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The Dynamics of House Prices and Income in the UK

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Asset prices and fundamentals can move apart, as is the case during bubble episodes. However, they should exhibit a stable relationship in the long run. For UK housing, previous studies have investigated whether house prices share a long run relationship with income. Results thus far have not yet found such stability in the interaction of the two variables. These previous papers have imposed linear adjustment on the relationship. Nonlinear adjustment, however, has been shown to be a feature in a number of housing market relationships. In this study, we utilize a data set that consists of home prices relative to first time buyer income for the UK and its twelve constituent regions, which gives us a direct measure of affordability. We test for the stationarity of the home price/first time buyer income ratio with linear tests, and, as in past studies, fail to find a long run relationship. However, we then employ a nonlinear test, and find a stationary relationship for the UK and seven of the twelve regions. In particular, the regions closest to London appear most clearly to have a stationary relationship between home prices and income.

Keywords

House Prices, Asset Prices, Bubbles, UK Regions

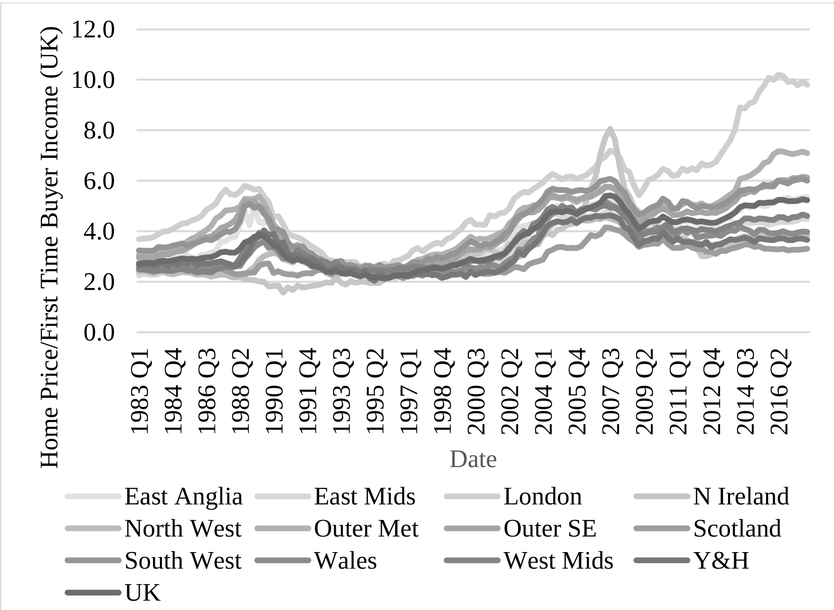
1. Introduction

Home values and fundamentals share a relationship that has yielded empirical puzzles. On the one hand, formal theory clearly implies that home values and income should share a stationary relationship (Holly et al., 2010; Leung, 2014). Indeed, the theory on the home price/income relationship is much clearer than that of the price/earnings relationship for equities (see Arnott et al. (2018) for a discussion of the long run price/earnings relationship for stocks). Empirically, however, studies which have sought to find a stationary relationship for house prices and income and imposed a linear adjustment process have failed to find such stationarity for the UK (Holly and Jones, 1997; Meen, 2002) and other countries (Gallin, 2006; Holly et al., 2010). One could imagine the ratio of home prices to income rising above a long run equilibrium value during a bubble, but presumably prices could not increase relative to income without limit, and this makes the failure to find a relationship between the two puzzling at first glance.

One possibility is that home prices and income do share a long run relationship, but that adjustment to that equilibrium from a shock could be nonlinear. There is certainly strong evidence that home prices and income exhibit nonlinearity. A couple of studies - Katrakilidis and Trachanas (2012) and Bahmani-Oskooee and Ghodsi (2016), do employ nonlinear estimation in examining home prices and income for Greece and the United States, respectively, and find evidence of stationarity that linear estimators did not detect. However, the method used - a nonlinear autoregressive distributed lag (ARDL) test for cointegration, requires that one variable is weakly exogenous. However, there is strong evidence that each variable affects the other.

In this paper, we examine the issue of the home price-income relationship for the UK and its twelve regions. As proper measurement of income can be problematic, i.e., if much real estate in a region is purchased by buyers outside the area, local income may not be a good "fundamental" indicator, we utilize a series-home price to first time buyer income that is collected by the Nationwide Building Society that clearly relates purchaser income to home value. We then allow for the possibility that the equilibrium home value to income ratio can change over time, as innovations such as greater mortgage credit or securitization can raise home values relative to income (see Baddeley (2005), for a discussion of changes in the UK housing market). In particular, we specify a linear trend for all thirteen home price-income ratios in our sample, to reflect the changes in mortgage finance since the early 1980s. These trends appear to be justified by the data on the home value-income ratio (Figure 1) which show a secular increase for the UK and its regions over the decades. We then apply standard linear tests to the ratios to test whether the home price/income variable, allowing for change over time, at least returns to a long-run trend. To anticipate our results, we find in no case can we reject the null of nonstationarity with these linear tests, which is a result consistent with previous findings for the UK and US. We then test the ratios for nonlinearity, and find that in all thirteen cases, there is substantial evidence of asymmetric adjustment. We then test all ratios for trend stationarity by using the Enders-Granger unit root test which allows for nonlinearity. The method does not impose assumptions of weak exogeneity as the ARDL test does. The results indicate that the UK national and seven regional ratios-all of which appear to have unit roots by the linear tests-are trend stationary.

Figure 1 House Price/Fist Time Buyer Income Over Time



The regions that have stationary price-income relationships are for the most part close to London, and in the southern part of the UK. In contrast, those that lack a stable price-income ratio are disproportionately in the north of the UK. Differences in the regional housing markets of the UK have been the subject of a large number of previous papers (see, among the many examples, MacDonald and Taylor (1993), Malpezzi (1999), Meen (2002) and Holmes and Grimes (2008)). Helping to explain our finding on greater stationarity in the south, we note that the northern regions have a higher debt relative to home value, as exhibited in the higher loan-to-value ratios, than those in the south. This regional disparity, in which the northern regions have higher levels of gearing, has been documented by previous authors such as Meen (2002). The impact of higher credit in generating higher house prices is consistent with the recent findings of Mian and Sufi (2018) for the US housing market.

Practically, these results suggest that an increase in the home price/income ratio over time does not necessarily indicate a bubble or imminent decrease in home values, but as home values do not increase ever further from their trends without adjusting, a rapid increase in the ratio could well indicate trouble ahead for the housing sector.

This paper proceeds as follows. The next section describes the previous literature. The third explains our data and methodology. The fourth section describes our results and the fifth concludes.

2. Previous Literature

The different housing markets of the UK, and the data available for each region, have made Great Britain the focus of numerous studies on housing issues. One key question for the UK market is whether there exists a “ripple effect”; that is, do house price changes in one region get transmitted to other markets? Typically London, or the south east UK region are postulated as undergoing an initial shock, and then the question is how the price change is propagated to the rest of the nation (see MacDonald and Taylor (1993) and Cook (2016) for discussions).

A related topic is whether home prices across the different regional UK regional markets converge in the long run (Holmes and Grimes, 2008). The results from papers on long run convergence are somewhat mixed. However, there is clear evidence on differences in regional house price dynamics. Meen (2002) finds clear differences in in the dynamics of home values between the south of the UK and the northern regions, a point that will be relevant to our study.

Another key topic for the UK and other nations is of course the stationarity of the home price-income ratio. Bubbles in the housing market-periods when values exceed their long-term relationship with a fundamental such as income could exist. Few dispute that home values in the US rose to unsustainable levels over the mid-2000s, for instance. On the other hand, it is difficult to conceive that home values could increase without limit relative to some long-run relationship with income.

Of course, if there is a long run relationship between home prices and income, it need not imply a constant ratio of the former to the latter. Changes in mortgage finance, or a greater tolerance for debt on the part of borrowers and lenders, or increases in housing quality over time could lead to an increase in home values relative to income, especially the income of first-time buyers. Baddeley (2005) for instance states that the Thatcher government in the UK sought to increase homeownership. “Encouraging homeownership was an essential element of Thatcher’s political agenda; policies to encourage home ownership were successful in achieving this goal, at least in the short-term (though the longer-term implications of sustained house price rises for first time buyers in the 2000s are less clear") (Baddeley, 2005, p. 5).

In particular, Baddeley (2005, p. 5) points to changes in financial policy-specifically the "deregulation of the building societies in 1981, which allowed rapid growth in mortgage liquidity…With financial deregulation, the pivotal role of building societies in providing mortgage lending backed by household savings was diluted; a wide range of other financial institutions were allowed into the mortgage lending market and this mortgage lending could be backed by a range of instruments, including short-term money market funds. The terms of mortgages became more flexible and generous (including one hundred percent mortgages)".

These and other changes of course increase the equilibrium ratio (if one exists) of home prices to income. However, such a relationship could, despite these changes, still indeed exist. Therefore, a researcher should account for these changes over time.

Empirically, an equilibrium stationary relationship between home value and fundamentals has often proven elusive. Holly and Jones (1997) test for the stationarity of the home price/income ratio in the UK and find that they cannot reject the null of a unit root. Meen (2002) examines home prices and income at the national level for both the UK and US. He specifies the variables, measured over the period of 1969-1986, as ARDL models and examines the possibility of cointegration, by applying ab augmented Dickey-Fuller (ADF) test to the residuals. Meen (2002, p.8) notes that his test statistics "are close to their critical values" (p. 8); that is, the test statistics are almost large enough that he can reject the null of no cointegration and formally find a long-run equilibrium. Similarly, Malpezzi (1999) applies data on the home price/income ratio for over one hundred metropolitan areas in the US. Malpezzi (1999) first applies a panel unit root test to the ratio, but fails to reject the null of a unit root. He then regresses home values on income, and uses the Levin-Lin Chu panel method to test the residuals for stationarity, which, using standard critical values, he appears to find. Thus, the two papers of Meen (2002) and Malpezzi (1999) seem to indicate a long run stationary relationship between home value and income, at least for the UK and US.

Gallin (2006), however, points out that these two studies have not established any such relationship. First, Gallin (2006) points out that Meen (2002) cannot reject the null of nonstationarity –his test statistic is, again, "close to", but not as much as the critical value. Gallin (2006) also questions the claim made by Malpezzis (1999) and stated that his two-step approach of regressing home prices on income and subsequently testing the residuals for stationarity "overstates the likelihood of cointegration because it ignores the first-stage estimation in the residuals-based cointegration test" (Gallin, 2006, p. 419).

Gallin (2006) himself examines home values and personal income for ninety-five US cities over the period of 1978-2000. He applies a panel cointegration test developed by Pedroni (1999) but finds that he still cannot reject the null of no stationary relationship between the two variables. Another paper on house prices and fundamentals which uses a panel method to test for stationarity is by Holly et al. (2010). They model home value as being driven by income and other fundamentals, and use data for US states that span from 1975 to 2003. They run regressions of home prices on the specified determinants and test the residuals for stationarity with a cross-sectionally augmented Im, Pesaran and Shin (IPS; CIPS) panel test. The authors reject the null hypothesis that all residuals are unit root processes. An initial, and incorrect, interpretation of these results would seem to indicate that home prices and fundamentals do share a long run relationship, but again this would be erroneous. The null hypothesis for the CIPS test is that all variables (here, the residuals from the aforementioned regressions for all fifty states) are unit root processes, while the alternative hypothesis is that at least one of the variables is stationary. Thus, all that can be concluded from Holly et al. (2010) is that for at least one state, home prices and fundamentals have a stationary relationship, and we do not know for which states that this condition holds.

Kishor and Marfatia (2017) test for cointegration among home prices, income and interest rates for fifteen (Organisation for Economic Co-operation and Development) OECD countries. Using the Engle-Granger method, the authors reject the null of no cointegration at the five or ten percent level for all countries. However, as with the findings in Holly et al. (2010), the results are highly questionable. First, Kishor and Marfatia (2017), as noted, test interest rates, as well as house prices and income for cointegration. However, for cointegration to exist, all three variables must have unit roots. Yet they do not test for unit roots in the variables. Moreover, interest rates have been shown to be stationary. While some tests on interest rates in years past have indicated that they are unit root processes, Lai (2008) finds that interest rates are stationary when structural breaks are allowed in the unit root tests. This result makes sense, as a nonstationary interest rate would contradict theoretical asset pricing models (indeed Holly and Jones (1997) find that interest rates in the UK are stationary by using just a linear Phillips-Perron test, and thus refrain from trying to include interest rates in a cointegrated system).

The results of Kishor and Marfatia (2017) are thus cast into doubt when it is considered that they seem to find cointegration with variables that are not all nonstationary. Moreover, the test for cointegration - the Engle-Granger method, entails regressing home prices on income and interest rates, and testing the residuals for stationarity. If the residuals from this regression are stationary, the variables would appear cointegrated. However, the Engle-Granger method is known to have size problems, which is the tendency to over-reject the null of no cointegration.

Thus the evidence discussed above offers little support for theories which hold that prices and income should have a stationary relationship. However, all of these studies have relied on linear estimators. That is, in all of the estimations and testing done in these papers, adjustment to a positive shock to the housing/income relationship is specified to be the same as that to a negative shock (from the opposite direction, of course). However, many financial as well as macroeconomic series, including home prices and income, have been shown to be nonlinear. Miles (2008) and Kim and Bhattacharya (2009) find evidence that home prices in the US exhibit nonlinearities. Furthermore, income has been shown to be nonlinear as well (periods of expansion exhibit different dynamics than recessions) in papers that go back as far as Hamilton (1989).

There have been studies which have attempted to account for the nonlinearities in the house price-income relationship. Katrakilidis and Trachanas (2012) and Bahmani-Oskooee and Ghodsi (2016) study the relationship for Greece and the fifty US states, respectively. They allow for nonlinearities by employing a nonlinear ARDL cointegration test to the two variables. Katrakilidis and Trachanas (2012) find nonlinear cointegration for the case of Greece, and Bahamani-Oskooee and Ghodsi (2016) find nonlinear cointegration for thirty of the fifty US states. There is a problem of interpretation, however. For the ARDL method to be valid, one of the variables must be weakly exogenous (see Enders (2014, p. 393) for a discussion). But of course income and house prices affect each other. Income obviously affects home purchases, and housing affects income through a variety of channels (see Hatzius (2008) for a discussion). We thus propose an alternative method for investigating this issue for the UK and its twelve regions.

3. Data and Methodology

We seek, as numerous previous studies have, to determine if there is a long run relationship between home prices and income, which in our case is for the UK. Measurement of income can present a challenge in such an investigation. In a given region, if many homes are purchased by outside investors, does the reported income of the given locality truly match up to that of the typical home buyer? Badarinza and Ramadorai (2018) for instance, find that many home purchases in London are made by buyers in other countries, to such an extent that house prices in the UK capital are sensitive to political developments abroad. Fortunately, the Nationwide Building Society collects data on a measure that relates home values specifically to purchaser resources-the home price to first time buyer income ratio. This data is quarterly and seasonally adjusted, and collected for the UK nationally and twelve constituent regions: East Anglia, East Midlands, London, North, North West, Northern Ireland, Outer Metro, Outer Southeast, Scotland, South West, Wales, West Midlands and Yorkshire and Humberside.

Figure 1 displays these ratios. As the figure demonstrates, there appears to be a palpable increase in this ratio over the last 34 years (the data is quarterly and runs from 1983:1-2017:4). As discussed, the changes in the UK housing markets that arise from financial innovation, government policy or other factors could lead to an increase in the ratio, but this does not invalidate the possibility that this ratio reverts to a long-run attractor in response to shocks. We will thus model each series with a linear trend. Arnott et al. (2018) also use a linear trend in their model of the price-earnings (PE) ratio, and state that they do so “in tacit acknowledgement that its equilibrium level is not static and that it should rise as the US market matures and becomes more efficient” (p. 2), but they still forcefully argue that the PE ratio is a measure of how elevated stock prices are compared to fundamentals.

We note that we could in principle investigate the possibility of a long-run relationship between house prices and income either by testing for the stationarity of the home price/first time buyer income ratio with a unit root test or for cointegration between the two variables. Testing for cointegration might be preferable, as studies such as Gallin (2006) have relied on cointegration methods. Other studies, such as that by Malpezzi (1999) use unit root tests. While the measure of prices to first time buyer income is, as noted, an improvement over previous measures, this metric is reported by Nationwide Building Society as a ratio - the two variables are not reported separately. Thus in order to take advantage of the better measurement afforded by this metric, we must rely on unit root tests, as some previous studies have done, rather than cointegration methods.

We will begin testing for a long-run relationship between home values and first-time buyer income with the ADF method, and include a constant and trend in our specification and use the Schwarz information criterion (SIC) to select the number of lags. To anticipate our findings, the ADF method, which imposes linear adjustment to shocks, and has notoriously low power, will yield results which indicate that neither the UK nor any of its twelve regions exhibit a stationary relationship between home values and income.

We will then apply the Ng-Perron unit root test to the ratios. This method entails first detrending each series to clearly distinguish between a linear and stochastic trend, and then using the *modified* Akaike information criterion (AIC) to choose the lag lengths on the filtered series. Adjustment to shocks is still specified as linear with this test, and to again anticipate our findings, we still appear to have unit roots in all of the ratios with the Ng-Perron test.

If a series undergoes some sort of structural change, or another form of nonlinearity, the strict linearity (or parameter constancy) that the ADF and Ng-Perron methods impose could lead to low power. This could lead to the possibly incorrect conclusion that house prices and income fail to share a long run relationship, when for at least some regions, they may. We thus conduct two other unit root tests. The first is the Lee-Strazicich test, which allows for a structural break in the process (Lee and Strazicich, 2003). If there has been a one-time "secular" break, this test has greater power than methods which impose parameter constancy.

However, the nature of nonlinearity in a series may be cyclical. That is, the behavior of the series may differ between two regimes, between which the series changes a number of times over the decades. This could be especially true for housing market relationships, which have been shown to follow cyclical behavior (Miles, 2008). Brooks (2019) makes the distinction between secular and cyclical changes as follows:

> "The behavior may change once and for all, usually known as a 'structural break' in a series. Or it may change for a period of time before reverting back to its original behavior or switching to yet another style of behavior, and the latter is typically termed a 'regime shift' or 'regime switch'" (p. 447).

We thus explore the possibility that the home price/first time buyer income ratio may exhibit nonlinear adjustment over different regimes or cycles. Put differently, the ratio may experience different dynamics in response to positive shocks compared to negative shocks, rather than undergoing just a one-time structural break. Enders (2014) discusses how standard unit root tests which impose symmetric responses to shocks have low power when the true process is nonlinear. We will thus test the ratios for nonlinearity with the Brock-Dechert-Scheinkman (BDS) method. This means estimating autoregressive models for each ratio and testing whether the residuals exhibit nonlinearity. In particular, the test examines whether the distance between any two residuals is constant for all residuals. If the distance is not constant, this is evidence of nonlinearity. We will use standard deviations as our measure of distance and a dimension of five for all series. The use of this method will reveal strong evidence of nonlinearity for the UK and its regions.

Given evidence of asymmetry, we will then test for stationarity with the Enders-Granger method. This test, unlike the ADF and Ng-Perron techniques, allows for nonlinearities. Furthermore, unlike the Lee-Strazicich test, the Enders-Granger method allows for recurrent switches between cycles. Standard unit root tests such as the ADF specify the series in question as follows:

$$\Delta y_t = \rho y_{t-1} + \varepsilon_t \tag{1}$$

(of course the actual series may contain a constant and trend and have more autoregressive lags, but the testing procedure is the same save for the critical values employed) and the test for stationarity is a test for whether $\rho = 0$ (accept the null of nonstationarity) or $\rho < 0$ (reject the null). This specification is linear, and if the true data generating process is nonlinear, a test based on Equation (1) will have low power.

Enders and Granger (1998) thus present an alternative specification:

$$\Delta y_t = I_t \rho_1 (y_{t-1} - \alpha_0) + (1 - I_t) \rho_2 (y_{t-1} - \alpha_0) + \varepsilon_t \qquad (2)$$

where $I_t = 1$ if $y_t \geq \alpha_0$ and $I_t = 0$ if $y_t < \alpha_0$, where α_0 is the attractor. The attractor could be zero, or a constant or constant plus trend. The null hypothesis with the Enders-Granger test is that that the series is I(1), i.e. a linear process with a unit root. The alternative hypothesis is Equation (2), which is a threshold autoregressive process. In Equation (2), y has one type of dynamic if y_{t-1} exceeds the attractor and another type of dynamic if y_{t-1} is below the attractor.

In addition to providing critical values for the unit root test, the procedure allows for testing whether the process is symmetric; i.e., $\rho_1 = \rho_2$. Given the documented nonlinearities in other financial relationships, we will use the Enders-Granger technique to test for a stationary relationship between home prices and income.

4. Results

The ADF unit root test results are shown in Table 1. All series are fitted with a constant and, given the increase in value over time shown in Figure 1, a trend, and the lags for each ratio are chosen to minimize the calculated SIC. The p-value column of Table 1 clearly shows that we cannot reject the null hypothesis of nonstationarity at anything near a standard level for the regions and the national UK ratio. This finding is consistent with the results of Holly and Jones (1997) and Meen (2002), where a stable relationship between house prices and fundamentals is not found for the UK.

Table 1 ADF Test Results

Region	Lag (no.)	Test Statistic	P-Value
East Anglia	3	-2.446	0.3542
East Midlands	1	-1.891	0.6901
London	2	-1.421	0.8507
North	0	-1.445	0.8432
North West	2	-2.332	0.4136
Northern Ireland	1	-2.233	0.467
Outer Metro	1	-1.631	0.7755
Outer Southeast	2	-2.108	0.5346
Scotland	0	-1.753	0.7218
South West	1	-1.703	0.7449
Wales	2	-1.858	0.6706
West Midlands	4	-2.841	0.1851
Y&H	3	-2.469	0.3426
UK	1	-1.939	0.6286

***Note*:** Lag lengths are determined by using the SIC.

We next apply the Ng-Perron test; the results are shown in Table 2. Despite the greater power of the Ng-Perron method, we are again unable to reject the null hypothesis of nonstationarity for any of the regional (or national) ratios. Again, a test which imposes linear adjustment has failed to find a long-run relationship between home values and first-time buyer income.

Table 2 Ng-Perron Test Results

Region	Lag (no.)	5% Critical Value	Test Statistic
East Anglia	4	-17.3	-12.79
East Midlands	1	-17.3	-6.51
London	5	-17.3	-6.58
North	0	-17.3	-3.67
North West	2	-17.3	-11.37
Northern Ireland	1	-17.3	-9.46
Outer Metro	1	-17.3	-6.13
Outer Southeast	2	-17.3	-10.14
Scotland	0	-17.3	-4.85
South West	1	-17.3	-5.59
Wales	2	-17.3	-7.19
West Midlands	6	-17.3	-13.06
Y&H	5	-17.3	-8.39
UK	5	-17.3	-5.16

***Note*:** Lag lengths are determined by using the AIC.

We next allow for a one-time "secular" change with the Lee-Strazicich test. The results, provided in Table 3, are still similar to those obtained with the ADF and Ng-Perron tests, in that it is impossible to reject the null of a unit root for any of the ratios, even at the ten percent level. It may thus be that either these ratios are truly nonstationary, or nonlinear, and this asymmetry may be more cyclical than secular in nature.

We thus investigate the possibility that the home price/income ratio is a nonlinear process. The BDS test results are listed in Table 4. All of the series are specified as an autoregressive process, with the number of lags chosen to minimize the SIC. For no region nor for the UK as a whole do we fail to reject the null hypothesis of linearity. We thus apply the Enders-Granger unit root test in which the alternative hypothesis, unlike that of standard unit root tests, allows for nonlinearity.

The results for each region and the UK are shown in Table 5. The row for each ratio first shows the constant and trend –the attractor-to which the series may revert. Columns ρ_1 and ρ_2 show the estimates for the parameters from Equation (2). The column labeled "φ_τ" shows the Enders-Granger test statistic, with the 5 percent critical value below for comparison. The column labeled "*F*-test" shows the results of testing the null hypothesis in that $\rho_1 = \rho_2$; i.e., there is actually only one regime, and the given ratio is actually a linear series. The number of lags for each ratio is based on the SIC.

Table 3 LS Test Results

Region	Lag (no.)	Test Statistic	5% Critical Value
East Anglia	3	-3.20	-4.11
East Midlands	1	-2.07	-4.20
London	2	-2.83	-4.11
North	0	-1.91	-4.20
North West	2	-2.86	-4.19
Northern Ireland	1	-2.73	-4.18
Outer Metro	1	-2.85	-4.08
Outer Southeast	2	-3.01	-4.08
Scotland	0	-2.55	-4.18
South West	1	-2.18	-4.18
Wales	2	-1.86	-4.19
West Midlands	4	-3.25	-4.19
Y&H	3	-2.92	-4.19
UK	1	-1.94	0.63

Note: Lag lengths are determined by using SIC.

Table 4 BDS Test Results

Region	BDS Test Statistic	Standard Error	P-Value
East Anglia	0.0548	0.0120	0.0000
East Midlands	0.0441	0.0080	0.0000
London	0.0120	0.0060	0.0461
North	0.0350	0.0062	0.0000
North West	0.0140	0.0057	0.0000
Northern Ireland	0.0923	0.0093	0.0000
Outer Metro	0.0115	0.0062	0.0637
Outer Southeast	0.0170	0.0053	0.0014
Scotland	0.0300	0.0090	0.0010
South West	0.0150	0.0050	0.0040
Wales	0.0180	0.0050	0.0000
West Midlands	0.0270	0.0080	0.0020
Y&H	0.0240	0.0050	0.0000
UK	0.0150	0.0040	0.0000

Note: One standard deviation as the distance and a dimension of five are used in all cases.

Table 5 Enders-Granger Test Results

	Attractor	ρ_1	ρ_2	φ_τ	F-test	Δy_{t-1}	Δy_{t-2}	Δy_{t-3}	Δy_{t-4}
East Anglia	4.0291 + 0.0108t	-1.27	-0.017	30.27	55.64	0.017	0.26	0.34	
		SE	SE	5% Critical Value		SE	SE	SE	SE
		0.168	0.0103	6.3		0.073	0.06	0.06	
East Midlands	2.73 + 0.0194t	-0.34	-0.015	5.26	6.84	0.409			
		SE	SE	5% Critical Value		SE	SE	SE	SE
		0.123	0.009	6.3		0.079			
London	4.7 + 0.0396t	-1.44	-0.011	5.766	7.584	0.318	0.254		
		SE	SE	5% Critical Value		SE	SE	SE	SE
		0.52	0.005	6.3		0.082	0.081		
North	3.00 + 0.0112t	-0.48	-0.0106	3.97	6.78				
		SE	SE	5% Critical Value		SE	SE	SE	SE
		0.183	0.011	6.3					
North West	2.18 + 0.018t	-0.07	-0.018	3.32	2.01	0.278	0.344		
		SE	SE	5% Critical Value		SE	SE	SE	SE
		0.039	0.0108	6.3		0.08	0.082		
Northern Ireland	5.92 + 0.0118t	-0.61	-0.0038	7.88	14.88	0.471			
		SE	SE	5% Critical Value		SE	SE	SE	SE
		0.159	0.004	6.3		0.073			
Outer Metro	4.676 + 0.0246t	-4.94	-0.007	7.477	11.68	0.631			
		SE	SE	5% Critical Value		SE	SE	SE	SE
		1.44	0.004	6.3		0.066			

(***Continued…***)

(Table 5 Continued)

	Attractor	ρ_1	ρ_2	φ_τ	F-test	Δy_{t-1}	Δy_{t-2}	Δy_{t-3}	Δy_{t-4}
Outer South East	4.17 + 0.0128t	-0.27	-0.013	7.016	10.13	0.343	0.33		
		SE	SE	5% Critical Value		SE	SE	SE	SE
		0.082	0.007	6.3		0.07	0.08		
Scotland	1.819 + 0.009t	-0.009	-0.44	3.06	5.5				
		SE	SE	5% Critical Value		SE	SE	SE	SE
		0.016	0.182	6.3					
South West	4.229 + 0.0161t	-0.414	-0.013	5.062	6.95	0.465			
		SE	SE	5% Critical Value		SE	SE	SE	SE
		0.151	0.008	6.3		0.076			
Wales	2.959 + 0.0205t	-0.71	-0.012	2.6445	3.34	0.37	0.29		
		SE	SE	5% Critical Value		SE	SE	SE	SE
		0.381	0.009	6.3		0.082	0.082		
West Midlands	3.0614+ 0.0197t	-1.129	-0.0159	12.91	21.32	0.167	0.203	0.15	0.27
		SE	SE	5% Critical Value		SE	SE	SE	SE
		0.24	0.008	6.3		0.07	0.08	0.07	0.08
Yorkshire & Humberside	3.39 + 0.0124t	-1.32	-0.013	7.31	12.33	-0.032	0.357	0.296	
		SE	SE	5% Critical Value		SE	SE	SE	SE
		0.372	0.009	6.3		0.081	0.076	0.087	
UK	3.13 + 0.0206t	-0.534	-0.0106	6.422	9.00	0.628			
		SE	SE	5% Critical Value		SE	SE	SE	SE
		0.174	0.0059	6.3		0.0665			

Note: ρ_1 and ρ_2 are the estimated coefficients above and below the attractor. The test statistic for a unit root is φ. The F-test is the test statistic for the null hypothesis in which both regimes are identical.

Note that, we can reject the null of nonstationarity at the five percent level for the national UK index in Table 5. We cannot do so with a linear specification that uses either the ADF or the more powerful Ng-Perron test, but we can do so when we allow asymmetric adjustment. This result stands in contrast to those of Holly and Jones (1997) and Meen (2002) where the null of no stationary relationship between home values and fundamentals for the UK cannot be rejected.

For the regions, we can reject the null of no long-run relationship between home values and first-time buyer income at the five percent level in six of the twelve cases: East Anglia, Northern Ireland, Outer Metro, Outer Southeast, West Midlands and Yorkshire and Humberside. In the case of London, we can reject the null at the ten, although not the five percent level. For the East Midlands, the test statistic is 5.2658, and the ten percent critical value is 5.27. Note that this critical value is for 100 observations, and we have 140. The critical value for 250 observations is 5.18.

The regions with a stationary ratio are for the most part contiguous to London-London itself (the ratio is stationary at the ten percent level), with Outer Metro and Outer Southeast clearly stationary, as well as East Anglia, which is contiguous with Outer Southeast. West Midlands is just contiguous to Outer Southeast. In addition, East Midlands, which is contiguous with Outer Southeast and East Anglia, is the region where we are just shy of being able to reject a unit root at ten percent, and Yorkshire and Humberside is contiguous with East Midlands. The one exception to this pattern is Northern Ireland.

In contrast, most regions for which stationarity does not appear to hold are further from London-North, North West, Scotland, South West and Wales. These results are consistent with previous findings which have indicated that the dynamics of house prices in the southeast differ from those further from London. There is a long literature on the “ripple effect”; the idea that home price movements in the south east of the UK ripple out towards more distant regions. One early example is Ashworth and Parker (1997), who find that prices in the southeast Granger cause values further from London, which highlights the different dynamics in home values. Holmes and Grimes (2008), while examining a somewhat different question from ours (do house prices in different UK regions converge) also find that “regions more distant from London exhibit the highest degree of persistence with respect to deviations in house price differentials” (p. 1531).

What might account for the regional differences? Generally, regions in the south, closer to London, have stationary relationships between home prices and income, while those in the north usually seem to lack such a stable, long-term relationship. What might explain for such divergent results?

There is of course a previous study on regional housing differences in the UK. Malpezzi (1999) seems to suggest that regional variation may be due to differences in the elasticity of supply, perhaps due to regulations. It may not be the case, however, that such differences could explain for our results. Presumably, a low elasticity of supply would cause prices to rise higher than otherwise, in response to a positive price shock, and could therefore lead to a failure to obtain a stationary house price-income relationship. However, it is doubtful that the elasticity of supply is lower in the wealthier, more densely populated southern UK than in the less prosperous north.

An alternative explanation is credit provision. Meen (2002) points out that down payment constraints (smaller loan-to-value ratios) can make house prices more volatile. In his sample, he notes that the LTV ratio was 67 percent in the south east UK, but 75 percent in the north in 1999. This means that there are greater down payment constraints in the south east UK than in the north. Meen (2002) presents a stylized model in which down payment constraints lead to higher house price volatility. And indeed, between 1969 and 1999, he finds that the standard deviation of house price changes was higher in the south east than in the north of the UK.

This presents something of a puzzle in relation to our results. While not investigating house price volatility per se, if the model of Meen (2002) is correct, we would expect to be more likely to find a stationary relationship between house prices and income in the north rather than the south, given what Meen (2002) finds to be greater down payment constraints in the latter than the former. And indeed, these down payment constraints continue. Using updated data from 2014-2019, Table 6 shows that the LTV ratio is highest (down payment constraints least binding) in the northern regions while the LTV is lowest (down payment constraints higher) in London and the south east (note that the regions in the table are almost, but not exactly identical to those compiled by the Nationwide Building Society for home prices). What might explain, then, for the greater likelihood of finding a stationary house price-income relationship in the southern regions, which at first glance seems to run counter to at least the intuition of the model in Meen (2002)?

We believe that the greater credit, as a fraction of home value, could make rising prices relative to income more, rather than less likely. This is especially the case in light of more recent research and experience. Mian and Sufi (2018) find that in the US, credit drove house price increases in the run-up to the financial crisis in the 2000s. They explain their results in light of previous theoretical work, such as Allen and Gale (2000) and Kindleberger and Aliber (2005) who show that credit is necessary for asset bubbles. The authors indeed cite Kindleberger and Aliber, who state that "asset price bubbles depend on credit" (Mian and Sufi, 2018). Thus looser moorings on prices relative to income in the north compared to the south appear to make sense when the higher gearing of the former compared to the latter is taken into account.

Further examining our results, we see that for all regions where the null hypothesis is rejected at the five (or ten) percent level, the null hypothesis of identical regimes (=) is also rejected, as shown in the "*F*-test" column in Table 5. Indeed only in the cases of North West and Wales, where nonstationarity could not be rejected, did we fail to reject the null of symmetric adjustment. Of course these results are only relevant for regions with stationary house price/income ratios. This clearly indicates that, at least for those regions where the ratios appear stationary, adjustment to shocks is not symmetric.

Table 6 Loan-to-Value Ratios Across UK Regions 2014-2019

Region	Loan-to-Value Ratio
Scotland	76.73
N. Ireland	75.31
Y&H	75
Wales	75
N. West	75
E. Midlands	72.69
W. Midlands	72.59
S. West	66.68
Eastern	65.78
South East	64.92
Central/Greater London	60

Source: Statista.

In interpreting the asymmetric adjustment to shocks for the UK overall and the seven regions that appear to have stationary ratios, it is important to refer to the results of the original study by Enders and Granger (1998). The authors investigate the US ten year government bond interest rate minus the US federal funds overnight rate. Enders and Granger (1998) are able, by using their nonlinear unit root test, to reject nonstationarity, as well as the null of symmetric adjustment.

Enders and Granger (1998) find that the estimate is statistically significant, while that of is not significant. The lack of significance for does not imply, of course, that the spread is a symmetric process. Instead, it only indicates that the adjustment is larger when the spread is above compared to when it is below the attractor.

For the house price/first time buyer income ratio, in all cases where the data indicate stationarity, our estimate of exceeds, in absolute value, that of , which mirrors the findings of Enders and Granger (1998) in their investigation. Furthermore as shown, the estimate is significant in all such cases with a t-statistic that well exceeds two in absolute value. Estimates of are not typically "as" significant, although the results vary by region. For the UK overall, the t-statistic for is -1.7966, which is close to significant. For London, the t-statistic for is -1.88, Outer Metro is -1.738 and West Midlands is -1.915. On the other hand, the corresponding t-stats for East Anglia, East Midlands, Northern Ireland, Outer South East and Yorkshire, and Humberside are not as close to significance.

That the absolute value of the estimates are larger than those of in all cases where stationarity is found indicates that adjustment to a shock is greater when the home price/income ratio is above compared to when below the attractor. It may be that when home values rise, income then follows. In the US, the housing sector is known to be a leading indicator for income (Leamer, 2007, 2015). When the ratio is below trend, prices may be growing at a relatively slow pace in response to a housing downturn. The precise nature of the dynamics in each region and the UK overall would be a topic for future research.

5. Conclusion

Home prices do appear to have some long run relationship with affordability, at least for the UK overall and regions relatively close to London. The precise type of asymmetric adjustment may well differ by region; some may be smooth (i.e. best estimated with, say a smooth transition 4 autoregressive (STAR) model), while for others, the standard threshold specification here may be most appropriate. There are numerous different types of asymmetric adjustment specifications, and the precise one best for each region will again likely differ.

The fact that there is some long run relationship for home prices and income does run counter to previous studies which had relied on purely linear models. Like other relationships in the housing market, that between prices and income exhibits nonlinearity.

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