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Icelandic boom and bust: Immigration and the housing market

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Abstract

Possible explanations for the rapid increase in house prices and housing investment in Iceland between 2004 and 2007 and the subsequent market crash are studied. The boom was driven in part by banking liberalisation, international financial conditions, and domestic policies. A simple demand and supply model, based on the study by Elíasson and Pétursson (2009), is fitted to data through the recent boom-bust period. The model is remarkably robust through the cycle despite its unprecedented amplitude. However, it does not capture fully the turbulence in housing market data for the period since 2003. Different methods to account for the rapid rise in house prices and housing investment dynamics are compared. The price equation (demand) is improved by including net immigration as an explanatory variable showing that demographic factors, in addition to mortgage market restructuring, help in explaining the apparent bubble in the housing market. The sharp fall in housing investment in 2009 cannot, however, be modelled without the introduction of a dummy variable, accounting for the sudden-stop in financing at the beginning of the financial crisis in Iceland in late 2008.

Key words: Housing cycles, housing finance, housing policy, asset price bubbles, immigration.

JEL Classification: E32, G12, G21, J11, R21.

[1] Email: le@cb.is. Views expressed in this paper are those of the author and should not be interpreted as the views of the Central Bank of Iceland. Thanks to Thórarinn G. Pétursson, Ásgeir Daníelsson and Bjarni G. Einarsson for helpful comments.

1. Introduction

The residential housing market in Iceland's capital region, where two-thirds of the population reside, boomed between 2004 and 2007. Following a slowdown in 2008 the market crashed in 2009. During the boom years house prices in the region rose by 95% in four years (59% in real terms), and residential investment grew by 74% at constant prices, rising to 7.7% of GDP in the fourth quarter of 2007. Housing markets were also booming in many other western countries, including USA, UK, Spain as well as Nordic and Baltic countries. House price inflation gained momentum in Iceland a few years later than in the other countries. When the market crashed, housing investment fell to historical lows and has remained subdued while real house prices dropped almost to their long-term average.

This paper looks at a few possible explanations for the recent boom and bust cycle in Reykjavík, Iceland, which is by far the largest in the city's history. Results from an empirical study of a simple demand and supply model for residential houses suggest that the upswing was driven by financial conditions and changes to housing policy. Following the initial market crash the adjustment in demand and supply has been slowed by policy measures as financing became more difficult following the crash than during the upswing, and by capital account restrictions which have been in place since late 2008, supporting domestic asset prices.

The housing market model in the paper is borrowed from Elíasson and Pétursson (2009) which was developed along the lines suggested by Poterba (1984). They estimated equations for house prices and residential investment using annual data through 2003. In order to test for the formation of a housing price bubble the data series is extended through the recent cycle, calling for moderate adjustments in the equations.

The next section describes the recent changes in the housing market, focussing on the period from 2004 to 2012. Then the two equation model for the housing market from Elíasson and Pétursson (2009) is re-estimated for the extended period through 2012. The presence of a housing bubble during 2004 to 2007 is studied, testing for the impact of growth in monetary aggregates and in immigration in both the house price and housing investment equations. Discussion and interpretation of the results follows.

2. The recent boom and bust cycle

This paper deals with developments in the Icelandic housing market, particularly during the boom period from 2004 to 2007 and the housing slump that followed. This housing cycle is unusual in its size, i.e. the amplitude of the swing in market variables, and also in its co-movement with housing cycles in other countries. The rise in house prices was, however, slower in Iceland than in many other countries at the beginning of the recent boom period. It gained momentum in 2004 and by 2005 house price inflation was extremely rapid in Iceland (table 1). Iceland also stands out among the countries experiencing a significant drop in real house prices in how quickly prices stabilised again following the downturn.

2.1. Description of market developments

A combination of factors fuelled the housing boom in Iceland in the years 2003 to 2007. House prices had been increasing in the United States, the United Kingdom, Scandinavia and many European countries since the turn of the century (table 1). Privatisation of Icelandic banks was completed in early 2003 and the banks soon tapped international bond markets, initially fuelling their growth abroad (Hreinsson et al. 2010). The government was actively prepaying foreign debt which stood at less than 7% of GDP in late 2006 and its credit ratings were at or close to triple A in 2005 and 2006. The banks had inherited the government's rating which they kept intact after privatisation. This allowed them to issue highly rated bonds in foreign markets which still carried somewhat higher interest rates than comparably rated bonds issued by banks in other countries. Since Iceland is a part of the European Economic Area its banks could set up branches and operate anywhere they chose in Europe on equal terms with banks in the European Union, thus facilitating their growth abroad.

Table 1. Fall in real house prices in several countries from peak to bottom.

	Change, %		Downturn starting around 2007			
	1995-2014	Largest YoY	Top Q	Bottom Q	Drop, %	Period, Qs
Norway	195.3	17.6	2007 Q2	2008 Q4	-14.0	6
Sweden	156.1	12.6	2007 Q3	2009 Q1	-5.8	6
Finland	97.5	13.9	2007 Q2	2008 Q4	-8.9	6
Ireland	96.8	23.9	2007 Q2	2012 Q4	-36.6	22
UK	96.8	25.8	2007 Q3	2012 Q4	-32.6	21
Denmark	73.4	23.1	2007 Q3	2012 Q1	-28.9	18
Iceland	66.3	33.6	2007 Q4	2010 Q4	-34.0	12
Switzerland	42.6	8.1	-	-	-	-
Spain	27.8	13.2	2007Q1	2014 Q2	-37.1	29
USA	24.5	12.3	2006 Q1	2012 Q1	-42.5	24

Calculations are based on broad, quarterly, house prices indices. The indices are moved to constant prices using consumer price indices for each country. The downturn is measured form a peak around year 2007, identifying the beginning of the financial crisis, until the lowest value reached before real prices start to rise again.

Sources: Macrobond, Registers Iceland, Statistics Iceland and author's calculations.

During 2004 through 2007 house prices almost doubled, rising about 60% more than the price level. Turnover in the housing market in the fourth quarter of 2004 was about 112 million ISK at 2012 prices, or 27.5% of GDP, compared to 17% a year earlier (figure 1). Market turnover in the housing market then slowed somewhat, but it increased again in 2007, again staying close to 28% of GDP during the second and third quarters. On average building started on a little fewer than 1,400 new houses each year during the nineties, with a maximum of 1,929 in 1990 and a minimum of 1,016 in 1998. The number of housing starts then began to grow, reaching 4,393 in 2005 and 4,446 in 2007 (figure 2). Mortgage lending by the government owned Housing Financing Fund (HFF), by the banks and the pension funds grew. New mortgage lending by the HFF and the banks, which totalled ISK 3.2 billion in July 2004, reached ISK 38.3 billion three months later. A significant share of the banks' mortgages was used to prepay debt issued by the HFF. Household debt grew steadily from 2004 to 2008. The share of bank provided credit increased at the expense of the HFF (figure 3).

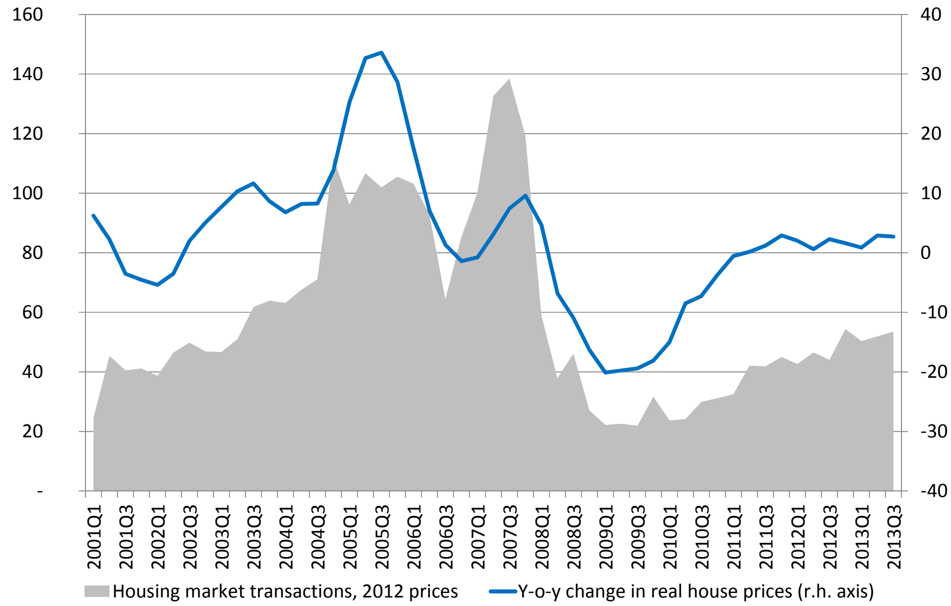

Figure 1. Housing market volume at fixed prices and year-on-year change in real house prices. Quarterly data. *Sources*: Registers Iceland, Central Bank of Iceland, Statistics Iceland and author's calculations.

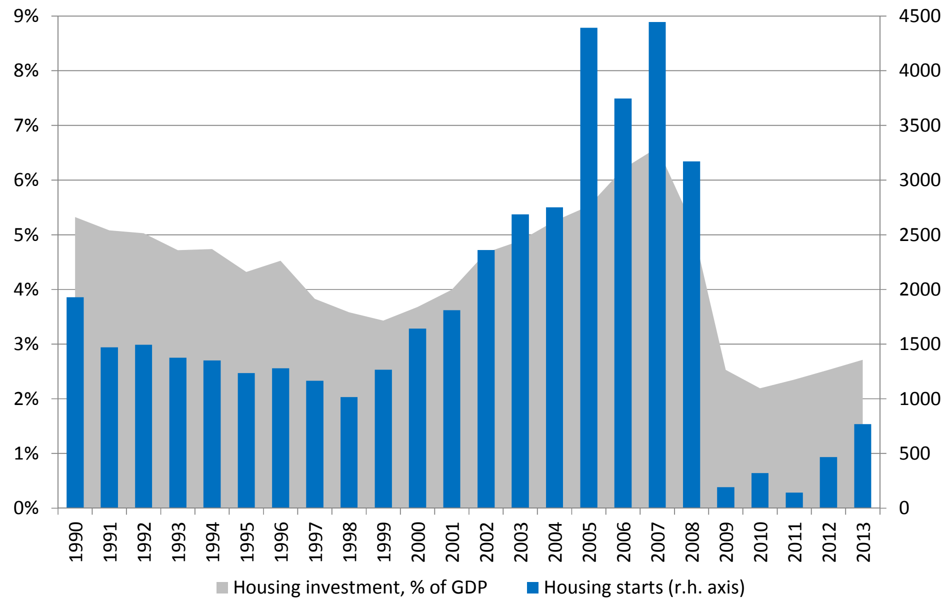

Figure 2. Housing investment as a share of GDP and new housing starts. Annual data. *Sources*: Statistics Iceland and author's calculations.

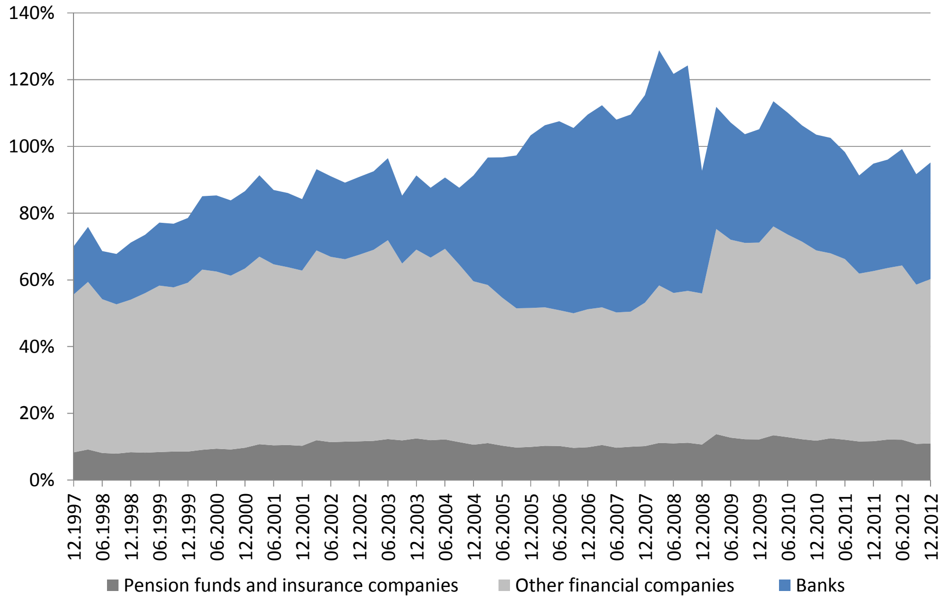

Figure 3. Households' debt to the credit system as a percentage of GDP. The bulk of "pension funds and insurance companies" is due to mortgage lending by the pension fund system. The HFF dominates the category "Other financial companies".
Source: Report of the Special Investigation Commission on the Housing Financing Fund (Stefánsson et al. 2013).

2.2. "This time is different"

Developments of fundamentals may offer some explanations of housing market dynamics and possibly contribute to the apparent bubble during 2004 to 2007. Falling household-size and net immigration supported demand, in combination with relaxing of credit constraint and easier access to funding due to financial innovation and market restructuring.

2.2.1. Demographics

Rising average age of the population was one of the possible factors contributing to the increasing demand for apartments. The average age of the population has increased by roughly 1.5 years every decade over the past 40 years, rising from 29.8 years in 1970 to 36.4 years in 2010. Other things equal rising average age implies a relative increase in the number of households.

This is related to another statistic which is the average number of persons in a household. The household size has been shrinking for decades. According to Ljuanen and Palmgren (2004) the average household size in Iceland fell from 4.48 persons in 1960 to 2.68 by 2000. According to Statistics Iceland the average number of persons in core-households, which do not include single-person households, has continued to decline, falling from 2.92 persons in 2000 to 2.86 in 2013. The average core-household in Reykjavík is smaller than the national average, with 2.79 persons in 2013.

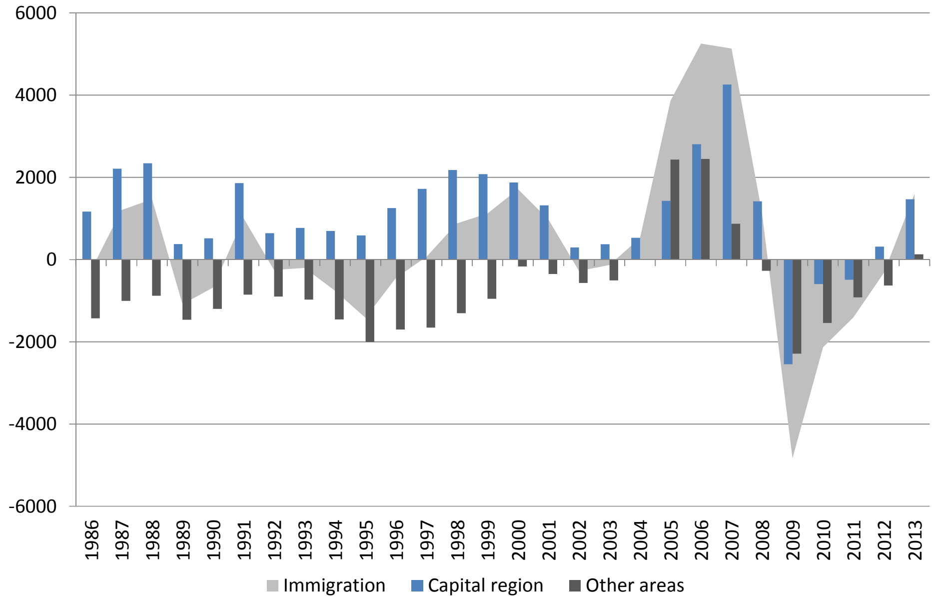

Figure 4. Net immigration, net migration to the capital region (from other areas of the country and from abroad) and net migration to other areas of the country (from the capital region and abroad).
Sources: Statistics Iceland and author's calculations.

Migration is another demographic factor potentially impacting the housing market. Throughout the twentieth century migration within the country was driven by urbanisation, with net migration into the capital region from other areas of the country (figure 4). This supported growing demand for housing in the capital region.

Net immigration to the country has moved in tandem with the business cycle during the past 15 years. Prior to that there was little evidence of immigration during upswings but some movement of labour out of the country was seen during recessions (Guðmundsson, Pétursson and Sighvatsson, 2000). Figure 4 shows clearly that swings in immigration were more pronounced starting in 2004 than previously. Real GDP grew by 28% during 2004 to 2007 but contracted by 10% over the next three years. Net immigration during 2005 to 2008 totalled over 15,000 or roughly 5% of the population. Net migration out of the country over the following three years totalled over 8000 persons. A significant portion of net immigration during the years 2005 to 2008 was due to foreign workers, particularly in the construction sector.

2.2.2. Mortgage market restructuring

In 2004 changes were made to the funding and lending at the HFF (see also Elíasson and Pétursson 2009). Since 1989 the fund and its predecessor had been financed by bond issues which roughly matched the loan terms. The bond series were many and small and mirrored to large extent the maturity and terms of the fund's loans. The bonds were callable bullets and prepayments of the fund's loans were transferred to the bondholders through a lottery. A review of the bond structure started in 2001. The goal was to push down interest rates on the HFF's mortgages by making the bonds more attractive, particularly to foreign investors, thus broadening the investor base and driving down interest rates. Some considerations were also made to lower the spread of mortgages over the funding rates, lowering the interest on mortgages further still (Stefánsson et al., 2013). In

July 2004 changes to the HFF's funding were enacted. Bond issues were simplified to three series with a fourth series added later in the year. The new bonds were annuities with bi-annual payments and final payments on the bond series where dispersed at ten year intervals. Aiming for large issues at the outset the HFF offered bondholders to swap the older bonds for the new non-callable ones. The average size of the HFF's outstanding bond series increased significantly. The new bonds were settled in international clearing houses, yet another factor improving their marketability. Immediately following initial issue of the new bonds the HFF lowered its mortgage rates. In the new system mortgage rates were determined by a rule, adding a premium on the market rate achieved in the latest issue of HFF bonds.

The manifesto of the Progressive party before the general elections in the spring of 2003 offered home buyers the possibility of a mortgage up to 90% of the property value through the government owned Housing Financing Fund. The party had been losing ground in the polls until it started promoting 90% mortgages a few weeks before elections but it managed a swift turn-around by focussing on 90% mortgages as its main issue for the elections. In December of 2004 the maximum loan to value (LTV) ratios at the HFF were raised to 90% and maximum loan amounts were raised significantly. The initial plans developed during the 2003 campaign called for a gradual increase in the LTV ratio and the maximum loan amount. The change in policy, apparent by the one step raise in the LTV and rapid increases in maximum loan amounts, was defended as a response to increased competition in the mortgage market, led by private banks which entered the stage in 2004 (Stefánsson et al., 2013).

In the summer of 2004 Iceland's three large private banks entered the mortgage market full force. The largest bank, Kaupthing, started to offer 40 year indexed mortgages carrying a 4.45% real rate in late August 2004. The interest rate was a little lower than on the HFF's mortgages. Kaupthing's offer was a novelty in Iceland as a housing market transaction was not a prerequisite for a loan. Homeowners were therefore able to withdraw equity from their houses more easily to fund additional consumption expenditure. The bank conditioned the new mortgages on full banking relations, trying to increase its domestic customer base. Other banks responded by matching its offer the very next day, and prepayments of mortgages immediately poured in at the HFF (fig. 3).

The effects of the HFF's changes to LTVs and maximum mortgage amounts on the housing market are analysed by Elíasson and Pétursson (2009, available as a working paper since early 2006). The estimated impact of the 2004 rise in mortgage amounts, loan-to-value ratios and lowering of the real interest rates were temporary. According to Elíasson and Pétursson house prices were expected to rise rapidly following the changes peaking the following year about 25% higher than otherwise. The effect died out in about four years and there was no long run effect on house prices. A similar response in housing investment was forecast by their model, peaking about two years following the changes.

2.2.3. Financial innovations

Housing markets have for a long time been known to be prone to boom-bust cycles. Schnure (2005) argued that the national market-based system of securitised mortgage finance had dampened these cycles, showing that house prices fell closer to forecasts based on fundamentals after the development of this type of financing than it did e.g. in the build-up of the Savings and Loan crisis in the early 1980s. Shiller (2007), however, argued that the boom in house prices, which became apparent in the US by 2005, could not be explained by changes in fundamentals and suggested the explanation that prices kept on rising due to a "social epidemic that encourages a view of housing as an important investment opportunity". Although there were opposing views on the contribution of financial innovation to the finance cycle, particularly in the housing market, during the boom period following the turn of the century, there appears to have been a general understanding that it had important impacts on the market.

Advances in housing financing also appeared in Iceland as Kaupthing bank issued mortgage backed securities to fund its entrance into the mortgage market, with the first issues appearing in 2006. The other large banks had not set up specific programs to fund their advance in the mortgage market. Rather than using funds from prepayments due to mortgage-refinancing the HFF bought mortgage portfolios from its competitors, thereby financing further lending at the banks, and increasing its own market risk (Stefánsson et al., 2013). The banks had relied on foreign bond issues to finance their growth in 2004 and 2005 but they quickly exhausted that source of funds. In late 2006 they were again able to issue foreign bonds as appetite for bonds issued by Icelandic banks reappeared. The bonds were used to spice the yield on CDOs as the Icelandic bank bonds had significantly higher yields than other bonds issued by institutions with comparable ratings.

In 2005 foreign banks, companies and sovereigns started issuing Eurobonds in Icelandic ISK, so called Glacier bonds. The currency was swapped with Icelandic banks who had amassed foreign currency funding. This increased demand for the Icelandic currency, caused it to appreciate, and inflated domestic asset prices. At its peak in the third quarter of 2007 Glacier bond issues totalled almost 30% of Icelandic GDP, equivalent to roughly 8% of the foreign debt of the banks. When the carry trade started to unwind the Glacier bonds were no longer rolled over and the currency became under pressure to depreciate. The banks had to maintain their foreign currency balance within required limits. Rather than repaying their foreign debt and shrinking their balance sheets the domestic banks increased their foreign currency lending to Icelanders, including foreign-currency linked mortgages. While the Glacier bonds were swapped with the Icelandic banks they were able to channel their foreign funding to domestic lending, with Glacier bond investors holding the currency risk. Once the banks started lending foreign funds directly to unhedged domestic borrowers they were exposed to increased risk of mass defaults in the event of currency depreciation.

In retrospect it appears that many of the financial innovations of the past decades facilitated considerably easier access to housing finance and thus contributed to the unusually large swing in the housing market, without distributing the risk effectively.

3. Housing market: model and data

A simple model of the housing market in Iceland is borrowed from Elíasson and Pétursson (2009). The model consists of a house price equation (demand equation) and a housing investment equation (supply equation). Housing demand is derived from a life-cycle model of utility maximising households and depends on the relative price of housing, the cost of financing, household income and debt (see Elíasson and Pétursson 2009 and references cited there). The housing price equation is derived as the inverse of such housing demand and the relative price of housing is a function of the ratio of real housing wealth to income, the ratio of household debt to income, and the real rate of interest. Housing investment depends on the ratio of the housing price and the cost of housing, i.e. a type of Tobin's-Q relation. It follows that the housing investment equation depends on the Q-ratio and reverts to an equilibrium ratio relative to the housing stock. Special adjustment is made to capture the slow drop in equilibrium investment intensity during the period.[2]

The data series used by Elíasson and Pétursson (2009) are extended by using the same sources. The latest values for the real interest rate are, however, taken as the market yield on the HFF's series which is closest to five year duration. The real house price series is extended by adding data from Registers Iceland's apartment price index for the capital region and deflating it using the consumer price index compiled by Statistics Iceland. Data on housing wealth, housing investment and real disposable income is obtained from the national accounts data from Statistics Iceland.[3] The building-cost index is also compiled by Statistics Iceland. The data on real household debt is supplied by the Central Bank of Iceland.

Elíasson and Pétursson used annual data from 1961 through 2003. In re-estimating the model the following changes were made:

1. The data series were extended through 2012, thus totalling 52 yearly observations.
2. The Tobin's-Q series (house-price to building-cost ratio) was re-scaled to 1 in 1999, corresponding to estimated cost of land amounting to 20% on top of building cost.
3. A dummy variable was included in the investment equation, taking the value 1 in 2009 and stepping down by 0.2 annually thereafter, accounting for the dearth in housing investment (possibly due to difficulties in funding) following the financial crisis of 2008.[4]

Key data transformations are shown in figure 5, extending the series from Elíasson and Pétursson (2009) beyond 2003, drawing attention to the turbulent times in the Icelandic housing market over the past decade. Real house prices rose by 66% during 2003 to 2007, rising 53% above the previous peak reached in 1982, after which it fell by 32% over the next three years, however, remaining above its 1982 peak. A similar swing is replicated by the ratio of house prices to building cost, rising 52% 2003 to 2007 after which it fell by 34%. A peak in the house price series also affects real housing wealth relative to real disposable income despite the significant increase in real disposable income during the period.

The investment intensity in the housing sector had been trending downwards through most of the period. It, however, started to rise again at the turn of the century and continued to ease upwards until 2008. It fell sharply during 2008 to 2010, losing 72% and falling 42% below its previous minimum value.

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[2] Estimation of the logistic trend of declining investment intensity results in $\kappa(t) = -2.69 - 0.53\,(1+e^{0.3(1-t)})^{-1}$ where t is a time trend taking the value 0 in 1981.

[3] Data was retrieved from the Statistics Iceland's web-site on May 27 2014.

[4] An alternative to the dummy variable was tested, using real lending growth to building contractors. That, however, was not successful. The bank failures in 2008, and subsequent transfer of assets to new banks, rends the data series unusable due to data inconsistencies as deep-discount on book values when the assets were transferred, later re-valuation of assets, debt forgiveness and write-downs are treated differently between banks and in a somewhat opaque manner. The 20% annual decrease in the dummy after 2009 reflects the *ad hoc* assumption that, whatever the cause of the sudden-stop in housing investment, its impact will die out linearly over a five year period, implying that it has disappeared by 2014.

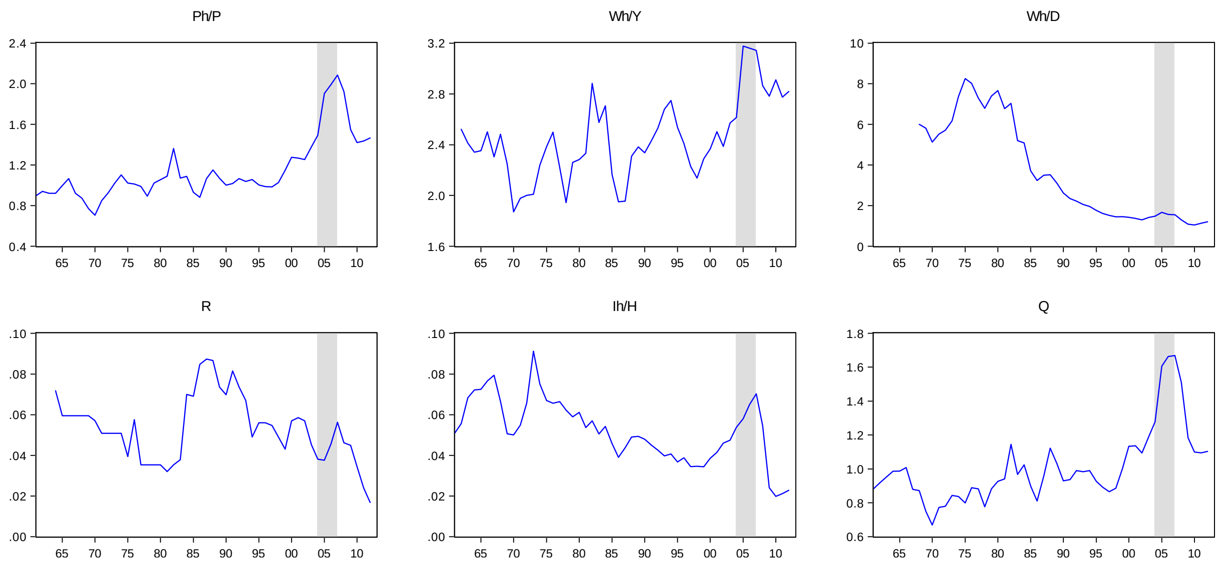


Figure 5. The data. The top row shows, from left to right, the real house price Ph/P, real housing wealth as a ratio of real disposable income Wh/Y, and real housing wealth relative to household debt Wh/D. The second row shows the real interest rate (R) on five year indexed government bonds (linked with HFF bonds starting in 2004), the investment intensity (Ih/H ratio), and the Tobins-Q, which is scaled at 1 in 1999. The apparent bubble period, 2004 to 2007, is shaded.

The house price equation with coefficient estimates using data from 1970 through 2012 is:

$$\Delta p_{ht} = \underset{(0.10)}{0.661} + \underset{(0.07)}{0.751} \Delta p_{ht-1} - \underset{(0.12)}{0.263} \Delta (w_h - d)_{t-1} - \underset{(0.09)}{0.535} (w_h - y)_{t-1} - \underset{(0.75)}{3.001} R_t \qquad (1)$$

T = 43, R^2 = 0.809, σ = 7.23 per cent, $JB(2)$ = 0.08, $BG(1,37)$ = 0.52, $W(14,28)$ = 0.45

where p_h is (the logarithm of) the house price index, w_h is (the logarithm of) real housing wealth, d is (the logarithm of) real household debt, y is (the logarithm of) real disposable income and R is real interest rate on five year government bonds. Standard errors are given in brackets, and *p*-values for the diagnostic tests. *JB* is the Jarque-Bera test for residual normality, *BG* is the Breusch-Godfrey LM test for first-order autocorrelation, and *W* is the White LM test for residual heteroskedasticity. All parameter estimates following re-estimation including newer data are well within two standard deviations off the Elíasson and Pétursson (2009) corresponding estimates.

Estimation of the residential investment equation results in:

$$\Delta i_{ht} = \underset{(0.29)}{0.811} + \underset{(0.12)}{0.628} \Delta q_t + \underset{(0.10)}{0.562} q_{t-1} - \underset{(0.07)}{0.547} (i_h - h)_{t-1} + \underset{(0.14)}{0.793} \kappa(t) - \underset{(0.07)}{0.714} D_{0912} \qquad (2)$$

T = 39, R^2 = 0.846, σ = 6.54 per cent, $JB(2)$ = 0.40, $BG(1,32)$ = 0.84, $W(18,20)$ = 0.00

where i_h is (the logarithm of) real housing investment, q is the Tobin-Q for housing, h is the real stock of houses, $\kappa(t)$ is the trend of investment intensity estimated by a logistic function (see Elíasson and Pétursson, 2009), and D_{0912} is the post-crisis dummy, allowing for the effects of increased difficulties in provision of funds for investment. The dummy variable D_{0912} in the investment equation has the value 1 for 2009, stepping down by 0.2 per year thereafter. Its coefficient is highly significant and negative as expected. All other coefficient estimates are within two standard deviations of the estimates in Elíasson and Pétursson (2009).

3.1. Actual and fitted housing-market data

The house price equation (1) has good explanatory power, with adjusted R^2 equal to 0.81, albeit a little less than in the Elíasson-Pétursson study (0.86). The Jarque-Bera test does not reject the null of a normal distribution at the 5% significance level (although it is rejected at the 10% level). Figure 6 (left panel) shows that during 2003 through 2008 the fitted change in house prices falls short of the actual change every year with accumulated growth in the fitted value amounting to 40% while actual house prices doubled, indicating the possibility of a price bubble (which is discussed in the next section). The right hand side of figure 6 shows the change in housing investment. The drop in investment following the boom years dominates the development, explaining the need for a dummy variable for the post crises period. During 2004 through 2007 the accumulated growth in the fitted variable sums to 37% while the actual investment increased by 63% during the same period. The housing investment equation (2) also shows good explanatory power with adjusted R^2 equal to 0.85, compared to 0.67 when using data prior to 2004 (Elíasson and Pétursson, 2009). The bulk of the improvement is due to the inclusion of the post-crisis dummy. The estimated equation, however, shows evidence of heteroskedasticity which was not present in the original estimation. A possible interpretation is that there is a variable missing from the equation, which may be particularly important during the extended estimation period.

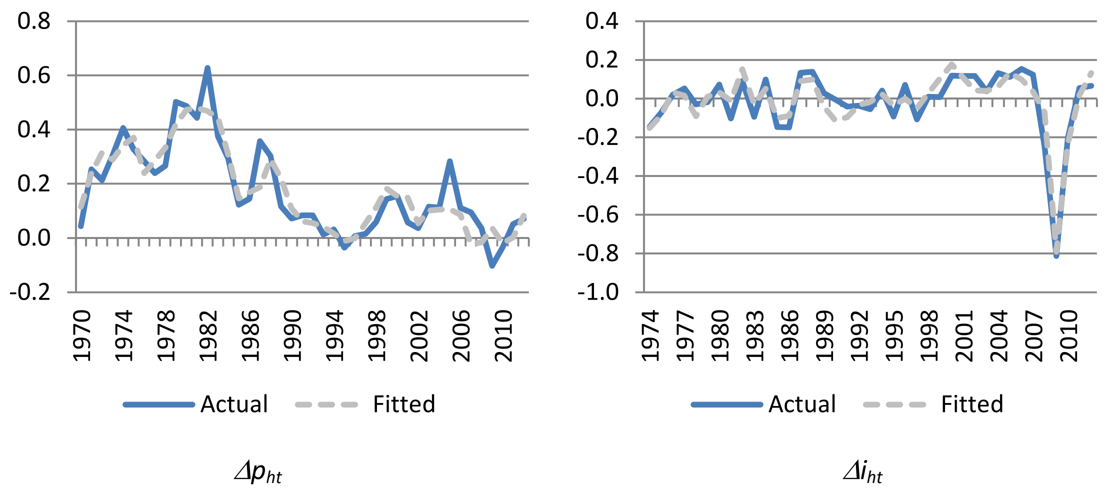


Figure 6. The actual data series for changes in real house prices (on the left) and real housing investment (on the right), along with the fitted series using equations (1) and (2), respectively.

4. Was there a bubble in the housing-market during 2004 to 2007?

The possibility of a "social epidemic" in the housing market is reflected by the rapid rise in real house prices between 2004 and 2008. There is, therefore, reason to test for the presence of a bubble in house prices during the 2004 to 2012 period, as well as looking for possible missing variables. Both house prices and housing investment rise more rapidly between 2004 and 2008 than explained by the variables included in the equations estimated above, and then plummet in the following year. This behaviour in asset prices is commonly referred to as a bubble. The term "bubble" is often used loosely in this context, without a proper indication of what constitutes a bubble. Several definitions have been given, some referring to the behaviour or motivations of investors, some to the deviation from predictions based on explanatory variables derived from economic fundamentals, and others to persistent deviations from expected long-run equilibrium values.

One definition of a bubble is a "substantial and long-lasting divergence of asset prices from valuations that would be determined from the rational expectations of the present value of the cash flows from the asset" (Malkiel 2010, p. 3). This definition implies that there is irrationality to asset price bubbles. Another definition of bubbles implies that expectations of price increases can be self-fulfilling and bubbles can thus be rational, at least temporarily. This is a result of the indeterminacy of the solution to rational expectations models, where any solution to price equations can include an explosive term. While prices continue to rise, regardless of the development of fundamentals, expectations of continued price increases area warranted (see e.g. Cuthbertson 1996, ch. 7).

Siegel (2003) reviews a variety of definitions of asset price bubbles, and then goes on to provide the definition that "a period of rising (or falling) prices in an asset market can be described as a *bubble* (or *negative bubble*) at time ***t*** if it can be shown that the *realised* return of the asset over a given future time period, that time period defined by the *duration* of the asset, can be shown to be inconsistent, i.e., more than two standard deviations from the *expected* return, given the historical risk and return characteristics of that asset at time ***t***." (Siegel 2003, p. 14). This definition is applicable decades after a potential bubble has occurred, i.e. once the actual cash-flow from the asset over its duration is known. Applying this definition to historical stock market prices Siegel concludes that periods commonly recognised as bubbles, due to the immediate price collapse which follows, are, however, periods when the difference in stock returns over bond returns is consistent with the risk and return profiles of these assets.

Although this is a useful definition for statistically testing for a bubble it is difficult to implement shortly after a suspected bubble period. The duration of housing is long and its cash-flow difficult to estimate. Gürkaynak (2005) looked at a number of econometric tests for the presence of a rational bubble in asset prices, defining a bubble rational if investors are willing to pay more for an asset than they know is justified by the value of the discounted cash-flow generated by the asset due to the possibility of selling that asset at an even higher price to other investors. Gürkaynak found that rational bubbles could not be detected to a satisfactory degree using econometric methods.

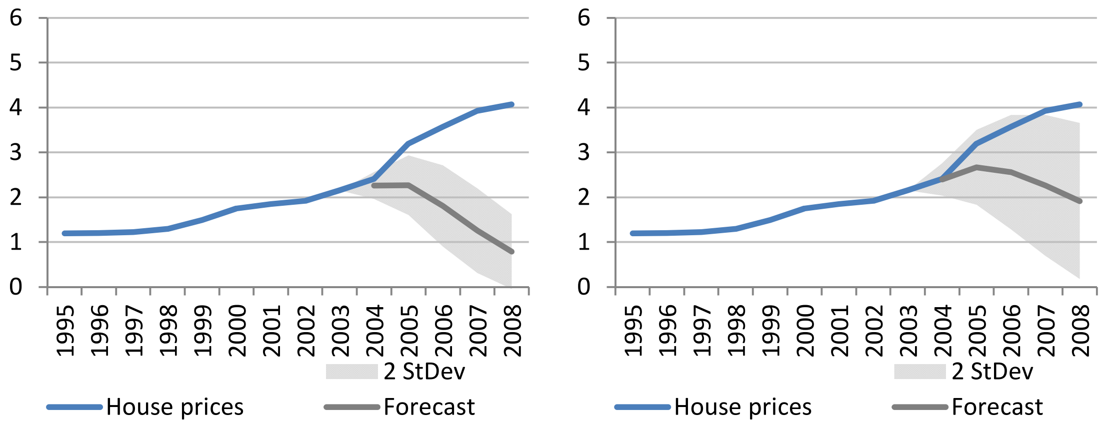
Irrational bubbles, on the other hand, are addressed by the literature on behavioural economics. Vissing-Jorgensen (2003) compares several behavioural models using a data set on investor beliefs and investor actions and finds support for, among other things, models showing momentum (i.e. winners keep outperforming losers) and biased self-attribution (where new public information supporting the investor's private information leads to more overconfidence). Similarly Case and Shiller (2004) find survey information from recent buyers important in determining the extent of a perceived bubble and use it to complement their analysis of excess house price inflation when compared to forecasts based on fundamentals. Scherbina (2013) gives an overview of recent models of rational and irrational bubbles.

4.1. Looking for a bubble in house prices

The potential presence of a bubble in housing prices during the period ending in 2008 was tested using two approaches. The first method is derived from Case and Shiller (2004) who study whether a bubble has appeared in various housing markets in the US. They show time series of actual house prices plotted against forecasts of the same variables which are derived from fundamentals. The second method is derived from the discussion on testing for rational bubbles in asset prices (Cuthbertson 1996, ch. 7) which is based on the cointegration between asset prices and their fundamental determinants.

Leaving aside the issue of what exactly "bubble" refers to in the context of house prices, the model estimated above was used to forecast the house-price during the years 2004 to 2008 (fig. 7). The house price, forecast using equation (1) estimated through 2003 fell significantly short of the actual price movements realised. In fact the actual price series lies well over 2 standard deviations above the forecast price for the years 2005 to 2008. Re-estimating equation 1, using data through 2008, the within-sample forecast of house prices in 2004 to 2008 falls much closer to actual house prices (fig. 7), which are now within 2 standard deviations of the forecast until 2007. The forecast series still behave differently than the actual series, showing stronger reversal to previous levels. By 2008 the forecast series has fallen almost to its 2000 level, while the actual series is still rising in 2008. Thus, there is a fast growing difference between house prices and its forecast using equation (1) even after re-estimating the parameters using data through the forecast period. This could be interpreted as evidence of a house price bubble.

The estimated equation is a combination of observed fundamentals. A forecast based on the fundamental relationship explaining how house prices evolve should move in tandem with the actual house price series. A failure of the fundamentals to track the actual variable could be interpreted as evidence of a bubble (Cuthbertson, 1996).



Estimation period 1970-2003 *Estimation period 1970-2008*

Figure 7. Actual and forecast house prices. The left hand side shows forecasts using eq. 1 estimated using data through 2003. The forecast on the right is derived after re-estimating using data through 2008.

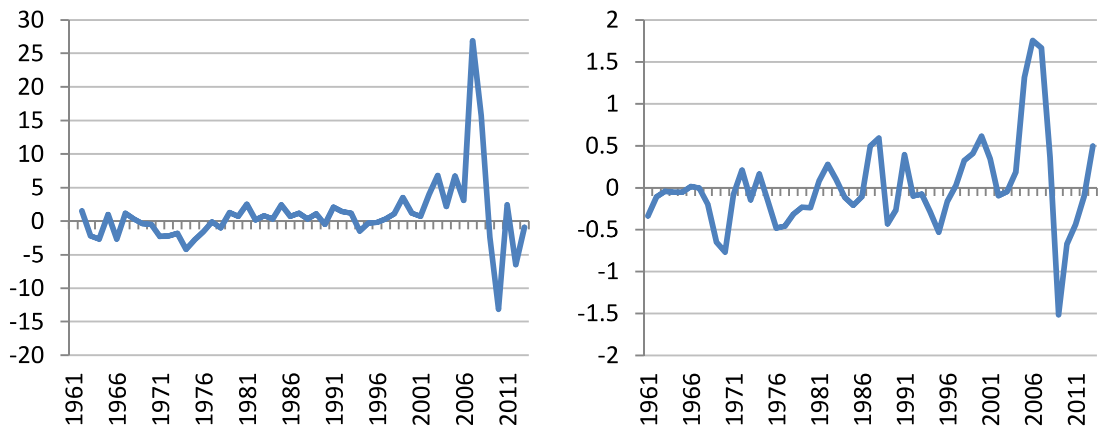
Testing this shows that the house prices series through 2008 is integrated of degree one (table 2). The dynamic forecast of house prices using estimated coefficients for the period 1970 to 2003, is also integrated of degree one. When the series are extended for five years, ending in 2008, their difference is, however, not stationary (table 2). The null hypothesis of a unit root in the series is not rejected. The interpretation is that there is a bubble in the house price series ending in 2008.[5]

Another interpretation is that there may be a variable missing, which is particularly important in explaining house price developments during the forecast period. In other words, these test results may only be indicating that this is not the correct model for house prices. Based on these considerations two new variables were introduced in the house price equation in an attempt to pick up the unusually rapid growth during the suggested "bubble" years, immediately followed by a sudden reversal. One such variable was chosen to represent developments in the financial system, which may have been undetected by the variables in the model, and another represents similar swings in demographics, which according to theory could be important in explaining behaviour in the housing market.[6]

Table 2. Tests for the presence of a house price bubble (H_0: There is a unit root in the series).

	P_h		ΔP_h		P_h^f		ΔP_h^f		$P_h - P_h^f$	
Period	1963	2008	1963	2008	1977	2008	1977	2008	1977	2008
***t*-statistic**		2.039		-2.983**		-0.385		-4.339***		1.974
Lag length		1		0		6		5		6

Significance levels for the first two columns are: -2.601 (10%), -2.927 (5%), -3.581 (1%). Significance levels for the last three columns are: -2.617 (10%), -2.957 (5%) and -3.654 (1%). Significance is indicated by: * at 10% level, ** at 5% level and *** at 1% level. Forecast variables are identified by an *f*. Δ is first difference. Lag lengths for the unit root tests are chosen by the Schwarz criterion.



Δ(M3/GDP) *Net immigration, % of population*

Figure 8. The figure shows the variables tested as explanations of the apparent bubble in house prices during 2004 to 2007: change in broad money as a percentage of GDP, and net immigration as a percentage of population.
Sources: Statistics Iceland, Central Bank of Iceland and author's calculations.

[5] The peak of the house price series, year 2008, is chosen as an endpoint for the series in this exercise in order to maximise the probability of finding a bubble. The intended interpretation is that if this test does not return evidence of a bubble for this period, than a bubble probably did not exist.
[6] Information on the household sector´s financial assets is absent from the house price equation. This variable was not included because reliable data is not readily available.

Net immigration is a natural candidate for an explanatory variable in housing demand. Previous tests using migration to the capital region proved unsuccessful. According to fig. 4 variations in net immigration were much larger, starting in 2004, than previously. Increased variation in immigration suggests that it could be a possible driver of house price movements, particularly from 2004 onwards. Net immigration to the country as a percentage of population exhibits unusual growth during the build-up of the housing bubble, followed by a sudden reversal. Data on immigration and population comes from Statistics Iceland.

Although the Central Bank raised its policy rate repeatedly during 2004 to 2008 in an attempt to rein in inflation, it has been criticised for being too accommodative during that period (see e.g. Hreinsson et al., 2010). The effects of interest rates on the markets should be present in the price equation through its effects on the real interest rate variable. Although monetary aggregates were not targeted by the Central bank of Iceland, changes in broad money could nonetheless hint at the effectiveness in monetary policy, as money aggregates are often thought to be another measure of the monetary policy stance. Broad money, M3, as a percentage of GDP increased rapidly during the build-up phase of the housing market bubble, after which it plummeted. Therefore it was included in the equation, testing whether changes in broad money supply as a percentage of GDP improved the performance of the estimated equations through the recent cycle. The M3 variable is provided by the Central Bank of Iceland.

Since an exponential growth in the underlying variables would show up as a time trend in differences in logarithms the house price equation was also re-estimated with the addition of a time trend, taking on the value 1 in 2004, and then increasing by one each year until 2007, returning to zero from then on. The purpose of this exercise was to establish if the behaviour of the dependent variable was, during that period, guided by exponential growth unrelated to the explanatory variables. The price equation (1) was re-estimated three times, including one of the above-mentioned variables in each case, and finally including all of them simultaneously. Results of the parameter estimation and diagnostic tests are given in table 3.

The estimation results shown in equation 1 above are repeated as model 1 in table 3. Model 2 in the table shows the estimation results after adding a trend variable during 2004 to 2007. The over-all fit of the equation is improved with adjusted R^2 rising from 0.81 to 0.84. The trend variable is significant and the estimated coefficient suggests that a trend in real house prices during 2004 to 2007 explains about 4.4% annual increase beyond changes explained by the explanatory variables included in equation 1. Addition of the trend also shifts the other parameter estimates slightly. Reversion to the wealth to debt and wealth to income ratios appears stronger than in equation 1 and closer to the estimates for the period prior to 2004. The real interest rate also shows a stronger effect on house prices. Autocorrelation and heteroskedasticity of the residuals are marginally rejected at the 10% level of significance. Swapping the trend variable for change in money supply (model 3) does not improve the fit (see table 3).

Table 3. Estimation results for the change in house prices. Model 1 is the basic model from Elíasson and Pétursson (2009) as given in equation (1). Model 2 includes a naïve time trend during 2004 through 2007. Model 3 adds change in M3 as a percentage of GDP. Model 4 includes net immigration as a percentage of the population and Model 5 tests all the variables combined.

	Model1		Model2		Model3		Model4		Model5	
		StDev		StDev		StDev		StDev		StDev
Constant	0.661	0.10	0.776	0.10	0.765	0.10	0.743	0.08	0.767	0.09
Lagged price inflation	0.751	0.07	0.755	0.07	0.744	0.07	0.742	0.06	0.741	0.06
Change in wealth to debt ratio	-0.262	0.12	-0.347	0.12	-0.294	0.12	-0.401	0.11	-0.395	0.11
Wealth to income ratio	-0.535	0.09	-0.662	0.09	-0.630	0.09	-0.592	0.07	-0.619	0.09
Real interest rate	-3.001	0.75	-3.321	0.69	-3.495	0.73	-3.710	0.65	-3.764	0.68
Trend 2004-2007			0.044	0.01					0.003	0.02
Δ(M3/GDP)					0.005	0.00			0.002	0.00
Net immigration							7.115	1.73	6.045	2.76
Diagnostic tests										
Adjusted R^2		0.809		0.843		0.834		0.865		0.860
StDev of Eq.		0.072		0.066		0.067		0.061		0.062
JB (p-value)		0.077		0.313		0.144		0.713		0.983
BG (p-value)		0.519		0.103		0.556		0.511		0.595
W (p-value)		0.451		0.108		0.435		0.189		0.557
Log likelihood		54.59		59.37		58.25		62.69		63.00

All estimated parameters are significant at the 5% level. JB is the Jarque-Bera test for residual normality (distributed as $\chi^2(2)$), BG is the Breusch-Godfrey LM test for first-order residual autocorrelation (distributed as F(1,37) in model 1, F(1,36) in models 2, 3 and 4, and F(1,34) in model 5). W is the White LM test for residual heteroskedasticity (distributed as F(14,28) in model 1, F(18,24) in model 2, F(20,22) in models 3 and 4 and F(31,11) in model 5).

Previous experiments with including demographic variables in housing market regressions using Icelandic data have proven unfruitful. Elíasson and Pétursson (2009) e.g. tried accounting for housing demand by including the population of the capital region as a fraction of total population and found it statistically insignificant. Net immigration as a percentage of total population is included in model 4 (table 3). The variable is statistically significant, implying that a 1% increase in net immigration to the country induces on average a 7.1% rise in real house prices. In addition, the estimated parameter on real interest rates in the house price equation becomes still larger, with 1 percentage rise in real interest rates corresponding to a 3.7% drop in real house prices. Adjusted R^2 of the equation rises to 0.87. When the three additional variables (net immigration, change in the M3 to GDP ratio, and a time trend) were all included in the equation (model 5 in table 3) the diagnostic equation tests yielded similar results as in the case when only net immigration was added (model 4). The adjusted R^2 was slightly smaller when all the variables were included and the coefficients on the 2004 to 2007 trend and on the change in the M3/GDP ratio were statistically insignificantly different from zero. Once net immigration was accounted for the presence of an unexplained trend in house prices during the “bubble” years was no longer detected.

Adding net immigration to the equation improves the fit of the equation the most. Neither the trend variable nor changes in the M3/GDP ratio are significant when net immigration is included.

The equation forecast also improves as shown in figure 9. The estimation period is extended to 2008 when including net immigration. Prior to the alleged bubble-period variation in net immigration was not sufficient to contribute significantly to the equation. The within-sample forecast of house prices for 2004 to 2008 is shown in figure 9 along with two standard deviations of the forecast. The actual house price series lies well within two standard deviations of the forecast variable when net immigration is included in the equation. The forecast follows the actual series much more closely than in the forecasts using model 1, shown in fig. 7.

A unit-root test of the difference between the house prices calculated using the estimated parameters from model 4 in table 3 and the given values of the explanatory variables on the one hand and the measured house prices on the other hand shows that the derived residuals are now stationary (table 4). The null hypothesis of a unit root is rejected at the 5% level of significance. This suggests that when net immigration has been added to the house price equation there is no significant bubble left in the series. This supports the evidence shown in figure 9. The conclusion from this is that the perceived bubble in house prices is driven to a large extent by development of economic fundamentals.

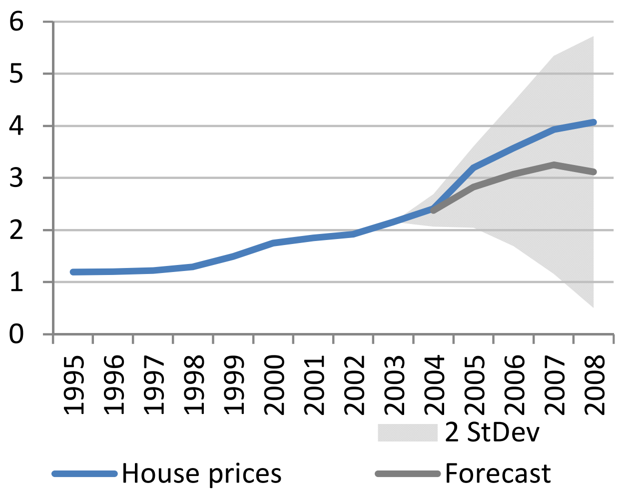


Figure 9. Actual and forecast house prices. The house price series is shown along with a forecast for 2004 through 2008 using the model 4 equation from table 3, i.e. including net immigration in the regression.

Table 4. Unit root test for the presence of a house price bubble for the case when the equation including net immigration is taken as the correct fundamental equation.

	Ph		**D(Ph)**		**Phf**		**D(Phf)**		**Diff**	
Period	1963	2008	1963	2008	1979	2008	1977	2008	1972	2008
***t*-statistic**		2.039		-2.983**		3.700		-3.454**		-3.215**
Lag length		1		0		8		5		1

Significance levels for the first two columns are: -2.601 (10%), -2.927 (5%), -3.581 (1%). Significance levels for the third column are: -2.621 (10%), -2.964 (5%) and -3.670 (1%). Significance levels for the fourth column are: -2.617 (10%), -2.957 (5%) and -3.654 (1%). Significance levels for the last column are: -2.610 (10%), -2.943 (5%) and -3.621 (1%). Significance is indicated by: * at 10% level, ** at 5% level and *** at 1% level. Forecast variables are identified by an *f*. Δ is first difference. Lag lengths for the unit root tests are chosen by the Schwarz criterion.

4.2. Revising the housing investment equation

In order to test for similar effects on the housing investment equation it was estimated with the addition of the same variables as were tested in the house price equation. The rational was simply to see if these variables did carry information about the excessive growth and subsequent dearth in housing investment. The estimation results are given in table 5.

Table 5. Estimation results for the residential investment equation. Model 1 is the basic model from Elíasson and Pétursson (2009) with the addition of a dummy variable from 2009 to 2012, which steps down 20% each year thereafter, as in equation (2). Model 2 adds a time trend during 2004 to 2007. Model 3 adds change in money supply, lagged one year. Model 4 uses net immigration as a percentage of the population as an explanatory variable.

	Model1		Model2		Model3		Model4		Model5	
		StDev		StDev		StDev		StDev		StDev
Constant	0.811	0.29	0.656	0.27	0.559	0.25	0.804	0.29	0.527	0.25
Change in Tobins-Q	0.628	0.12	0.490	0.12	0.641	0.10	0.594	0.15	0.674	0.13
Lagged Tobins-Q	0.562	0.10	0.380	0.11	0.606	0.08	0.536	0.12	0.571	0.12
Investment to housing ratio	-0.547	0.07	-0.552	0.06	-0.416	0.07	-0.543	0.07	-0.462	0.07
Investment intensity	0.793	0.14	0.752	0.13	0.580	0.13	0.788	0.14	0.617	0.13
Post-crisis dummy	-0.714	0.07	-0.677	0.07	-0.668	0.06	-0.695	0.09	-0.726	0.08
Trend			0.048	0.02					0.035	0.03
Lagged Δ(M3/GDP)					-0.009	0.00			-0.007	0.00
Net immigration							1.185	3.36	-4.833	3.53
Diagnostic tests										
Adjusted R^2	0.846		0.871		0.893		0.842		0.894	
StDev of Eq.	0.065		0.060		0.055		0.066		0.054	
JB (p-value)	0.404		0.482		0.450		0.456		0.473	
BG (p-value)	0.842		0.305		0.285		0.783		0.467	
W (p-value)	0.000		0.693		0.821		0.010		0.495	
Log likelihood	54.26		58.22		61.86		54.34		63.36	

All estimated parameters are significant at the 5% level with the exception of β_8, i.e. the coefficient on net immigration in model 4, which is statistically insignificant. JB is the Jarque-Bera test for residual normality (distributed as $\chi^2(2)$), BG is the Breusch-Godfrey LM test for first-order residual autocorrelation (distributed as F(1,32) in Model1 and F(1,31) in models 2, 3 and 4). W is the White LM test for residual heteroskedasticity (distributed as F(18,20) in Model 1, F(22,16) in model 2, F(24,14) models 3 and 4, and F(8,30) in model 5 (where cross-terms were excluded due to data availability)).

Adding the trend variable for 2004 to 2007 improves the fit of the residential investment equation (model 2 in table 5). Adjusted R^2 rises to 0.87 and residual heteroskedasticity is now rejected. The estimated coefficient on the trend indicates on average a 4.8 percent increase in residential investment per year during 2004 to 2007, beyond what is explained by the right hand side variables included in equation 2 (model 1). Substituting $\Delta(M3/GDP)_{t-1}$ for the trend variable further improves the equation. Adjusted R^2 rises to 0.89 as the variable appears statistically significant. Residual diagnostics do not indicate presence of autocorrelation or heteroskedasticity (model 3 in table 5). The sign on the coefficient, however, is negative. It can therefore not be interpreted as an additional route for the effects of loose monetary policy. An alternative explanation, and one which fits the sign of the estimated coefficient, is that growth in broad money instruments is in fact a measure of the availability of alternative investments. With increased supply of financial instruments relative to the size of the economy there will be less demand for investing in residential housing as a form of savings. If broad money increased by 1% of GDP in the previous year then, other things equal, residential investment will fall by 0.9%. Looking at the M3 series (fig. 8) it is clear that its variation over the sample period is dominated by a couple of observations, immediately prior to and following the 2008 bank failures. This large swing in money growth may therefore be picking up similar behaviour in housing investment without any structural relation between the variables. The observed contribution of changes in M3/GDP to housing investment may simply be a statistical fluke.[7]

Testing if net immigration affected residential investment showed it to be insignificant (model 4 in table 5). When all three variables (trend, lagged change in broad money, and net immigration) were included (model 5, table 5) the overall equation fit improved slightly. Significance of the coefficients on the trend and on net immigration, however, is rejected at the 10% level and the coefficient on net immigration is negative.

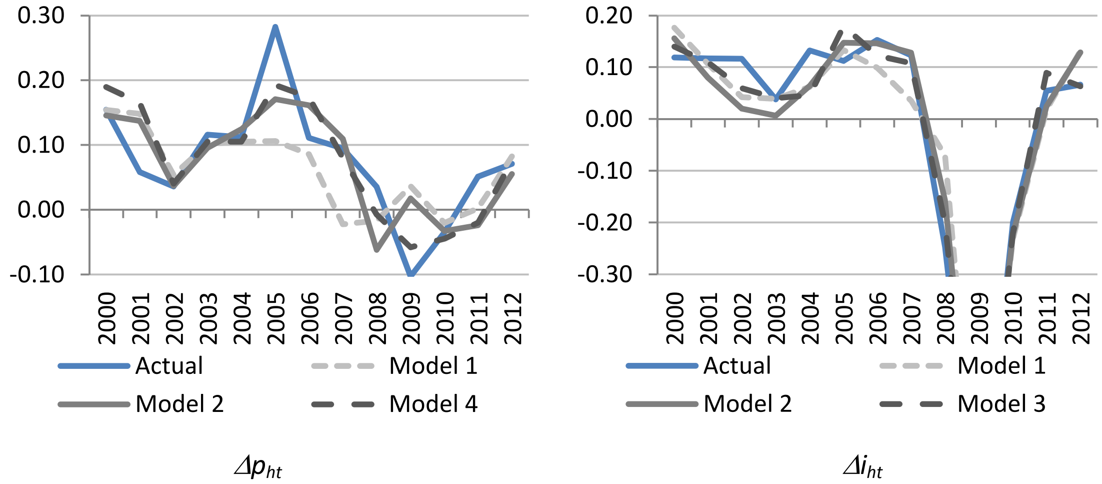


Figure 10. Actual and fitted data. Change in house prices (left) and change in housing investment (right). Each graph shows actual data with solid dark line, fitted data using the updated equations above (dotted light line), data fitted by adding a trend for 2004 to 2007 (solid light line) and using data on immigration for house price inflation (left) and lagged change in money supply for investment (right) (dotted dark line).

The fit of the estimated equations to actual data for the period 2000 to 2012 is shown in figure 10. It appears consistent with what was implied by the empirical results shown in tables 3 and 5. The left hand side of fig. 10 shows that model 4 in table 3, i.e. the equation including net immigration, best replicates the actual change in real house prices. The right hand side of fig. 10 shows that model 3 from table 5, i.e. the equation including lagged change in M3 follows the actual change in residential investment slightly better than the alternative models.

The model's effectiveness in forecasting developments in house prices and housing investment immediately after the boom years was also assessed. Figure 11 shows house prices and housing investment along with four forecasts for each for the post-crash period 2009 to 2012.

[7] Dropping the change in M3/GDP in favour of separate dummy variables for 2008 and 2009 slightly improved the equation fit (with adjusted R^2 = 0.895 compared to 0.893). Including all the variables, however, led to sequential rejection of the new dummy variables while keeping the change in M3/GDP in the equation.

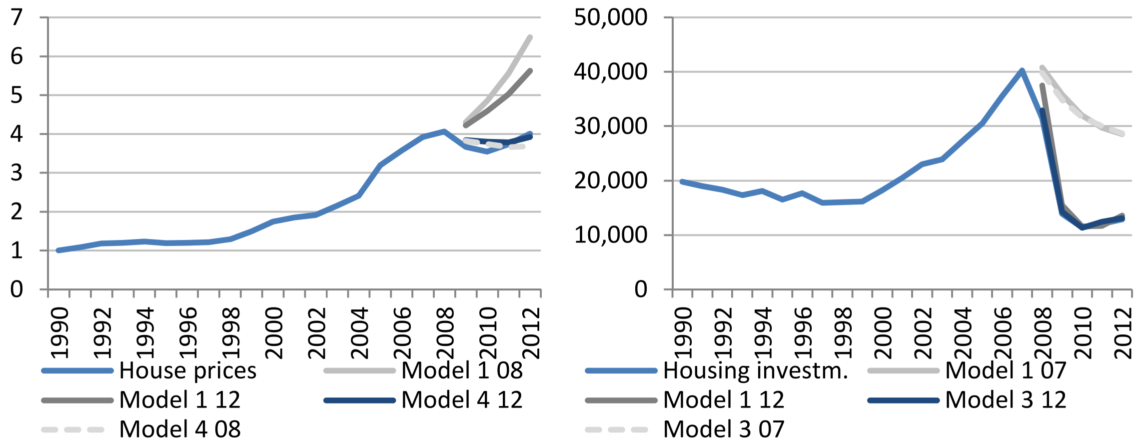


Figure 11. Forecasts for 2009 to 2012. The left hand side shows the house price index for 1990 to 2012, its forecast value for the period 2009 to 2012 using equation 1 estimated using data through 2008 (model 1 08), estimated through 2012 (model 1 12), and using model 4 from table 3 estimated through 2008 (model 4 08), and estimated through 2012 (model 4 12). The right hand side shows housing investment, its forecast for 2008 to 20012 using equation 2 and estimated through 2007 (model 1 07), estimated through 2012 (model 1 12), using model 3 from table 5 estimated through 2007 (model 3 07), and estimated through 2012 (model 3 12).

When equation 1 is estimated through 2008 and used to produce a dynamic forecast of house prices for 2009 to 2012 the forecast is far off track and completely misses the turnaround in house prices in 2009 (right hand side of figure 11). The actual house prices observed in 2009 and 2010 actually lie just outside 2 standard deviations below the forecast values. Re-estimating the equation over the whole period improves the forecast only marginally.

Adding net immigration as an explanatory variable improves the forecast considerably and moves it in line with the observed data, even if the equation is estimated only using measurements up to 2008.

Forecasts for housing investment in fig. 11 are shown for the period 2008 to 2012, but housing investment started to slow down significantly in 2008. When the equations are estimated using only data through 2007 adding the change in the money to GDP ratio does not help. In either case the forecasts fall far off the actual data and miss the sharp decline in housing investment. Re-estimating the housing investment equation using data through 2012 requires that the post-crises dummy is included for the years starting in 2009. Otherwise the equation breaks down. This implies that something happened that is missing from the relationship. This could be manifestation of the effects of the capital controls which were put in place in November 2008; or the effect of the collapse of the banking system and balance sheet restructuring, which slowed down financing of new projects for years.

5. Discussion and conclusions

The Icelandic housing market went through an unusually pronounced cycle during 2004 to 2012. House prices rose swiftly to new heights in 2007 and then fell sharply. Residential investment behaved similarly. The boom was no-doubt in part induced by developments in international markets, financial innovations and mortgage market restructuring. These effects are captured by the two equation model by Elíasson and Pétursson (2009), where house price inflation depends on housing wealth relative to household debt, housing wealth relative to disposable income and the real interest rate. Improved access to mortgages will affect these variables. The model also relates changes in residential investment to the ratio of market prices of houses to building cost and to investment intensity.

The Elíasson and Pétursson (2009) model of the housing market in Iceland is remarkably robust through the recent boom-bust cycle, which was considerably larger than previous swings in the market. During 2004 to 2007 house prices and housing investment increased, however, beyond what was implied by access to mortgages and falling real interest rates. The 2004 to 2008 period is commonly referred to as a bubble in the housing market. Two simple tests for a bubble are applied, indicating that the rapid rise in house prices during the period cannot be explained by the house price equation, suggesting that there was indeed a bubble in house prices. However, adding net immigration to the country as an explanatory variable improves the house price equation significantly, in particular tightening the fit during the recent boom-bust cycle. Applying the bubble tests to the improved equation does not reveal any significant evidence of a bubble, indicating that the rapid rise in house prices was simply a response to changes in underlying fundamentals. In addition, the revised equation shows highly-significant impact of a demographic variable in the housing market; an effect consistent with theory but previously undiscovered in Icelandic data. Movements in net immigration in relation to the total population were much larger during the past ten years than previously. This calls for a close observation of population statistics when forecasting housing market developments.

The investment equation does not hold through the period unless a dummy variable for the 2009 to 2012 post crisis period is added, accounting for the dearth in residential investment, perhaps due to difficulties in financing after nearly the entire banking sector failed in the fall of 2008. The fit of the residential investment equation is further improved by addition of lagged change in broad money supply, which other things equal reduces investment in housing. This is consistent with growth in M3 representing deepening of financial markets, providing viable alternatives to housing for savings. However, the significance of changes in broad money in the investment function depends heavily on a couple of observations, making it difficult to draw strong conclusions about the relationship.

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