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Abstract

The aim of this study is to determine whether house prices in the UK react differently to negative and positive shocks using the asymmetric cointegration approach. The asymmetric adjustments from disequilibrium are likely to exist following different shocks due to the collective reactions of policymakers, homeowners, mortgage lenders and investors. Using the MTAR model we test whether prices move back to equilibrium more quickly after a fall than a rise, potentially as a result of intervention by the authorities who are more concerned by falls due to the potentially damaging affects this can have for the whole economy. The empirical results reveal the existence of an asymmetric long-run relationship between house prices and housing market fundamentals, where negative shocks to the housing market cause convergence between the variables and positive shocks result in divergence. The results also suggest this varies across housing types, although there is little evidence that housing follows a political housing cycle.

Key Words: House prices; asymmetric; cointegration; intervention

J.E.L: E6, R2.

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1. Introduction

The house price bubble leading up to the financial crisis of 2007 and 2008 was one of the largest ever and most damaging to the wider economy. Over the preceding 10 years, property transactions had grown by 38% and house prices had trebled, however in 2007 the market reached its peak with the initial fall in house prices contributing to the subsequent financial crisis. However the house price bubble never totally deflated, as house prices remained relatively stable after 2010, despite the UK economy's "worst peacetime decline" in output (King, 2009). The aim of this study is to determine if there is any asymmetry in the speed of adjustment of house prices depending on whether they are above or below their equilibrium level, possibly through intervention by the authorities being more likely and more pronounced when house prices are below equilibrium than when above.

House price bubbles are feared due to the potential consequence of a deflated bubble. At an individual level, home owners may find themselves in negative equity which could potentially lead into bankruptcy or homelessness; on a microeconomic level, a burst bubble may increase unemployment and loss of value to owners of capital due to the decline in housing related industries; and on a macroeconomic and political level, due to the well documented wealth effect whereby consumption increases as perceived wealth increases, a fall in house prices may send the overall economy into recession (Thornton, 2009).

The housing bubble was the one of the central elements prior to the 2008 financial crisis and that irrational exuberance combined with a weakly regulated financial system led to rapid growth in mortgage lending and property purchases (Baker, 2008). The housing market began to decline in 2007 and then there was contagion, as confidence in the economy and property prices along with the financial markets vanished. But despite the initial 20% decline in house prices, the property bubble didn't completely burst, or as shown in Figure 1 fall as much as the stock market. This is potentially because as mortgage approvals and house prices fell, the government and central bank intervened to support the housing market and consequently, the house price decline slowed down, before returning to an upward trend in 2012.

Despite there being a considerable amount of literature with regards to the housing market and macroeconomic fundamentals, this paper addresses the different speeds of adjustment depending on whether house prices are above or below a particular threshold. In particular, this paper is the first to use the momentum threshold autoregressive model; M-TAR model to investigate the asymmetric relationship between house prices and the conventional housing market fundamentals, across a range of housing types. In addition it attempts to link the asymmetry to a political housing cycle, whereby booms in the housing market coincide with general elections.

This study tests the divergence of UK house prices[1] from their underlying fundamentals when house prices rise and the convergence to equilibrium when house prices fall using the asymmetric cointegration approach, which has been extensively used in studies of asset prices(Shen, et al., 2011), (Tsai, et al., 2012), (Posedel & Vizek, 2010). The MTAR approach is particularly suited to modelling intervention by the authorities in the housing market, as if the speed of adjustment differs depending on whether the market is above or below a threshold value, it implies some policy actions are causing that difference. Enders & Siklos (2001) explain that the type of asymmetry explained by the M-TAR model is particularly relevant when policy makers are more tolerant of disequilibrium in one direction than the other.

[1] This type of study is particularly suited to the UK market, where the majority of people own their own homes, giving a reasonably strong link between the housing market and macroeconomy as a whole.

The remainder of this paper presents a review of the economic literature on the housing market, describes the econometric methodology used in this project, explains the results of the research and concludes with policy implications.

2. Literature review

Due to its significance to the macroeconomy, there is an extensive range of literature on the relationship between housing and macroeconomic fundamentals within the linear framework. Results from these studies are somewhat conflicting when it comes to investigating the key drivers of the housing market. This could be due to the weak power of linear models, when there is in fact nonlinearity or threshold effects (Balke & Fomby, 1997). Studies such as Shnure (2005), Sutton (2002), McQuinn & O'Reilly (2008) and Meen (2002) confirm the importance of the housing market fundamentals of income and interest rates to the level of house prices.

In comparison to the research carried out on linear house price models, there is relatively little literature that incorporates nonlinear properties into the housing market. Tsai & Chen (2009) investigated the asymmetric volatility of house prices using a GJR-GARCH model. Using house price data from 1955 to 2005, they captured the asymmetric impact of positive and negative shocks upon the volatility of house prices. They found that lagged innovations are negatively correlated with housing return. A possible explanation for this is provided by Shafrin & Statman (1985) who have argued that investors tend to sell investments that have increased in price and hold assets that have dropped in value.

Using the M-TAR model proposed by Enders & Siklos, (2001), Tsai et al (2012) found asymmetric cointegration between stock prices and house prices. They discovered that when stock prices are growing faster than house prices, there is a strong relationship between them and a quick correction to the long run equilibrium after a shock. However, they found no such statistically significant result when house prices outperform the stock market. These results support their prediction that the relationship between stock prices and house prices only exists when stock price performance is better than house price performance. In addition using a different approach, Tsai (2013) found evidence of asymmetric adjustment of house prices to money supply, especially downward price rigidities[2]. Using a LM approach, they find evidence of a threshold effect, as well as asymmetries in terms of negative shocks affecting housing volatility differently to the positive shocks. Chen *et al*. (2012) find similar evidence of asymmetry between housing and monetary policy in Taiwan.

Posedel & Vizek (2010) investigate how house prices deviated from the housing market fundamentals of GDP and interest rates across four developed countries and four transition countries. Interestingly, they found that asymmetric price adjustment was present in the transition countries and the US but that the other three developed countries, including the UK, do not have the threshold cointegration. They predict that this is why the transition countries experienced a more intensive house price boom between 1998 and 2006. For the five countries that they did identify as having an asymmetric adjustment process, the adjustment is faster when the disequilibrium is below the threshold. This indicates that when house prices fall, there is a quicker adjustment process back to the long-run equilibrium and that when house prices rise, there is a slow adjustment to equilibrium. This leads to the conclusion that house price booms are persistent and reasonably sustainable.

[2] There is in general a lack of literature explaining and investigating whether house prices are sticky downward and if they are, why that is the case. Coy (2007) suggests that house prices are sticky downwards because sellers want a price close to recent sales values achieved within the neighbourhood during boom-times.

Due to data constraints in some of the transition countries, Posedel & Vizek investigated the UK housing market over a relatively short time period and since cointegration is a long-run phenomena and asymmetric cointegration looks at the adjustment process from booms and busts, the results from this period are not that reliable. In an attempt to address this issue Posedel & Vizek also investigated UK annual data from 1969-2008. Although this data set involves periods of house price growth and declines, the results are only based on 40 observations.

Although there is very few studies that analyse the political business cycle with respect to the housing market, Rogoff (1990) suggests that politicians can use expenditure on high profile projects to signal their competence to the electorate, the housing market could be included among such projects. Veiga and Veiga (2007) use local government data for Portugal and show that investment in the more high profile projects, such as miscellaneous construction increases prior to elections, although there is no evidence that investment in land and housing does, possibly because of the long time lag before this becomes evident to the electorate.

3. **Methodology**

This paper predicts that there is a significant difference between the adjustments to long-run equilibrium in the housing market depending on whether there is a positive or negative shock. This is because policy makers are more likely to intervene in the market if house prices fall, due to the potential problems to the wider economy. Cointegration exists where a combination of non-stationary variables follows a stationary path. When there is asymmetry in the adjustment to long-run equilibrium, symmetric cointegration is misspecified (Balke & Fomby, 1997). Therefore, to investigate the predicted asymmetric relationship between house prices and housing market fundamentals, the TAR and M-TAR models as proposed by

Enders & Granger (1998) and Enders & Siklos (2001) are employed. Enders & Granger (1998) and Enders & Siklos (2001) have developed the threshold autoregressive (TAR) and momentum-TAR (M-TAR) models to test for cointegration where there is asymmetry in the adjustments to equilibrium.

The models test the asymmetric adjustment to the long-run equilibrium:

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\rho_2\mu_{t-1} + \varepsilon_t \tag{1}$$

Where I_t is the Heaviside indicator function such that

$I_t = 1$ if $\mu_{t-1} \geq \tau$

$I_t = 0$ if $\mu_{t-1} < \tau$

μ_t is the residuals from the regression of house prices against a constant and the explanatory variables, τ is the threshold, ε_t is a random vector with zero mean and constant variance and ρ_i are the speed of adjustment coefficients.

If μ_{t-1} is above or below its long run equilibrium, the adjustment is $\rho_1\mu_{t-1}$or $\rho_2\mu_{t-1}$ respectively. For example, if $\rho_1 > \rho_2 > -1$, the positive phase of μ_t will tend to be more persistent than the negative phase assuming equal magnitudes of positive and negative shocks. The special case of the TAR cointegration model where $\rho_1 = \rho_2$is the case of linear cointegration. If the null hypothesis of $\rho_1 = \rho_2$ is rejected however, the adjustment is asymmetric.

In the M-TAR model, Enders & Siklos (2001) suggest an alternative model whereby the rate of decay depends on the changes in the regression residuals. In this case, the Heaviside indicator's threshold depends on the change in the lagged variable:

$I_t = 1$ if $\Delta\mu_{t-1} \geq \tau$

$I_t = 0$ if $\Delta\mu_{t-1} < \tau$

The M-TAR model captures a different type of asymmetry to the TAR model. In the M-TAR model, if for example $\rho_1 > \rho_2 > -1$, positive shocks tend to persist and negative shocks revert quickly to equilibrium irrespective of the magnitude of disequilibrium. Enders & Siklos (2001) explain that the test for whether asymmetric cointegration exists, consists of firstly testing whether there is a long run relationship between the variables using the φ statistic to test the null hypothesis $\rho_1 = \rho_2 = 0$ followed by testing for asymmetric adjustments from disequilibrium using the F statistic to test the null hypothesis $\rho_1 = \rho_2$. Critical values for the test of the long run relationship for a multivariate relationship are provided by Wane et al (2004). In terms of the difference between TAR and MTAR models with regard to interpretation, Sichel (1993) defines two types of asymmetry:

1. Deepness – the magnitude of the distance from equilibrium differs between positive or negative shocks i.e. house prices differ more from the long run equilibrium after a positive/negative shock. This asymmetry type is captured by the TAR model.
2. Steepness – the adjustment speeds of economic variables differs between positive or negative shocks i.e. house prices react quicker in response to a positive/negative shock from the long run equilibrium. This asymmetry type is captured by the M-TAR model.

If there is asymmetric cointegration found in the TAR model, it will be concluded that there is a long run relationship and that the size of the disequilibrium following positive or negative shocks to house prices differ. If there is asymmetric cointegration found in the M-TAR model, it will be concluded that there is a long run relationship and that the rate of adjustment from disequilibrium is quicker in response to a positive or negative shock. If there is no cointegration in any of the models, it will be concluded that there is no long run relationship between house prices and the housing market fundamentals specified.

In conventional economic analysis of house prices and as supported by research from McQuinn & O'Reilly (2008), Reichert (1990) among others, the key housing market fundamentals are personal income and the interest rates on mortgages. The baseline model[3] estimated looks at the relationship between house prices and these standard explanatory variables.

$$hp_t = \alpha_0 + \alpha_1 y_t + \alpha_2 i_t + \mu_t \qquad (2)$$

Where hp_t is log real house prices, y_t is log real personal income, i_t is the mortgage rate, α is a constant and μ_t is the error term. It is expected that when personal income is greater, individuals are willing and able to spend more on housing and hence a positive relationship between house prices and personal income is expected. A negative relationship between interest rates and house prices are expected as investments in houses become less attractive and affordable when mortgage payments increase.

After asymmetric cointegration has been established, the short-run responses to positive and negative shocks can be investigated through an error correction model (ECM) as explained by Enders & Granger (1998). To test for the existence of a political housing cycle, we have added a dummy variable, which takes the value of one in the quarter when an election occurs

[3] Although many other studies have added alternative factors in addition to the ones included here, such as inflation, the low levels of inflation over the time span included here would make this less relevant.

and zero otherwise. We would expect this to be positive and significant if a political business cycle exists, as this would suggest that house prices were above average before and during an election. The ECM is then:

$$\Delta hp_t = \alpha_0 + \beta_1(L)\Delta hp + +\beta_2(L)\Delta y_{t-1} + \beta_3(L)\Delta i_{t-1} + \gamma_1\mu^+_{t-1} + \gamma_2\mu^-_{t-1} + Dummy + \varepsilon_t \tag{3}$$

Where μ^+_{t-1} is μ_{t-1} if $\mu_{t-1} \geq \tau$; otherwise $\mu^+_{t-1} = 0$. μ^-_{t-1} is μ_{t-1} if $\mu_{t-1} < \tau$; otherwise $\mu^+_{t-1} = 0$. (L) is a lag operator. γ_1 and γ_2 represent the speed of adjustment to long-run equilibrium following positive or negative shocks respectively. Dummy is the general election dummy variable[4].

This paper aims to investigate the following hypotheses: The adjustments from disequilibrium are asymmetric where there is a greater speed of adjustment to equilibrium following negative shocks than positive shocks. Following a positive shock, house prices rise faster than their explanatory variables, they inflate explosively in a bubble. Anticipating further house price rises, buyers believe that it is a profitable investment and lenders believe that there is less risk in mortgage lending. Transactions and demand then grow at an increasing pace due to herd behaviour and hence a bubble is formed. When this is the case, there is a slow adjustment back to the long run equilibrium.

When there is a negative shock to the housing market, such as following a banking crisis, transactions fall because sellers are averse to losses and mortgage approvals decline as a result of increased perceived risk in the property market. This produces a potential for a

[4] Other windows for the dummy variable were also tried, but they didn't improve the results.

decline in house prices. In addition, the reaction of the policymaker following a positive or negative shock is likely to be different, as it is in the interests of policymakers to have increasing house prices thus they are more likely to intervene in a declining market than a booming one. This results in a much quicker adjustment to long-run equilibrium when property prices are below equilibrium. Monetary and fiscal policy measures, such as quantitative easing or 'help to buy' schemes are frequently used to boost house prices when growth is below average but that contractionary policy when house prices are above equilibrium is very rare. There are many reasons for why this might be the case.

Ansell (2009) found that rising house prices leads to cabinet stability and hence politicians have an incentive to act when house prices fall but not intervene when house prices rise. Over 60% of the UK population are homeowners so it is in the policymakers' interest to please this majority by helping to inflate house prices (O'Brien, 2013). Popa (2013) found that the larger the proportion of homeowners in a country, the more 'artificial' house price appreciation will emerge from the political process. Popa's research suggests that with a large proportion of homeowners, policy makers will subsidise home buying through relaxed credit conditions in order to satisfy the demands of the majority of voters.

Falling house prices are likely to have a negative wealth effect and any resultant decrease in consumption is likely to deepen into an economic slump. In addition, Richards (2013) argues that intervention to boost the housing market is a popular policy and hence comes at "convenient" times in the electoral cycle. This also follows analysis of Rogoff (1990) who suggests before elections more visible investment is likely to be encouraged. Richards (2013) also suggests that the banks benefit most from house price rises. Since the banking market is so significant to the prosperity of the UK economy, the government may have no choice but to only implement measures that increase the rate of house price appreciation.

We also assess whether the presence of asymmetric cointegration varies across different types of housing, with the cheaper end of the market more likely to provide evidence of asymmetry. As many of the policies introduced over the years to encourage the housing market have been aimed at first-time buyers, we would expect the asymmetry to be more evident in the types of houses they are most likely to buy, which would be the flats and terraced properties. Examples of this type of policy include, the help-to-buy scheme introduced in 2013 as a result of the financial crisis and fall in the supply of mortgages from the banks. In addition there have been many examples of fiscal changes to encourage the cheaper end of the housing market, such as raising the threshold at which stamp duty is paid, which for instance during the fall in house prices in the early 1990s was raised from £30,000 to £60,000. Although this type of policy can help all property types, we would expect it to affect smaller properties relative to the larger ones.

4. Data and Results

This study uses quarterly data from 1980:Q1 to 2013:Q2 (134 observations) for the combined housing type index and 1991:Q1 to 2013: Q2 for the individual housing type indexes, as the latter data only begins in 1991. The Nationwide seasonally adjusted quarterly index of all properties is employed for house prices, as well as the indexes for flats, terraced houses, semi-detached houses and detached housing. This index provides data that refers to the 'typical house' in the market and, according to Ward (2012), it provides trends that are more consistent with other indices than the alternative long running data set by Halifax.

The Office for National Statistics (ONS) seasonally adjusted quarterly disposable income data (determined from the sum of household final consumption expenditure and savings less the change in net equity of households in pension funds) is obtained as a measure for personal income. Oxford Economics building society mortgages quarterly interest rate data provides a long period data set of the effective interest rate in relation to the UK housing market. As data is only available from 1980, this limits the period of time that is analysed.

Enders & Siklos (2001) explain that the linear cointegration strategy can be biased towards the conclusion of no cointegration when the relationship is asymmetric. Therefore, both forms of asymmetric cointegration, TAR and M-TAR are investigated to determine whether there is any long-run relationship present between house prices, mortgage rates and personal income. Table 1 reports the tests for a unit root, suggesting all the variables are I(1).

Table 2 reports the results from the TAR asymmetric cointegration test[5]. Asymmetric cointegration is tested firstly through the TAR model, which investigates whether the 'deepness' of positive or negative shocks are greater. As can be seen in table 2, the results suggest that there is not a statistically significant long run relationship that can be explained after considering the existence of different magnitudes of disequilibrium from positive or negative shocks. Although this finding suggests that this type of asymmetry doesn't exist, the M-TAR model tests for an alternative form of asymmetry in the relationship. To investigate whether economic agents 'react' differently when the housing market underperforms its fundamentals to when it outperforms them.

Table 3 reports the results from the M-TAR asymmetric cointegration, the M-TAR model investigates 'steepness' asymmetry; i.e. it tests for whether there is a quicker speed of response for positive or negative shocks. Unlike the TAR model, when the threshold level is determined efficiently by the data, the φ statistic is significant at the 10% significance level

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[5] Results from the Ljung-Box test for serial correlation, suggests that the residuals are white noise and hence there is no issue of serial correlation in these tests.

allowing the null hypothesis of no cointegration to be rejected. In addition, the F-Statistic is significant at the 1% level allowing the null hypothesis of symmetric cointegration to be rejected.

The results suggest that the M-TAR test with the data-determined threshold was most successful in detecting cointegration. This could be as a result of the greater power of the M-TAR model (Enders & Siklos, 2001) and/or because there is asymmetry in the speed of response from positive and negative shocks rather than asymmetry in the magnitude of the disequilibrium from positive and negative shocks. This is certainly the case with house price booms and busts. Policy makers aim to avoid house price falls at all costs but are not worried by disequilibrium caused by house price bubbles. In addition, this type of asymmetry could suggest that policy makers are reactive rather than proactive in response to negative shocks to the housing market; i.e. the policy maker implements policy in response to shocks to help return the housing market to equilibrium but does not reduce the magnitudes of these shocks when they are about to occur.

In this M-TAR model, the sign of ρ_2 is negative, which explains that when there is a negative shock, there is convergence to the long-run equilibrium. This result is statistically significant at the 1% level. This fast adjustment from disequilibrium following a negative shock to the housing market supports our hypothesis of intervention supporting the housing market after a negative shock. As previously discussed, numerous factors explain this sticky price phenomenon, preventing the market from further decline. Policymakers know the substantial negative effects of falling prices on the economy, and their popularity, and so react to the decline with expansionary policy.

On the other hand, the point estimate of μ_{t-1} for positive shocks to the housing market, show ρ_1, is positive. This suggests that after a positive shock, the housing market diverges from its equilibrium relationship with housing market fundamentals. When house prices rise, individuals and banks believe house prices will continue to rise. This makes investing in property less risky and, as a result, banks are more willing to lend and individuals are eager to buy as soon as possible to make the most of the rising market. This results in an increase in demand hence house prices inflate at an even faster rate. Despite disequilibrium in the market, policymakers see no need to respond as rising house prices boost spending through the wealth effect and also increases their probability of re-election since the majority of voters in the UK are homeowners. This divergence discussed above is not statistically significant. However, what is clear from this M-TAR model is that there is little or no convergence for positive $\Delta\mu_{t-1}$ but substantial decay for negative $\Delta\mu_{t-1}$. This means that increases tend to persist but decreases tend to revert quickly to equilibrium.

It is important to note that the efficient threshold determined by the data that is used to draw the above conclusions is slightly negative. This suggests that for small negative changes in the error term, i.e. small negative shocks to the housing market, there is little or no adjustment back to equilibrium. This could be because economic agents do not react to small negative shocks as they do not see it as a significant change in the market.

The results for the individual housing types follow a similar pattern to the combined housing index, in that there is no evidence of asymmetric cointegration based on the TAR model, but strong evidence when using the MTAR model. Again the positive error terms tend to be insignificant, whilst the negative errors are correctly signed and also highly significant, implying a quick return to equilibrium. The speed of adjustment for the negative shocks seems to be quickest for the terraced and semi-detached houses, rather than the flats, possibly indicating that policy makers are most concerned with this group of houses as it is where the floating voters are most likely to live.

The existence of asymmetric cointegration justifies the investigation of the error correction model in order to estimate the short-run dynamics of the relationship. The estimation results are shown in Table 4. As can be seen, the error correction terms for both positive and negative shocks are statistically insignificant. This result of asymmetric cointegration but statistically insignificant error correction terms in the error correction model is consistent with the findings of Enders & Siklos (2001). This suggests that even though there is long-run asymmetric cointegration, there is no reaction to disequilibrium in the short-run. This could be because economic agents only respond to prolonged periods of disequilibrium or because of the significant lag time between actual house price performance and the resultant effects of the reaction of economic agents to the market news. For example, Case et al (2013) identified recognition, implementation and response lags for monetary and fiscal policy and, according to the Bank of England (2014), the response lag alone for monetary policy is 2 years.

The ECMs for the individual housing types produce more mixed results suggesting different dynamics across the different housing types, reflecting potential differences in the wealth of those buying the houses. Although the positive error correction terms are all insignificant, again suggesting little adjustment when above equilibrium, for flats and detached houses the error correction is significant when below equilibrium, with flats as expected having the quickest speed of adjustment. However for the medium range houses, there is little evidence of significant adjustment, possibly because the intervention policies are aimed at them to a lesser extent. The dummy variables measuring the political housing cycle are not significant for the combined housing index and the flats and terraced housing also produces insignificant dummy variables. However both semi-detached and detached housing produce significant variables indicating these houses tend to follow a political housing cycle to some extent.

5. Conclusion

This study finds evidence of asymmetry in the long-run relationship between UK house prices and the macroeconomic fundamentals, due to the differing reactions of policy makers, homeowners and lenders to positive and negative economic shocks to the housing market. Policy makers intervene in a weak housing market but are less inclined to introduce appropriate policies when house prices are booming due to the importance of the housing market to the economy and possibly voting. Also in a rising market, where there is no incentive for the authorities to intervene, potential house price bubbles can occur through inaction by the authorities as well as herd behaviour

The results of the initial M-TAR model reveal that there is a long-run equilibrium relationship between house prices and the property market fundamentals of mortgage rates and personal income and that there is asymmetric adjustment from disequilibrium. In addition, the findings reveal convergence to equilibrium following negative shocks to house prices but divergence from equilibrium following positive shocks. This result is the case regardless of the type of housing.

Results from the asymmetric error correction models suggest little evidence of asymmetric adjustment to positive and negative shocks in the short-run. However the ECMs of the different types of housing do produce differing results, with both flats and detached houses having significantly negative error correction terms when below equilibrium, with as expected flats being the most significant and suggesting the quickest adjustment back to equilibrium from below. There is little evidence of a political housing cycle as the dummy variables are mostly insignificant. This could suggest that the impetus for moving housing back to its equilibrium following a negative shock comes from the monetary authorities rather than being politically motivated.

With regard to the policy implications of these findings, the results suggest that policies aimed to boost the housing market, for example the current ‘Help to Buy’ scheme in the UK, may have the desired effect of boosting house prices over a prolonged time period. However the rises will need to be closely monitored to prevent an unstable bubble forming in the housing market and a contingency policy will need to be prepared to ensure the rises aren’t excessive and cause long-term damage to the economy. To an extent this may already be happening as the financial sector sets more rigorous criteria for granting mortgages, following advice from the central bank. But in the future the authorities may need to be more prepared to intervene in the housing market when it is above equilibrium, as well as when below. Future research could analyse this asymmetric effect in housing across the regions in the UK as well as countries where the housing market is not as significant, such as Germany, although data is still fairly limited in this case.

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Table 1 – Unit root test results

ADF Test		Test for I(0)		Test for I(1)	
		T-statistic	Critical Value (5%)	T-statistic	Critical Value (5%)
Log real house prices	Without trend	-1.1373	-2.8834	-4.6422	-2.8834
	With trend	-1.8372	-3.4440	-4.7173	-3.4442
Log real stock prices	Without trend	-2.0440	-2.8832	-11.9043	-2.8834
	With trend	-2.1373	-3.4440	-11.9958	-3.4442
Log real personal income	Without trend	-1.0011	-2.8832	-11.2599	-2.8834
	With trend	-2.7208	-3.4440	-11.3454	-3.4442
Mortgage rates	Without trend	-1.2701	-2.8832	-9.8939	-2.8834
	With trend	-2.5539	-3.4440	-9.8644	-3.4442

Null hypothesis: There is a unit root
Lag length determined by the Schwarz Info Criterion

KPSS Test		Test for I(0)		Test for I(1)	
		T-statistic	Critical Value (5%)	T-statistic	Critical Value (5%)
Log real house prices	Without trend	1.1335	0.4630	0.1183	0.4630
	With trend	0.1550	0.1460	0.1145	0.1460
Log real stock prices	Without trend	1.1462	0.4630	0.1877	0.4630
	With trend	0.2695	0.1460	0.0344	0.1460
Log real personal income	Without trend	0.8633	0.4630	0.3070	0.4630
	With trend	0.2854	0.1460	0.1033	0.1460
Mortgage rates	Without trend	1.3290	0.4630	0.0389	0.4630
	With trend	0.2770	0.1460	0.0326	0.1460

Null hypothesis: The variable is stationary

Table 2 – TAR asymmetric cointegration test results

	All	Flats	Terraced	Semi-Detached	Detached
τ (threshold value)	0.2810	0.2710	0.203	0.203	-0.062
ρ_1	-0.085	-0.116	-0.108	-0.107	-0.099
	(0.034)	(0.057)	(0.050)	(0.050)	(0.048)
ρ_2	-0.030	-0.050	-0.030	-0.0322	-0.030
	(0.038)	(0.064)	(0.070)	(0.072)	(0.073)
$\rho_1 = \rho_2 = 0$ (ϕ statistic)	3.386	2.280	2.357	2.378	2.177
$\rho_1 = \rho_2$ (F statistic)	1.152	0.600	0.834	0.757	0.627

Notes: Numbers in the brackets are standard errors.
***, **, * represent statistical significance at the 1%, 5% and 10% significance levels respectively.
Critical values of ϕ statistic obtained from (Wane, et al., 2004).

Table 3–MTAR asymmetric cointegration test results

	All	Flats	Terraced	Semi-Detached	Detached
τ (threshold value)	-0.007	-0.015	-0.028	-0.019	-0.007
ρ_1	0.006	0.036	0.023	0.035	0.037
	(0.032)	(0.043)	(0.032)	(0.035)	(0.040)
ρ_2	-0.162	-0.417	-0.680	-0.572	-0.408
	(0.039)	(0.070)	(0.075)	(0.070)	(0.066)
$\rho_1 = \rho_2 = 0$ (ϕ statistic)	8.625	17.870	42.214	34.550	19.403
$\rho_1 = \rho_2$ (F statistic)	11.189	30.369	77.022	62.167	33.610

Table 4 – Error correction model statistics based on the MTAR model

Variable	All	Flats	Terraced	Semi-Detached	Detached
constant	0.001	-0.002	-0.001	-0.003	-0.001
	(0.002)	(0.004)	(0.002)	(1.074)	(0.002)
μ_{t-1}^{+}	-0.008	0.026	-0.003	0.710	0.006
	(0.010)	(0.023)	(0.014)	(0.384)	(0.017)
μ_{t-1}^{-}	-0.023	-0.104	-0.041	-0.022	-0.048
	(0.021)	(0.037)	(0.027)	(0.013)	(0.024)
Δhp_{t-1}	0.789	0.460	0.754	0.735	0.653
	(0.064)	(0.106)	(0.082)	(0.083)	(0.093)
Δy_{t-1}	0.017	0.045	0.068	-0.002	0.026
	(0.038)	(0.607)	(0.043)	(0.006)	(0.042)
Δi_{t-1}	-0.008	-0.027	-0.017	-0.016	-0.007
	(0.003)	(2.316)	(0.006)	(0.006)	(0.006)
Dummy	-0.008	0.012	0.013	0.023	0.019
	(0.008)	(0.016)	(0.009)	(0.009)	(0.009)
Adjusted R^2	0.566	0.195	0.510	0.497	0.389

Notes: The table reports the estimation results for the following asymmetric error correction model:

$\Delta HP_t = \alpha_0 + \beta_1 \Delta HP_{t-1} + \beta_2 \Delta Y_{t-1} + \beta_3 \Delta i_{t-1} + \gamma_1 \mu_{t-1}^{+} + \gamma_2 \mu_{t-1}^{-} + \varepsilon_t$

Figure 1. The UK house prices relative to UK stock prices