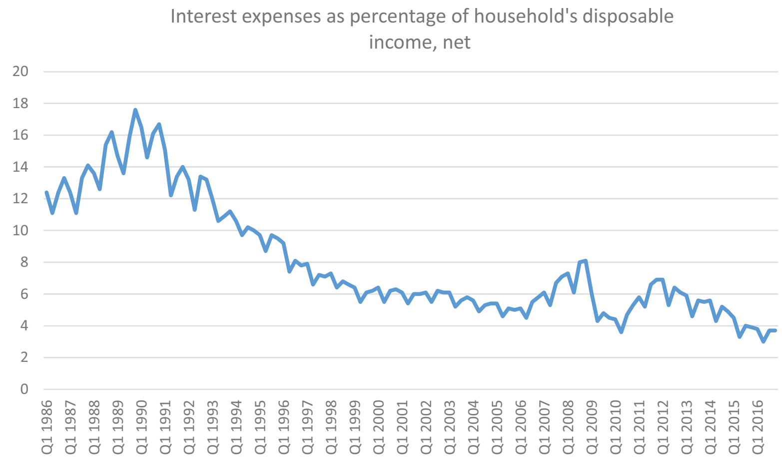

Figure 7.
Household debt-service ratio (DSR) as percentage of disposable income, 1986-2016

estimating the risk premium entails a negative user cost in certain years. A negative user cost implies that housing consumption is costless and that home owners additionally obtain capital gains, which is unsustainable in the long run. This scenario is what a bubble is all about: buying to benefit from future price increases instead of to live in the house. It is this motive that leads to a possible burst of the bubble when the investment motive weakens.

Clearly, if expectations of capital gains follow consumer prices, then a different conclusion is reached. For example, measuring capital gains as the expected inflation rate yields a user cost of 11.235 per cent. For example, a two-bedroom apartment that rents for SEK 6,000/month (SEK 72,000/year) should sell for an unrealistically low value of SEK 808,920. The question is then whether these bubble measures hold up in a richer framework.

In summary, we find that the assessment of housing bubbles based on user cost is extremely sensitive to assumptions about expected capital gains. If real house prices are expected to continue to grow at an average rate that is similar to that of past years, then the Swedish housing market has been overvalued since 2013, even after adjusting for a generous risk premium. As interest rates and risk premiums do not fluctuate much relative to potential expectation changes, expectation formation is key. Only under the assumption that expectations of capital gains follow consumer prices and that rents rise to market value will there be no bubbles. In a long-run equilibrium, actual changes over time must equal expected changes. This condition implies that for current prices to be consistent with long-run equilibrium, actual prices in the future must increase at the inflation rate of 2 per cent. Is this possible under reasonable assumptions about fundamentals? The next section explores this issue.

5.5 Econometric analysis

Judgments about housing valuation also require a determination of the characteristics of time series of the fundamental variables in the model. The chosen methodology for this endeavor is a VECM. This model not only treats both nonstationarity and endogeneity problems but also is capable of jointly estimating short- and long-run interactions between the variables within a consistent framework. First, we determine the order of integration of the fundamental variables via an augmented Dickey–Fuller (ADF) test. Second, if the fundamental variables are integrated to the same order (e.g. I (1)), then we apply the Johansen method of cointegration to determine the long-term relationship between housing prices and their fundamentals. Third, if the variables are cointegrated, then we apply the VECM to assess the short-term dynamics of the endogenous variables and the speed of adjustment of house prices to their cointegrated relations.

Quarterly data from 1986Q1 to 2016Q4 are used. Based on equations (6) and (7), the following variables are considered: real house price (rhp); aggregate household real disposable income (rdisp); real after-tax mortgage rate (atmr); real effective exchange rate (reer); housing stocks (stocks); unemployment rate (unemp); population (pop); real household debt (rhd); and rent[3]. All data are transformed to their natural logarithms, except for atmr and unemp (for a full description of the variables and data sources, see Table AI in the Appendix).

5.5.1 Testing for stationarity. We begin by testing for stationarity of the studied data using the technique of Dickey and Fuller (1981) to check whether these data are first-order integrated. Table I reports the results of ADF test statistic for the presence of a unit root in level with the inclusion of the only constant and constant plus trend. The results shown (Columns 2-5) cannot reject the null hypothesis of the presence of unit roots (i.e. the data are nonstationary) in level for all the fundamental variables, which is a precondition for the application of cointegration analysis. We repeat the test using the first differences of each

Table I.
Results of augmented Dickey–Fuller test statistic for the presence of unit root

	Level				First difference				
	Constant		Constant + Trend		Constant		Constant + Trend		
Variables	*t*-Statistics	Prob.*	*t*-Statistics	Prob.*	*t*-Statistics	Prob.*	*t*-Statistics	Prob.*	Order of integration
RHP	−0.12	0.94	−3.11	0.11	−3.49	0.01	−3.57	0.04	I(1)**
RDISP	0.88	0.99	−1.95	0.62	−3.33	0.02	−6.52	0.00	I(1)*
RGDPCAP	−0.53	0.88	−2.09	0.55	−5.08	0.00	−5.06	0.00	I(1)*
ATMR	−2.72	0.07	−2.88	0.17	−7.47	0.00	−7.45	0.00	I(1)*
UNEMPLOYMENT	−3.18	0.02	−2.93	0.16	−2.46	0.13	−2.67	0.25	I(0)
STOCKS	−2.30	0.17	−2.23	0.47	−3.08	0.03	−3.11	0.11	I(1)**
POULATION	0.72	0.99	−2.48	0.34	−2.13	0.23	−2.13	0.52	I(2)
REER	−1.33	0.61	−3.26	0.08	−7.96	0.00	−7.94	0.00	I(1)*
RCC	0.10	0.96	−1.75	0.72	−4.84	0.00	−4.90	0.00	I(1)*
RHD	1.13	1.00	−0.93	0.95	−8.81	0.00	−8.90	0.00	I(1)*
RENT	−3.24	0.02	−2.88	0.17	−2.59	0.10	−3.31	0.07	I(1)*
Critical values									
0.01	−3.49		−4.04		−3.49		−4.04		
0.05	−2.89		−3.45		−2.89		−3.45		
0.10	−2.58		−3.15		−2.58		−3.15		

Notes: Augmented Dickey–Fuller test including constant as well as constant plus trend; Lag length criteria: automatic selection based on Schwarz info criterion; *t*-statistics and probability are reported. All variables are expressed in logs except real after-mortgage rate, ATMR and Unemployment; * and ** indicate significance at 1 and 5% level, respectively; Number of observations is 122

series (Columns 6-9) and find that we can reject the null hypothesis of nonstationarity for all variables (e.g. I (1)) except population, which becomes I (2). Thus, the assumption that all fundamental variables included in the VAR are nonstationary processes appears to be validated by the sample data. One of the puzzling aspects of these results is the difficulty in rejecting the unit root hypothesis for real exchange rates, which implies that shocks to the real exchange rate are never reversed and that there is no tendency for purchasing power parity to hold even in the long run. These results motivate the inclusion of the real exchange rate variable in the long-run equation and are consistent with McDermott (1996), among many others, who find that only one of the 22 real exchange rates exhibits evidence against unit roots.

5.5.2 Testing for cointegration. Provided that all variables are nonstationary, we start by testing the assumption that real house prices are cointegrated with a single fundamental variable (real disposable income or rent). We apply the Johansen test, which is powerful even when the sample size is small, as is the case in this study (sample size = 118). The Johansen procedure involves the use of two test statistics for cointegration: the trace test, which tests the hypothesis that there are at most r cointegrating vectors, and the maximum eigenvalue test, which tests the hypothesis that there are $r + 1$ cointegrating vectors (Johansen, 1991). The corresponding test results are presented in Table II. The trace and maximum eigenvalue tests cannot reject the null hypothesis of no cointegration between house price and real disposable income (panel A) at the 0.05 level. Similarly, the results provide evidence in favor of no cointegration between prices and rents (panel B). The absence of a long-run relationship between real house prices and real disposable income (or rents) suggests the presence of a bubble in the Swedish housing market or that rents and incomes are not the only fundamentals that explain housing consumption[4]. Lower interest rates, relaxed lending standards, sluggish rents and weak currency, among other factors, are likely to be important drivers of Swedish housing prices in recent years.

Next, we test the hypothesis that real house prices are cointegrated with a broader set of fundamentals, namely, real disposable income, real after-tax mortgage rates, unemployment rate, the real exchange rate and housing stock[5]. Table III reports the results of the Johansen trace test (Panel A) and the maximum eigenvalue test (Panel B). Whereas the trace test indicates three cointegrating equations, the maximum eigenvalue test indicates four cointegrating equations at the 0.05 level. The null hypothesis of no cointegration is strongly rejected because the trace and maximum eigenvalue test statistics are greater than the critical values and suggest the presence of at least three cointegrating equations at the 0.05 level among the six variables in the system. Therefore, we may conclude that house prices are explained by an equilibrium of these housing demand and supply factors in the long run.

5.5.3 Long-run relationships. As indicated in Table IV, the estimated long-run relationships using fully modified least squares indicate that real disposable income is an important variable in the explanation of real housing prices in the long run. Specifically, the cointegration equations reveal that a 1 per cent increase in real disposable income will lead to a 0.88 per cent increase in real house prices. The estimated magnitude of the impact of the increase in real disposable incomes on housing prices, at 0.88, is less than that found in Turk (2015) and Caldera and Johansson (2013) and Claussen (2013) and Adams and Füss (2010), who obtain 1.295, 2.825, 1.3 and 0.99, respectively. The results also suggest that real house prices will decrease in the long run by 2 per cent in response to a 1 percentage point increase in the real after-tax mortgage rate. These results support the financial accelerator effect developed by Bernanke *et al.* (1996), which postulates that given easier access to credit facilitated by financial innovation and in the presence of financial frictions, the impact of changes in the interest rates on consumer wealth and the housing market is stronger when leverage is high, as it is in Sweden[6].

Our results point to the real effective exchange rate as one of the most important variables driving the surge of real housing prices in the long run. In other words, a 1 per cent increase in the real effective exchange rate (e.g. a deterioration of Swedish competitiveness) leads to a 1.7 per cent decrease in real house prices. This lends support to the findings of Sá *et al.* (2014), who find that the depreciation of domestic currencies and the resulting capital inflows have a significant and positive effect on real house prices in OECD countries. Finally, the long-run impact of housing stock has an unexpected positive sign. The estimated magnitude of the effect of housing stock on real housing prices is 0.19. One

	Trace test 0.05					Max-Eigenvalue test 0.05			
No. of CE(s)	Eigen value	Statistic	Critical value	Prob.**	No. of CE(s)	Eigen value	Statistic	Critical value	Prob.**
Panel A Co-integration between real house prices and real disposable income									
None	0.084	13.944	15.495	0.085	None	0.084	10.408	14.265	0.187*
At most 1	0.030	3.535	3.841	0.060	At most 1	0.030	3.535	3.841	0.060
Panel B Co-integration between real house prices and rent									
None	0.11	15.11	15.49	0.06	None	0.11	13.83	14.26	0.06*
At most 1	0.01	1.28	3.84	0.26	At most 1	0.01	1.28	3.84	0.26

Notes: Trace and Max-Eigenvalue tests indicate no cointegration at the 0.05 level up to 4 lags; *denotes rejection of the hypothesis at the 0.05 level; **MacKinnon *et al.* (1999) *p*-values

Table II. Johansen cointegration test between real house prices, real disposable income, real GDP per capita and rent: 1986Q1 to 2016Q4

Table III. Unrestricted cointegration rank Testt–Johansen method: Null H: No cointegration

Panel A: Trace					Panel B: Maximum Eigenvalue				
Hypothesized No. of CE(s)	Eigen value	Trace Sta.	0.05 Critical Value	Prob.**	Hypothesized No. of CE(s)	Eigen value	Max-Eigen Sta.	0.05 Critical Value	Prob.**
None*	0.37	141.0	95.75	0.00	None*	0.37	54.22	40.08	0.00
At most 1*	0.30	86.84	69.82	0.00	At most 1*	0.30	41.34	33.88	0.01
At most 2*	0.15	45.50	47.86	0.08	At most 2 *	0.15	19.32	27.58	0.39
At most 3	0.12	26.18	29.80	0.12	At most 3*	0.12	15.25	21.13	0.27
At most 4	0.08	10.94	15.49	0.22	At most 4	0.08	9.27	14.26	0.26
At most 5	0.01	1.66	3.84	0.20	At most 5	0.01	1.66	3.84	0.20

Notes: While the Trace test indicates 3 cointegrating eqn(s) at the 0.05 leve., the Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level; *denotes rejection of the hypothesis at the 0.05 level; **MacKinnon–Haug–Michelis (1999) *p*-values; Series: RHP RDISP ATMR STOCKS REER UNEMPLOYMENT. In both panels, the length pf the lags used in the VAR model is determined by the Akaike Information Criterion (AIC)

Table IV. Fully modified least squares (FMOLS) estimate of the long-run determinants of real house prices. Period estimated 1986Q1- 2016Q4

Variable	Coefficient	Standard error	*t*-statistic	Prob.
RDISP	0.88	0.04	20.14	0.00*
ATMR	−0.02	0.01	−2.24	0.03*
STOCKS	0.19	0.05	3.65	0.00*
UNEMPLOYMENT	0.001	0.01	0.01	0.99
REER	−1.71	0.11	−15.09	0.00*
R-squared	0.88	Mean dependent var		5.10
Adjusted *R*-squared	0.87	S.D. dependent var		0.36
S.E. of regression	0.13	Sum squared resid		1.89
Long-run variance	0.04			

Notes: All variables are expressed in logs except Real After-Mortgage Rate, ATMR, and UNEMPLOYMENT; *indicate significance at 1% level

possible explanation for the positive link between the housing stock and real housing prices is that an increase in housing stocks leads to a decline in both nominal house prices and the consumer price index. Given sluggish house prices, the decline in the CPI following a rise in completion surpasses the decline in housing prices, meaning that the net impact is positive. An alternative explanation is that changes in tenure structures related to the desirability of home ownership as a form of tenure (as against the leading alternative of renting) occupy a peculiarly important role in Sweden[7].

5.5.4 Short run dynamics and vector error correction. We begin by including the percentage changes of all explanatory variables identified in the long-run relationship up to 8 lags. We then include population growth, the growth in real household debt (Δ rhd), and the growth in rent (Δ rent), as orthogonalization is not an issue here because the variables considered are expressed as percentage changes[8]. Table V presents the estimated VECM short-run dynamics in addition to the effects of the exogenous and endogenous variables in the short-run dynamics (equation (7)), with nonsignificant variables eliminated[9]. Before interpreting the results, a number of diagnostic and parameter stability tests are performed to ensure that the residual is white noise. The Breusch-Godfrey serial correlation LM test (Table AII), the Breusch-Pagan-Godfrey heteroskedasticity test (Table AIII), the histogram normality test (Figure A1), and the CUSUM stability test (Figure A2), all of which are presented in the Appendix, are all satisfactory. Moreover, standard diagnostic tests do not indicate specification issues[9].

Allowing the short-run model dynamics to capture housing price expectations, as opposed to explicitly modeling expectations via the user cost variable, leads to significant short-term lagged endogenous variables. Housing price growth shows significant persistence, with lagged coefficients summing to more than 56 per cent. This finding is in line with those of Shiller (2007) and Arestis and González (2013). These estimates also reveal a positive effect of real disposable income changes on real housing price appreciation and indicate that a 1 per cent change in real disposable income leads to a 0.06 per cent change in real house prices. The elasticity of real house price changes in relation to mortgage credit growth (0.26) is significant at the 1 per cent level. These results suggest that the relaxation of credit standards encourages the entry of new homebuyers into the market and helps increase the demand for housing, which in turn increases prices. Increases in the real effective exchange rate, real after-tax mortgage rates, and rents lead to real house price deflation. The elasticities of the respective growth rates of the real effective exchange rate (−0.13), real after-tax mortgage rates (−0.01) and rent (−0.26) are significant and negative. More importantly, the first row presents the value of the error correction term ($\varepsilon_{t\text{-}1}$), which indicates the proportion of disequilibrium between short-run dynamics and the cointegration relationship that is dropped out in each period. This coefficient is negative and significant and suggests a very slow, gradual correction of housing prices toward equilibrium at a rate of only 1 per cent per quarter or 4 per cent per year. In other words, without any policy correction, it takes decades for real house prices to return to their long-run fundamentals. The speed of adjustment found here is much less than those found in Claussen (2013), Adams and Füss (2010) and Turk (2015). In addition, the value of the coefficient of determination (R^2) indicates that only 58 per cent of the variation in changes in house prices is explained by changes in fundamentals. The combination of the slow adjustment speed and the low R^2 suggests the presence of intrinsic rational bubbles that – unlike explosive bubbles – do not continuously diverge but periodically revert to their

Variable	Coefficient	Standard error	*t*-statistic	Prob.
$\varepsilon\ (t-1)$	−0.01	0.00	−2.44	0.02**
ΔRHP1 (t − 1)	0.32	0.07	4.55	0.00*
ΔRHP1 (t − 4)	0.24	0.08	3.24	0.00*
ΔRDISP (t − 1)	0.06	0.01	3.85	0.00*
ΔATMR (t − 4)	−0.01	0.00	−3.08	0.00*
ΔRHDT (t − 4)	0.26	0.08	3.38	0.00*
ΔREER (t − 1)	−0.13	0.05	−2.54	0.01*
ΔRENT (t − 7)	−0.28	0.07	−4.13	0.00*
R-squared	0.58	Mean dependent var		0.01
Adjusted *R*-squared	0.56	S.D. dependent var		0.02
S.E. of regression	0.01	Akaike info criterion		−5.50
Sum squared resid	0.02	Schwarz criterion		−5.31
Log likelihood	327.18	Hannan-Quinn criter		−5.43
Durbin–Watson stat	1.93			

Notes: Δ denotes the first difference and t-n refers to the nth lag; $^{**}p < 0.05$; $^{*}p < 0.01$

Table V. VECM Estimates of the Swedish real house prices. 1986Q1-2016Q4 fundamental value. The correction mechanisms of mispricing back to equilibrium can take decades. Because the results are based on the entire sample period, which spans more than 20 years, we must identify the subperiods in which the Swedish housing market was in a bubble, which we do in the following section.

6. Robustness check

Our VECM based on the structural model is not the only specification that can explain Swedish housing prices. Additional structural variables can always be found, and some combination of these variables may provide a better explanation of real housing prices. However, as we add variables to our model, the available degrees of freedom are quickly exhausted. Our robustness tests therefore include statistical tests, the replacement of structural variables with alternatives to examine the time series properties of real house prices, the price-to-income ratio and the price-to-rent ratio. To that end, we combine the VECM methodology that tests for bubbles with right-tailed Dickey–Fuller (DF) statistics and the Hodrick–Prescott (HP) filter method.

6.1 Right-tailed Dicky–Fuller statistics: subperiod analysis

Right-tailed DF statistics make it possible to test, identify and date-stamp explosive bubbles in the Swedish housing market. This method was developed by Phillips *et al.* (2015). It has been used extensively to detect stock price and housing bubbles before they burst (Diba and Grossman, 1988a, 1988b; Engsted *et al.*, 2016; González *et al.*, 2013; Yiu *et al.*, 2013). In essence, testing for a bubble (with an explosive behavioral component) is based on a right-tailed variation of the standard ADF unit root test, in which the null hypothesis is of a unit root, and the alternative hypothesis is a mildly explosive autoregressive coefficient. In its simplest form, the test is based on the following equation:

$$\Delta y_t = \mu + (\delta - 1)y_{t-1} + \varepsilon_t \tag{8}$$

The null hypothesis is unit root behavior (*H0*: $\delta = 1$), and the alternative hypothesis is an explosive bubble (*H1*: $\delta > 1$). Formally, we test for *H0*: $\delta = 1$ against the alternative, *H1*: $\delta > 1$.

Table VI presents the four test strategies of the right-tailed ADF – standard ADF, RADF (rolling ADF), SADF (sub ADF) and GSADF (generalized ADF) – applied to real house prices, the price-to-income ratio and the price-to-rent ratio. The origination date of a bubble corresponds to the date on which the sub DF statistic becomes greater than appropriate series critical values. In all four tests, the DF statistics are greater than the critical values; therefore, the null hypothesis is rejected. For example, the RADF test with 1,000 replications and 21 windows yields results that indicate the presence of an explosive component in the rational bubbles of real house prices at the 1 per cent significance level (because $2.967 > 0.722$).

Figures 8, 9 and 10 show the SADF tests for bubbles in the real house price series, price-to-income series and price-to-rent series, respectively. The bottom panel of the spool presents the date-stamping procedure for the SADF test and identifies the dates of the bubbles. The graphs include the series (in green), the ADFr2 statistic sequence (in blue) and the corresponding 95 per cent critical values sequence (in red). The diagrams clearly show that Swedish real house prices have been overvalued since 2004 by this measure. Despite dips in 2008 (following the global financial crisis) and 2011-2013 (following the introduction of a mortgage cap of 85 per cent LTV), the extent of overvaluation has been accelerating since 2014. Specifically, the SADF test identifies two bubble periods in real house prices

Table VI. Right tailed ADF tests

	ADF		RADF		SADF		GSADF	
	t-Statistic	Prob.*	*t*-Statistic	Prob.*	*t*-Statistic	Prob.*	*t*-Statistic	Prob.*
Null hypothesis: log real house prices has a unit root								
	0.93	0.00	2.967	0.002	1.998		3.32	0.002
Test critical values								
99%	0.49		0.722		1.965		2.73	
95%	−0.02		0.026		1.301		2.06	
90%	−0.44		−0.34		0.964		1.71	
Null hypothesis: PRICE-TO-INCOME has a unit root								
	4.33	0.00	9.62	0.00	5.08	0.00	10.18	0.00
Test critical values								
99%	0.49		0.72		1.97		2.73	
95%	−0.02		0.03		1.30		2.06	
90%	−0.44		−0.34		0.96		1.71	
Null hypothesis: PRICE-TO-RENT has a unit root								
	7.44	0.00	21.80	0.00	7.44	0.00	21.80	0.00
Test critical values								
99%	0.49		0.72		1.97		2.61	
95%	−0.02		0.03		1.30		1.99	
90%	−0.44		−0.34		0.96		1.71	

Note: *Indicates significance at 1% level

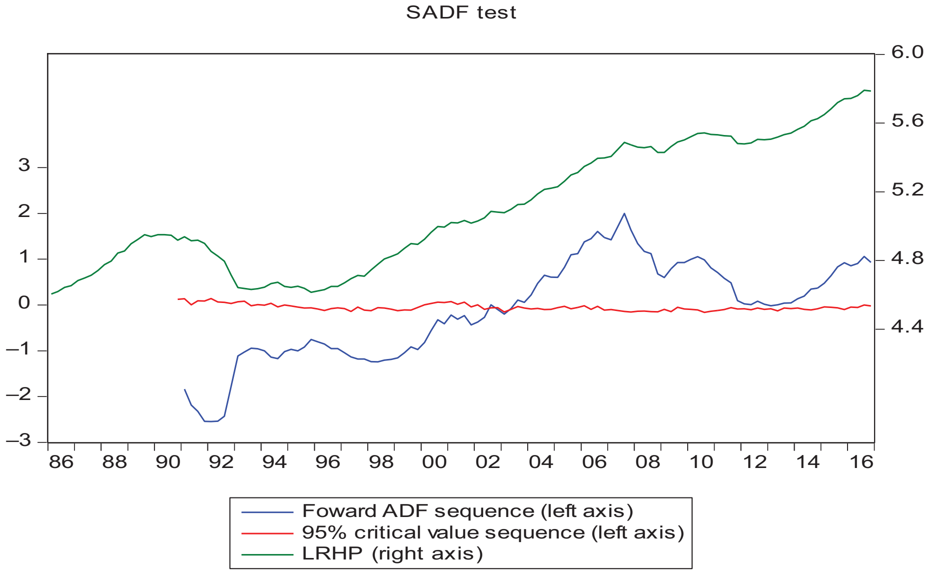

Figure 8. SADF test for the presence of bubble using real house prices.

(2003Q3-2011Q4 and 2014Q1-2016Q4), three bubble periods in the price-to-income ratio (2005Q1-2008Q3, 2009Q3-2011Q2 and 2014Q1-2016Q4) and two bubble periods in the price-to-rent ratio (the early 1990s and from circa 2005Q3 to 2016Q4)[10]. The extent of overvaluation using the price-to-income ratio and the price-to-rent ratio has been unprecedented since 2014[10].

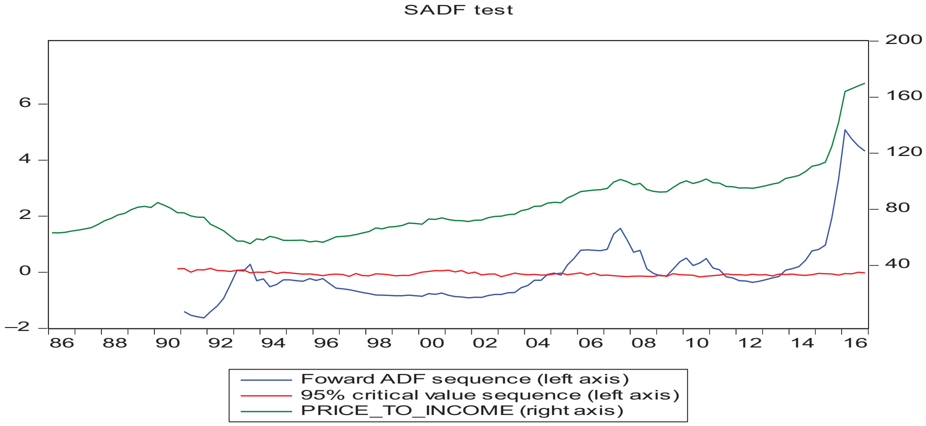

Figure 9.
SADF test for the presence of bubble using price-to-income ratio

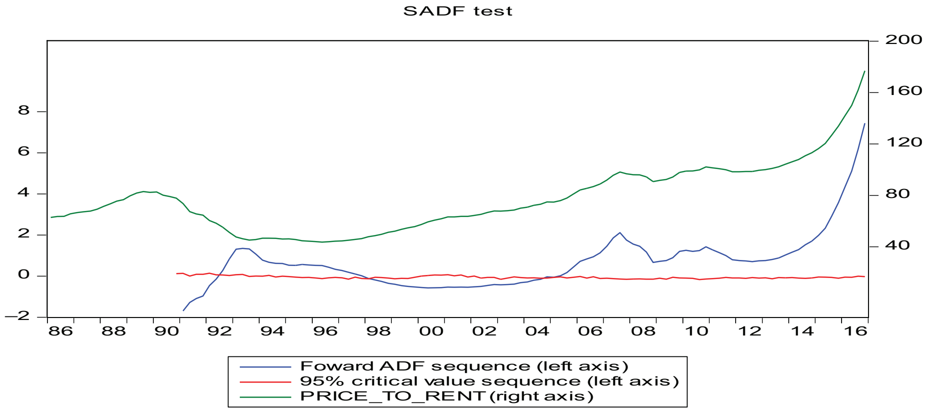

Figure 10.
SADF test for the presence of bubble using price-to-rent.

6.2 Testing for bubbles using the Hodrick–Prescott filter

In this section, we provide additional evidence of real house price overvaluation and its possible link to real effective exchange rate undervaluation using the HP filter method. The HP filter is a smoothing process that is frequently used by macroeconomists to find a smooth estimate of the long-term trend component of a series. This method assumes that the series combine stochastic and deterministic trends simultaneously to avoid obtaining misleading results. Hodrick and Prescott (1997) propose interpreting a trend component g_t as a very smooth series that does not differ substantially from the observed y_t. It is calculated as follows:

$$min\{gt\}_{t=-1}^{T}\left\{\sum\nolimits_{t=1}^{T}(y_t-g_t)^2+\lambda\sum\nolimits_{t=1}^{T}(g_t-g_{t-1})-\left(g_{t-1}-g_{t-2)}{}^2\right\}\tag{9}$$

When the smoothness $\lambda\ \rightarrow 0$, g_t is simply the series y_t itself, whereas when $\lambda\ \rightarrow\infty$, the procedure amounts to a regression on a linear time trend (that is, it produces a series whose second difference is exactly 0). The common practice is to use a value of $\lambda = 1600$ for a quarterly time series[11].

Figure 11 shows real house prices (red line) and their long-run trend (blue line) in addition to the cyclical component (green line), calculated as the percentage difference between actual real house prices and the HP filter of real house prices. This difference can be interpreted as over- or undervaluation. The figure shows that house prices have been overvalued since the mid-2000s, and despite dips following the global financial crisis and during 2013-2014, overvaluation is expected to continue in the near future unless drastic action is taken.

Similarly, Figure 12 shows the extent of real exchange rate undervaluation (cyclical component), which is calculated as the percentage difference between the actual real effective exchange rate and the HP filter of the real effective exchange rate. Between 2000 and 2016, the real effective exchange rate undervaluation accounted for an average of −1.1 per cent per year or −17.9 per cent over the course of 16 years.

Figure 13 shows the relationship between real effective exchange rate undervaluation and housing price overvaluation. This figure shows that except for the 2003-2004 and 2012-2013 periods, both series move together throughout the sample period[11].

7. Conclusion

Several approaches and techniques have been used to examine the presence of a housing bubble in Sweden. The results suggest that Swedish real house prices have been above their long-run average since 2004 and above their long-run trend since 2006. The diverging relationships between house prices and both incomes and rents indicate that Swedish

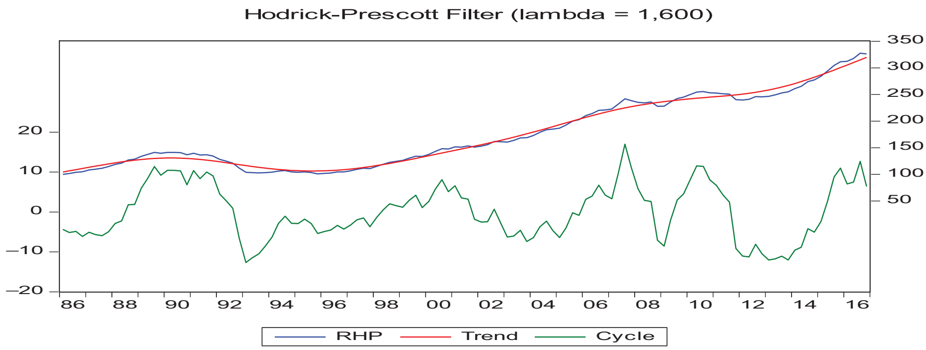

Figure 11. Testing for overvaluation in Swedish real house prices, Hodrick–Prescott filter method

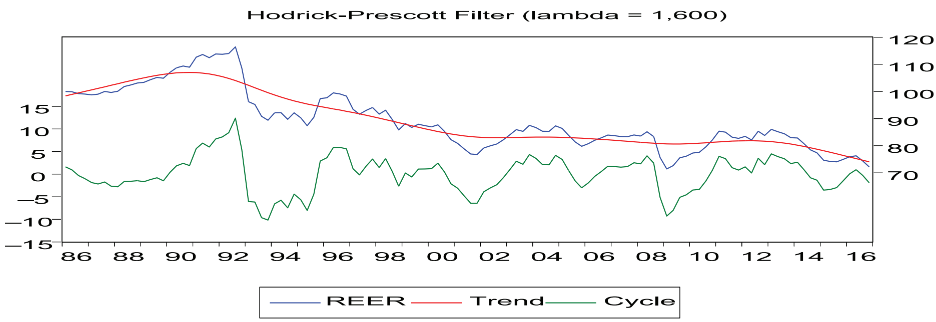

Figure 12. Testing for undervaluation in Swedish real effective exchange rate, Hodrick–Prescott filter method

houses are currently valued at 152.8 per cent of their historic price-to-income ratio and 170 per cent of their historic price-to-rent ratio. We also find that the assessment of housing bubbles based on user cost is extremely sensitive to assumptions regarding expected capital gains. If real house prices continue to grow at the average of past years' rates, then the Swedish housing market has been overvalued since 2013, even after adjusting for a risk premium for an eventual price drop.

Our econometric results suggest that although the disequilibrium between short-run dynamics and the cointegration relationship is corrected over time, the correction mechanisms of mispricing back to equilibrium can take decades. The slow speed of adjustment indicates the presence of rational speculative bubbles that, unlike explosive bubbles, do not continuously diverge but instead periodically revert to their fundamental values. These results have been subject to various robustness checks to support the findings. The subperiod analysis of the univariate right-tailed unit root test identifies two bubble periods in real house prices (2003Q3-2011Q4 and 2014Q1-2016Q4). Finally, the application of the HP filter yields results that support the same conclusion, suggesting that Swedish real house prices have been overvalued since the mid-2000s and that undervaluation of the real exchange rate partially explains the recent buildup of the housing bubble.

The results suggest that the overvaluation of housing prices in Sweden has been driven largely by three factors:

(1) highly expansionary monetary policy in the form of extremely low policy interest rates and financial innovations, which is likely to amplify the effect of interest rate movements on the rise of mortgage credit and housing prices;

(2) structural factors, such as housing supply rigidities and tax incentives; and

(3) persistent real exchange rate undervaluation coupled with capital inflows.

Nevertheless, more research is necessary to improve our understanding of the interaction between capital inflows and the housing market.

The policy implication is that monetary policy designed to contain mortgage demand and thereby prevent burst episodes in the housing market must address external imbalances, as revealed in real exchange rate undervaluation. It is unlikely that current policies will stop the rise of house prices, as the growth of mortgage credit, improvement in Sweden's international competitiveness and the path of interest rates are much more important factors. The negative impact of the mortgage rate over both the long and short

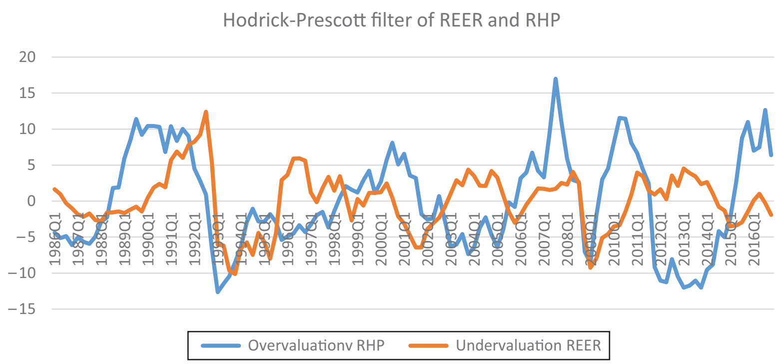

Figure 13.
Undervaluation of REER and overvaluation of real housing prices, Hodrick–Prescott filter method

runs suggests that a gradual phasing out of mortgage interest deductibility is likely to have a manageable effect on housing prices and household debt.

Notes

1. Institutional factors such as the tax system have also played a role in the decline of Swedish user costs since 2000. The 2007 abolition of the wealth tax and the 2004 reduction of the inheritance tax affected the user cost of the average household. As of 2008, government property tax on dwellings was abolished and replaced by a local real estate fee of a maximum of 0.75% of the tax assessment value.
2. For comparison, we have also calculated the imputed rent-to-income ratio along with its 25-year average to judge whether households are being outpriced from the market if income is also rising. The results are similar to Figure 6 and indicate the same periods of overvaluation: 1994-2000 and 2013-present. Note that Early Swedish literature (e.g. Englund, 2011) treats factors other than the real after-tax interest rate as constants and sets $\tau_t(i_t^m + \omega_t) + \delta_t + \theta_t - g_{t+1} + \gamma t$ =7%. The assumption is that the variation in the user cost over time is determined solely by the variation in the real after-tax interest rate, and the factors other than the real after-tax interest rate are set at a constant = 7%.
3. Additional sensitivity checks do not have a significant effect on the main results. One such test replaces the housing supply used in the analysis with housing supply per capita, real construction costs and the composite of both houses and apartments (e.g. multi-dwellings).
4. We examined the contemporaneous cross-correlations among the exogenous variables in equation (6) to address the issue of multicollinearity. The variables' correlation coefficients suggest the absence of strong multicollinearity.
5. The population variable was found to be highly correlated with several other variables, and thus, we excluded this variable from the long-run equation.
6. Several innovations in the mortgage market have expanded the borrowing opportunities available to Swedish households. For example, the range of mortgage varieties has expanded over the last decade to include interest-only loans and to allow households to choose between fixed and flexible rates. Furthermore, restrictions on minimum downpayment amounts have been relaxed.
7. Not only is a preference for homeownership increasingly accepted by the overwhelming majority of Swedes, but the government has undertaken considerable measures to encourage homeownership, including abolishing the inheritance tax in 2005, eliminating the property tax in 2008 and offering tax deductibility of 30% for mortgage interest payments. As a result, owner-occupancy rates in Sweden increased from 68% in 2007 to approximately 71% in 2016, compared to 51% in Germany and 62% in Denmark.
8. We also included two dummies in the short-run estimate to examine the impact of two lending restrictions implemented after the financial crisis – the Mortgage Cap and Amortization Requirements – and the coefficients of these dummies were nonsignificant. Specifically, the Swedish Financial Supervisory Authority introduced a mortgage cap in October 2010 that requires an 85% maximum loan-to-value (LTV) ratio, i.e. the portion of the house purchase price that can be financed with loans. Amortization requirements applied to new loans and came into force on June 1, 2016; they implied that new loans for apartments and houses must be amortized by 2% per year for an LTV of 70% and by 1% per year for an LTV of 50%. In addition, the Swedish FSA (Finansinspektionen) recently proposed, as a possible new measure of macroprudential policy, a debt-to-income (DTI) limit of 600%.
9. We determined the appropriate lag lengths using different selection criteria, all of which are based on the log likelihood (LogL) function. All tests suggest that the VAR regression model is optimal in the case of a four- to eight-period lag.

10. The GSDF function provides similar results, which are available upon request.
11. Another method of determining whether and to what extent a currency is misvalued is to examine the real effective exchange rate series over time. Under either absolute or relative PPP, there should be no change in real effective exchange rates over time if currencies are in equilibrium. However, because consumption patterns can change faster than the market baskets constructed by statisticians — as can trade policies, tariffs and transportation costs — deviations in real effective exchange rates do not necessarily indicate fundamental misalignment.

References

Adams, Z. and Füss, R. (2010), "Macroeconomic determinants of international housing markets", *Journal of Housing Economics*, Vol. 19 No. 1, pp. 38-50.

Ambrose, B.W., Eichholtz, P. and Lindenthal, T. (2013), "House prices and fundamentals: 355 years of evidence", *Journal of Money, Credit and Banking*, Vol. 45 Nos 2/3, pp. 477-491.

Arestis, P. and González, A. (2013), "Modeling the housing market in OECD countries", Working Paper no. 764, Levy Economics Institute of Bard College, New York, NY.

Bergman, M. and Sørensen, P.B. (2013), "Estimating fundamental house prices in Sweden", Working Paper, Department of Economics, University of Copenhagen.

Bernanke, B.S., Gertler, M. and Gilchrist, S. (1996), "The financial accelerator and the flight to quality", *The Review of Economics and Statistics*, Vol. 78 No. 1, pp. 1-15.

Black, A., Fraser, P. and Hoesli, M. (2006), "House prices, fundamentals and bubbles", *Journal of Business Finance and Accounting*, Vol. 33 Nos 9/10, pp. 1535-1555.

Bourassa, S.C. Hoesli, M. and Oikarinen, E. (2016), "Measuring house price bubbles", Real Estate Economics, Online Version, doi: 10.1111/1540-6229.12154.

Brunnermeier, M.K. and Julliard, C. (2008), "Money illusion and housing frenzies", *Review of Financial Studies*, Vol. 21 No. 1, pp. 135-180.

Caldera, A.S. and Johansson, Å. (2013), "The price responsiveness of housing supply in OECD countries", *Journal of Housing Economics*, Vol. 22 No. 3, pp. 231-249.

Case, K.E. and Shiller, R.J. (1989), "The efficiency of the market for single-family homes", *American Economic Review*, Vol. 79 No. 1, pp. 125-137.

Case, K.E. and Shiller, R.J. (2003), "Is there a bubble in the housing market?", *Brookings Papers on Economic Activity*, Vol. 2003 No. 2, pp. 299-362.

Claussen, C. (2013), "An error-correction model of Swedish house prices", *International Journal of Housing Markets and Analysis*, Vol. 6 No. 2, pp. 180-196.

Claussen, C., Jonsson, M. and Lagerwall, B. (2011), *A Macroeconomic Analysis of House Prices in Sweden*, The Riksbank's Commission of Inquiry Into Risk on the Swedish Housing market, Sveriges Riksbank.

Dermani, E., Lindé, J. and Walentin, K. (2016), "Is there an evident housing bubble in Sweden?", *Sveriges Riksbank Economic Review*, Vol. 2, pp. 7-55.

Diba, B.T. and Grossman, H.I. (1988a), "Explosive rational bubbles in stock prices?", *American Economic Review*, Vol. 78 No. 3, pp. 520-530.

Diba, B.T. and Grossman, H.I. (1988b), "The theory of rational bubbles in stock prices", *Economic Journal*, Vol. 98 No. 392, pp. 746-754.

Dickey, D.A. and Fuller, W.A. (1981), "Likelihood ratio statistics for autoregressive time series with a unit root", *Econometrica*, Vol. 49 No. 4, pp. 1057-1072.

Emanuelsson, R. (2015), "Supply of housing in Sweden", *Economic Review*, Vol. 2, pp. 47-75.

Englund, P. (2011), ""Swedish house prices in an international perspective", *The Riksbank's Inquiry into Risks in the Swedish Housing Market, Sveriges Riksbank*.

Engsted, T., Hviid, S.J. and Pedersen, T.Q. (2016), "Explosive bubbles in house prices? Evidence from the OECD countries", *Journal of International Financial Markets, Institutions and Money*, Vol. 40, pp. 14-25.

European Commission Report (2016), "Country report Sweden 2016", Commission Staff Working Document SWD 95, Brussels.

Fox, R. and Tulip, P. (2014), "Is housing overvalued?", Research Discussion Paper, Reserve Bank of Australia.

Gallin, J. (2006), "The long-run relationship between house prices and income: evidence from local housing markets", *Real Estate Economics*, Vol. 34 No. 3, pp. 417-438.

Gallin, J. (2008), "The long-run relationship between house prices and rents", *Real Estate Economics*, Vol. 36 No. 4, pp. 635-658.

González, G.J., Joya, O., Guerra, C. and Sicard, N. (2013), "Testing for bubbles in housing markets: new results using a new method", Working Paper no. 164, Federal Reserve Bank of Dallas, Globalization and Monetary Policy Institute, 30 January.

Himmelberg, C., Mayer, C. and Sinai, T. (2005), "Assessing high house prices: bubbles, fundamentals and misperceptions", *Journal of Economic Perspectives*, Vol. 19 No. 4, pp. 67-92.

Hodrick, R.J. and Prescott, E.C. (1997), "Postwar US business cycles: an empirical investigation", *Journal of Money, Credit and Banking*, Vol. 29 No. 1, pp. 1-16.

Holly, S., Pesaran, M.H. and Yamagata, T. (2010), "A spatio-temporal model of house prices in the USA", *Journal of Econometrics*, Vol. 158 No. 1, pp. 160-173.

IMF (2016), "Sweden: selected issues", IMF Country report 15/330, International Monetary Fund, Washington, DC.IMF.

Johansen, S. (1991), "Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models", *Econometrica*, Vol. 59 No. 6, pp. 1551-1580.

Lind, H. (2009), "Price bubbles in housing markets", *International Journal of Housing Markets and Analysis*, Vol. 2 No. 1, pp. 78-90.

MacKinnon, J.G., Haug, A.A. and Michelis, L. (1999), "Numerical distribution functions of likelihood ratio tests for cointegration", *Journal of Applied Econometrics*, Vol. 14, pp. 563-577.

McCarthy, J. and Peach, R.W. (2004), "Are home prices the next 'bubble'?", *FRBNY Economic Policy Review*, Vol. 8 No. 2, pp. 139-158.

McDermott, J. (1996), "Estimation of the near unit root model of real exchange rates", IMF Working Papers, Vol. 96 No. 50.

Mayer, C. (2011), "Housing bubbles: a survey", *Annual Review of Economics*, Vol. 3 No. 1, pp. 559-577.

Nneji, O., Brooks, C. and Ward, C. (2013), "Intrinsic and rational speculative bubbles in the US housing market: 1960-2011", *Journal of Real Estate Research*, Vol. 35 No. 2, pp. 121-151.

Oikarinen, E. (2009), "Interaction between housing prices and household borrowing: the finnish case", *Journal of Banking and Finance*, Vol. 33 No. 4, pp. 747-756.

Phillips, P.C.B. and Yu, J. (2011), "Dating the timeline of financial bubbles during the subprime crisis", *Quantitative Economics*, Vol. 2 No. 3, pp. 455-491.

Phillips, P.C.B., Shi, S.P. and Yu, J. (2015), "Testing for multiple bubbles", *International Economic Review*, Vol. 56 No. 4, pp. 1043-1078.

Phillips, P.C.B., Wu, Y. and Yu, J. (2011), "Explosive behavior in the 1990s NASDAQ: when did exuberance escalate asset values?", *International Economic Review*, Vol. 52 No. 1, pp. 201-226.

Sá, F., Towbin, P. and Wieladek, T. (2014), "Capital inflows, financial structure and housing booms", *Journal of the European Economic Association*, Vol. 12 No. 2, pp. 522-546.

Shiller, R.J. (2007), “Understanding recent trends in house prices and home ownership”, Working Paper 13553, National Bureau of Economic Research, Cambridge.

Stiglitz, J.E. (1990), “Symposium on bubbles”, *Journal of Economic Perspectives*, Vol. 4 No. 2, pp. 13-18.

Turk, R.A. (2015), “House prices and household debt interactions in Sweden”, IMF Working Paper No. 15/276.

UBS (2016), “UBS global real estate bubble index for housing markets of select cities”, Working Paper, UBS, Zürich.

Wheaton, W. and Nechayev, G. (2008), “The 1998-2005 housing ‘bubble’ and the current ‘correction’: what’s different this time?”, *Journal of Real Estate Research*, Vol. 30 No. 1, pp. 1-26.

Yiu, M.S., Yu, J. and Jin, L. (2013), “Detecting bubbles in Hong Kong residential property market”, *Journal of Asian Economics*, Vol. 28, pp. 115-124.

Zhou, W. and Sornette, D. (2006), “Is there a real estate bubble in the US?”, *Physica A: Statistical Mechanics and Its Applications*, Vol. 361 No. 1, pp. 297-308.

Appendix

Variable	Description	Data source
Real Housing Price, rhp.	House price index deflated by the consumer price index rebased to 1986Q1 in logs. The index estimates development of prices and values of the existing stock of one- or two-dwelling buildings in the entire country. The index is constructed based on repeated sales and takes into consideration that the houses sold may not be a random sample of the housing stock and that the mix or composition of houses may vary from one-quarter/year to the next. One- or two-dwelling buildings for permanent dwelling include detached one- or two-dwelling buildings, terraced houses and linked buildings	Statistics Sweden and Datastream
Real household disposable Income, *Rdisp*.	Aggregated Real household disposable income, seasonally adjusted in logs	Statistics Sweden and Datastream
Household Financial Assets Net of Liabilities, NHFW	Real total household financial assets minus liabilities in logs, backdated using the quadratic-match average and interpolated to a quarterly frequency	Swedish National Wealth
Real After-Tax mortgage rate, ATMR	The real after-tax deductibility mortgage rate is calculated using $r_t{}^m(1-\tau_t)-\pi_t$, where r_t is a 5-year mortgage rate, τ_t is the amount of the interest rate tax deduction (50 % from 1986 to 1989 and 30 % thereafter), and π_t is the inflation rate	Statistics Sweden, Riksbanken, and Datastream
Real User Cos, μ_t	We use the following formula: $\mu_t = r^f{}_t + \omega_t - \tau_t\ (i_t^m + \omega_t) + \delta_t + \theta_t - g_{t+1} + \gamma_t$. The risk-free rate ($r^f{}_t$) is measured by the government bond yield on 10-year maturities; ω_t is the property tax rate; the effective tax rate on income subjected to tax deductibility (τ_t) is calculated as 50 % from 1986 to 1990 and 30 % since 1991; mortgage nominal interest ($r_t{}^m$) is measured by Sweden's mortgage rate on 5-year maturities; maintenance and other carrying costs (δ_t) are assumed to be 1 % per year; depreciation (θ_t) is assumed to be 2 % per year; expected capital gain (g_{t+1}) is calculated as the moving average of the previous three years; and the risk premium is (γ_t) is assumed to be 5% per year	Statistics Sweden, Riksbanken, Datastream, and Skatteverket
Real Effective Exchange Rate, REER	The nominal effective exchange rate (a measure of the value of the Swedish krona against a weighted average of Sweden's largest trade partners) divided by a price deflator in logs. An increase in the real effective exchange rate implies that exports become more expensive and imports become cheaper; therefore, an increase in the real effective exchange rate indicates a decrease in trade competitiveness	IMF, OECD, and Datastream

(*continued*)

Table AI. Variable definitions and data sources

Variable	Description	Data source
Real Household Debt, HDEBT	MFI's lending to households for housing deflated by the consumer price index in logs	Riksbanken and Datastream
Housing Stock, Stocks	Quarterly dwellings completed –one or two –dwelling buildings	Statistics Sweden and Datastream
Tobin's Q	The nominal house price index deflated by the total construction cost rebased to 1986Q1	Statistics Sweden
Population	Population transformed to a quarterly frequency using a quadratic-match average	Statistics Sweden
Unemployment	The annual unemployment rate for people between 15 and 74 years of age transformed to a quarterly frequency using a quadratic-match average	Statistics Sweden

Table AI.

Residual diagnostic and stability tests

Table AII.
Breusch–Godfrey serial correlation LM test

F-statistic	0.57	Prob. F(2.106)	0.57
Obs**R*-squared	0.00	Prob. Chi-Square(2)	1.00

Table AIII.
Heteroskedasticity Test: Breusch–Pagan–Godfrey

F-statistic	1.55	Prob. F(17.98)	0.09
Obs**R*-squared	24.53	Prob. Chi-Square(17)	0.11
Scaled explained SS	19.40	Prob. Chi-Square(17)	0.31

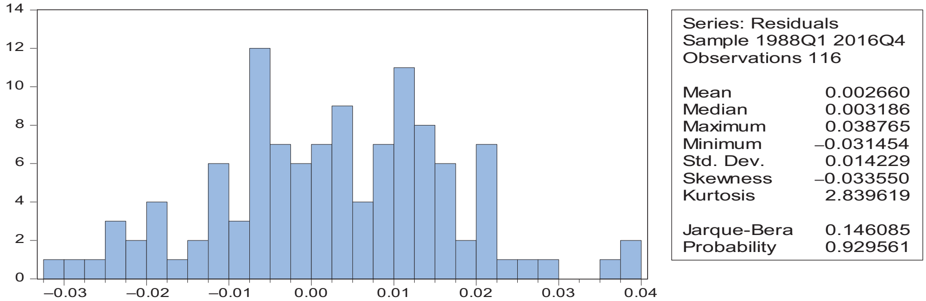

Figure A1.
Histogram normality test

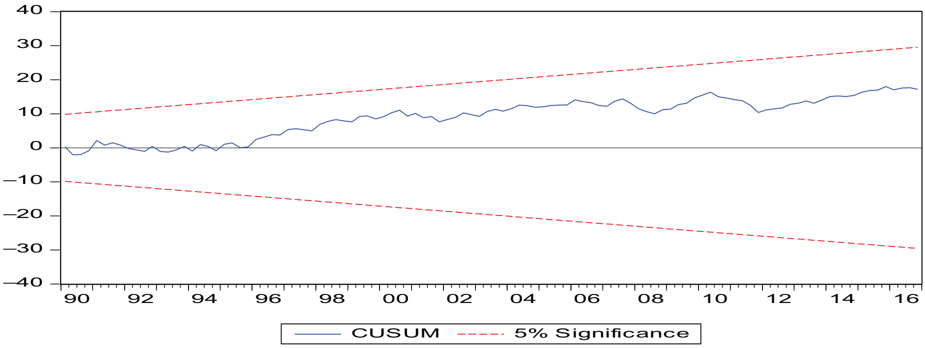

Figure A2.
CUSUM stability test

Corresponding author
Maher Asal can be contacted at: maher.asal@hv.se