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Regional house price convergence: implications of monetary policy

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ABSTRACT

Motivated by the structural change since the adoption of inflation targeting in October 1992, this research investigates regional house price convergence in the UK over the period 1973:Q4–2020:Q4. By using subsample comparisons, results show that all regions in the inflation-targeting regime converges to one club until the Global Financial Crisis. The finding suggests that the successful inflation-targeting policy can promote integration among regions.

KEYWORDS

housing; monetary policy; regional house price convergence

JEL E52, R1

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1. INTRODUCTION

Since the pioneering study about ripple effects operating in the UK housing market by Meen (1999), the resulting implication about the long-run convergence of regional house prices has been extensively examined in the literature (for related works, see Antonakakis et al., 2018; Apergis & Payne, 2019; Blanco et al., 2016; Cook, 2003, 2005, 2012; Gong et al., 2016; Gray, 2018, 2020; Holmes et al., 2011, 2017, 2019; Holmes & Grimes, 2008; Kim & Rous, 2012; Miles, 2015, 2019; Montanes & Olmos, 2013; Montagnoli & Nagayasu, 2015). Understanding the convergence of regional housing markets is important, as it can shed light on balanced national development and a portfolio diversification strategy (Antonakakis et al., 2018). Housing comprises a significant portion of the wealth in the economy and is the largest asset owned by households in most countries (e.g., Brounen et al., 2014; Poterba, 2000; Xie & Jin, 2015). Its importance is especially intensified following the recent Global Financial Crisis (GFC) (e.g., Bayer et al., 2010; Goetzmann et al., 2012). Thus, governments play an important part in shaping the housing market through fiscal and monetary policy (Lin, 2022).

While the convention of existing studies on regional house price convergence has focused on various markets of interest and modelling methods, little attention is paid to the structural change in the convergence. This research relates the structural change in the UK housing market to the change of monetary environments. Since October 1992, the UK government has adopted the inflation-targeting policy and established a distinctive separation between low and high inflation environments. The history of UK inflation motivates the present research to explore regional house price convergence over time.

Convergence theory argues that regional differentials will decrease over time, as low-priced regions catch up with high-priced regions (Gray, 2020). According to Garcia-Hiernaux et al. (2016), the spatial markets can become more integrated through the reduction of arbitrage possibilities in two approaches. One is to reduce the structural cost differential, while the other is to synchronise the nominal price variations. Inflation-targeting policy can play a role in the latter process. The literature has established that a successful inflation targeting that creates a stable macroeconomic environment can promote private investment (e.g., de Mendonca & Lima, 2011; Montes, 2013). Housing serves as a dual good of consumption and investment. For investment property, investors are not restricted by location. They will sell overvalued property and buy undervalued property across regions. These can help to reduce the spatial arbitrage between high- and low-priced regions. Therefore, it follows that the degree of equilibrium convergence among regions is stronger in the inflation-targeting regime.

To test the proposed hypothesis, the adoption of inflation-targeting policy in October 1992 is used as a natural setting for a structural change. We investigate the convergence across UK regional housing markets, by using subsample comparisons before and after the

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introduction of the inflation-targeting regime. Using standard methods of correlation and pairwise unit root analyses, the preliminary evidence shows a trend of convergence since the inflation-targeting policy. Following recent studies on housing convergence (e.g., Apergis et al., 2015; Blanco et al., 2016; Holmes et al., 2019; Kim & Rous, 2012; Montagnoli & Nagayasu, 2015), we further apply a log *t*-test developed by Phillips and Sul (2007) to examine the presence of convergence clubs. Unlike other approaches in which regions are grouped a priori, one key strength of Phillips and Sul's study enables the endogenous determination of convergence clubs (Blanco et al., 2016).

Empirical results of the log *t*-test affirm our hypothesis, showing a higher degree of house price convergence across regions, since the introduction of the inflation-targeting regime. Before the introduction of the inflation-targeting policy in October 1992, three convergence clubs are found. Nevertheless, a singular convergence club for all regions is identified during the inflation-targeting regime until the GFC. Following that, three clubs are formed, with one non-convergent group. As argued by Dale et al. (2010), the inflation targeting is less effective since the GFC, due to structural change in the markets and public concerns in the banking system. These suggest that equilibrium correction for all regions occurs during a successful inflation-targeting regime, eliminating the existence of multiple convergence clubs.

This study complements the literature on regional house price convergence, particularly a series of literature employing a log *t*-test developed by Phillips and Sul (2007) to identify multiple convergence clubs (e.g., Apergis et al., 2015; Blanco et al., 2016; Holmes et al., 2019; Kim & Rous, 2012; Montagnoli & Nagayasu, 2015). This research suggests that the patterns of housing convergence can vary significantly in different monetary environments. Altogether, the results show that house prices in the UK converge towards a unique common component particularly in an effective inflation-targeting regime.

The remainder of the paper is structured as follows. Section 2 provides a literature review, section 3 presents the research motivation, section 4 discusses the empirical methods, section 5 describes the data, section 6 provides the empirical analysis and section 7 concludes.

2. LITERATURE REVIEW

2.1. History of UK house prices

The housing market and its relationship with the overall economy has received wide attention from both academics and practitioners. Among all the markets, the UK and US housing markets are of particular interest to economists, since these markets have been through periods of significant business cycles which have motivated many studies to investigate either transmission mechanisms or ripple effects (Antonakakis et al., 2018). Tse et al. (2014) note that the UK housing market is complex and deserves further investigation. Muellbauer and Murphy (1997) indicate that the financial liberalisation of mortgage markets during the early 1980s along with the fall in interest rates sparked the house price boom in the UK in the late 1980s. Additionally, they find that the reversal of the contributing factors (the rise in interest rates, weak income growth and tight lending criteria) led to the house price downturn in the 1990s.

Following this period, the UK housing market experienced house price growth for more than a decade until the 2007–08 GFC. Concurrently, the growth rate of house prices in the UK increased faster than the rate of inflation (Bone & O'Reilly, 2010). Factors contributing to the UK house price growth before the financial crisis can be attributed to accommodative monetary policies, low interest rates and easy access to credit (Bone & O'Reilly, 2010; Whitehead & Williams, 2011). Tsai (2015a) empirically verifies that housing returns are significantly increased through a monetary easing environment in the UK and, in turn, housing bubbles are formed due to non-reasonable house price fluctuations.

The declining interest rates and increasing earnings, rather than insufficient supply, were argued to be major causes of increasing home values in Britain between 1996 and 2006 (Mulheirn, 2016). As highlighted by Mulheirn (2019), London prices have grown significantly since the GFC and are almost 50% higher than their 2005 level in real terms; growth in prices outside the Greater South East have relatively remained stable since the 1990s. Furthermore, Mulheirn argues that the divergence of house prices in London from the rest of the UK is not driven by the increasing demand from people to live there, but by the increasing global investor demand. The global wealth elites view global cities such as Dublin, London, New York and Vancouver as 'safe deposit boxes' for primary investment rather than residence, due to their highly liquid and socio-cultural characteristics (e.g., Fernandez et al., 2016; Gray, 2020; Ley, 2017; Ley & Tutchener, 2001; Moos & Skaburskis, 2010; Richmond, 2007; Walks, 2014). Therefore, much of the housing price change is not only affected by domestic factors, but also by 'global' factors.

2.2. The relationships among regional house prices

The relationships among regional house prices in the UK have been extensively researched. UK house price growth rates remained stable between 1970 and 1980, after which a separation occurred among the most expensive house price regions (Greater London, South East, South West and East Anglia) and the rest of the UK (Hamnett, 1983). Since the late 1980s, the research has focused on two main issues. The first is concerned with the 'ripple effect', whereby the change in house prices caused by shocks initially observed in one region (core region) will move to other regions over time. Meen (1999) suggests that this effect is caused by adjustments within regions rather than between regions through factors such as equity transfer, migration, spatial arbitrage and spatial patterns in the determinants of house prices. The South East region is typically identified as the main cause of information

spillover, after which the ripple effect occurs across the rest of the south followed by the northern regions (e.g., Alexander & Barrow, 1994; Holmans, 1990; MacDonald & Taylor, 1993; Meen, 1999; Montagnoli & Nagayasu, 2015; Tsai, 2015b).

Along with testing the ripple effect, the resulting implication of a long-run convergence of UK regional house prices have also been examined (e.g., Cook, 2003, 2005, 2012; Gray, 2018; Holmes et al., 2019; Holmes & Grimes, 2008; Montagnoli & Nagayasu, 2015). More specifically, this refers to the convergence and divergence of house prices over time which is the other issue commonly examined in the literature. While most studies support the notion of a causal link in the South East to other regions, there have been mixed results that a long-run equilibrium relationship exists among UK regional house prices.

Based on Meen's (1999) conjecture that the ripple effect implies a long-run constant ratio of regional house prices to the aggregate UK house price, Cook (2003) reveals asymmetry in the regional to national house price ratios and concludes that regional house price differentials mean-revert. Cook (2003, 2005) notes that the extent of any convergence within house prices may be dependent upon the cyclical phase of the housing market. Holmes and Grimes (2008) find overall convergence but suggest that the movement towards a long run equilibrium involves a long and slow process. Cook (2012) expands on the notion of cyclical dependency and confirms that although convergence is present between 1973 and 2009 in the UK, it is driven by an apparent convergence of house prices during cyclical downturns.

A resurgence of recent literature employs a log t-test developed by Phillips and Sul (2007) to investigate the presence of convergence clubs (e.g., Apergis et al., 2015; Blanco et al., 2016; Holmes et al., 2019; Kim & Rous, 2012; Montagnoli & Nagayasu, 2015). In the context of the UK housing market, Montagnoli and Nagayasu (2015) identify several convergence clubs (i.e., multiple steady states). They find that UK regions can be grouped into four clusters, suggesting more complicated features in the UK housing market than what the conventional macroeconomic model would suggest. Similar results about the existence of several convergence clubs are also found in other countries such as one in the United States by Kim and Rous (2012), in Spain by Blanco et al. (2016), in South Africa by Apergis et al. (2015), etc.

By using the number of cointegrating vectors as a measure of integration among regions, Gray (2018) finds a similar grouping of regions in the UK to Montagnoli and Nagayasu (2015). Both papers find convergence within the northern regions and conclude that London has a distinctive trend, different from the rest of the south-east of England. Holmes et al. (2019) expand by considering multiple types of housing (detached, semi-detached, terraced housing and flats) in the UK and find that convergence is more likely for flats than other types. While most extant studies have primarily investigated the regional house price convergence via different modelling methods and markets of interest, little attention is paid to its structural change in the club formation. This research aims to bridge this gap through the lens of change of monetary environment as discussed in section 3.

3. THEORY

3.1. Research motivation

This research is the first, or one of the first, to extend the previous literature by relating regional house price convergence to changes of the monetary policy. The UK experienced a major shift from a high to a low inflationary environment caused by the introduction of inflation targeting in October 1992. Figure 1, showing the UK annual inflation rate from 1961 to 2020, illustrates an explicit change in the structure of the inflation rate. The vertical dashed line represents the introduction of inflation targeting in 1992.

One of the major objectives for the Bank of England is to achieve price stability, preferably with moderate inflation. Through inflation-targeting policy, the government announces a projected target inflation rate and uses that nominal anchor to control the general rise in the price level. One central element of an inflation-targeting regime is the flexibility of the exchange rate, as adopted in the UK monetary policy since 1992. A floating exchange rate allows the Bank of England to implement inflation targeting more directly than a fixed exchange rate (Allsopp et al., 2006). An antecedent of the inflation targeting was Black Wednesday on 16 September 1992 when a collapse in the pound sterling rate forced Britain to withdraw from the European Exchange Rate Mechanism (ERM). While the government tried to cut borrowing, restrict money supply and rejoin the ERM to secure low and stable inflation, low and stable inflation was achieved via inflation targeting (Elliott, 2012).

Since the housing market and wider economy recovered during the second half of the 1990s along with falling interest rates, specialist lenders began to increase again (Thomas, 2017). It should also be acknowledged that since the adoption of inflation targeting, housing price inflation remained quite low until the 2000s, following a housing price bubble burst in the GFC. Arguably, while the interest rate was low and more supply of credit was provided for home purchases, the GFC resulted from the fact that the inflation-targeting central bank ignored the build-up of financial imbalances, which contributed to real house price growth and a housing price-to-rent ratio (Frappa & Mesonnier, 2010). Reflecting on the effectiveness of inflation targeting, Dale (2009) notes that policy is not tailored to accommodate all future change to the structure of the markets and shocks hitting them and suggests improving the robustness of the macroeconomic policy framework by expanding the policy instruments rather than by focusing on the change of the short-term interest rate.

Therefore, consistent with the prior work (e.g., Lin, 2022), our sample period of the investigation of inflation targeting ends before the onset of the GFC to avoid

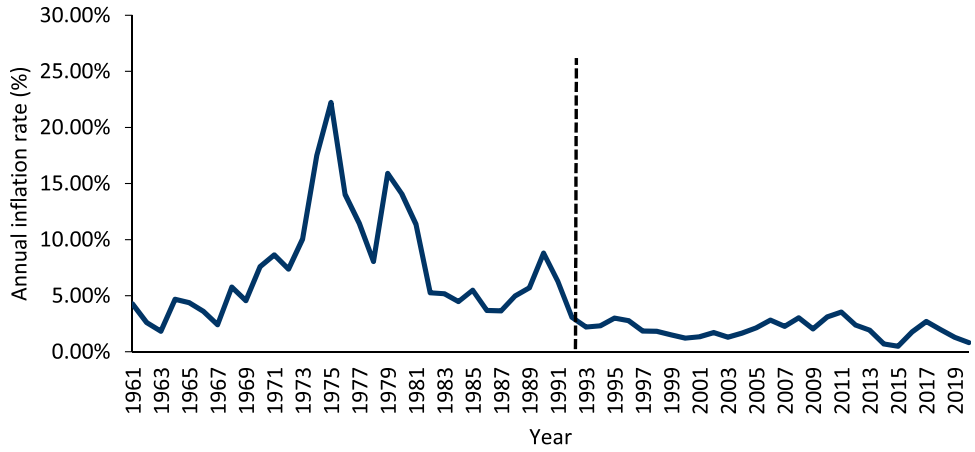

Figure 1. Inflation rate change.
Note: The annual inflation rate is measured as the first difference of the natural logarithm of UK consumer price index (CPI) published by the Organisation for Economic Co-operation and Development (OECD) (2021). The vertical dashed line indicates the time period of the adoption of the inflation-targeting policy.

confounding effects. From the early 1990s until the GFC in 2007, the UK economy had experienced exceptional stability regarding inflation and gross domestic product (GDP) growth, which was viewed as the period of 'great stability' (e.g., Dale et al., 2010). Following that, the recession undermined the public confidence in the banking system, raising the concerns of effectiveness of inflation targeting. Moreover, since the 1990s, regional housing prices in the UK had been increasing stably until the outbreak of the GFC. Therefore, it is important to consider this regional structural change on the evolution of regional house price convergence (e.g., Trojanek et al., 2023).

Overall, since 1992, the UK has continuously adopted the inflation-targeting policy. Initially, a target was set in a range of 1–4% in the UK between 1992 and 1995, followed by a point target of 2.5% (Mihailov, 2006). As evidenced in Figure 1, inflation risk was high before 1992, and thereafter the annual inflation rate was consistently below 3.1%. The test for a structural break (a supremum Wald test) with an unknown break date also statistically shows that a structure change occurs in 1992, which concurs with the time of inflation-targeting policy.[1] These justify our approach of using the inflation-targeting policy as a structural change in the monetary environments.

3.2. Hypothesis development

Based on the neo-classical theory, an interregional difference could promote the migration of business and households to low cost location, leading to the long-run convergence of income and economic growth even at a justly low pace (e.g., Barro et al., 1991). In the setting of housing markets, the convergence can be formed via pricing ripples spreading out through migration, equity transfer, spatial arbitrage and spatial patterns in determinants of housing prices (Meen, 1999). Garcia-Hiernaux et al. (2016) add that the spatial markets can become more integrated via decreasing arbitrage opportunities in two channels: the reduction of a structural cost differential or synchronisation of the nominal price variations. In this research, we argue that inflation-targeting policy can play a part in the latter process.

The empirical literature has shown that a successful inflation targeting that creates a stable macroeconomic environment can foster private investment (e.g., de Mendonca & Lima, 2011; Montes, 2013). Housing is not only a consumption good but also an investment asset. While housing consumers are exposed to a particular area mostly due to their job and birthplaces, investment demand for housing is not restricted by location. For investment property, investors are motivated to sell overvalued property and buy undervalued property to exploit the arbitrage opportunities across regions. For instance, investors living in London would find properties in Liverpool attractive for investment, as the properties in Liverpool are significantly cheaper. Spatial arbitrage can be further reduced between high- and low-priced regions, particularly when private investment is fostered in a stable monetary environment. These follow that the degree of convergence among regions is stronger in the inflation-targeting regime.

Overall, we argue that a successful inflation-targeting policy that promotes private investment can accelerate the process of regional house price convergence, as spatial arbitrage is reduced. According to Meen (1999), regional housing prices tend to move towards a single equilibrium in the long-run. The formation of convergence clubs indicates common factors cause regional house prices to converge to a similar price level. These lead to our conjecture that the degree of equilibrium among regional convergence is stronger in the inflation-targeting regime.

4. METHODS

The empirical methods adopted in this research are unit root and log t-tests. The univariate unit root testing by Dickey and Fuller (1981) and the multivariate one by Levin et al. (2002) and Im et al. (2003) are conventional methods.[2] Therefore, this section concentrates on the description of log t-test by Phillips and Sul (2007).

Phillips and Sul (2007) start by decomposing the panel data, X_{it} as:

$$X_{it} = g_{it} + a_{it}, \tag{1}$$

where g_{it} are permanent common components that lead to cross-sectional dependence and a_{it} are transitory components, with the number of individuals (i) at time (t). To separate the common components from the idiosyncratic components, equation (1) is further transformed as:

$$X_{it} = \left(\frac{g_{it} + a_{it}}{\mu_t}\right)\mu_t = \delta_{it}\mu_t, \tag{2}$$

where δ_{it} denotes the time-varying idiosyncratic components, whereas μ_t are the time-varying common components to all individuals. δ_{it} is modelled in a semiparametric form:

$$\delta_{it} = \delta_i + \sigma_i \xi_{it} L(t)^{-1} t^{-\alpha}, \tag{3}$$

where δ_i is fixed, $\xi_{it} \sim iid(0, 1)$ across i yet weakly dependent on t, and $L(t)$ is a slowly varying function for which $L(t) \to \infty$ as $t \to \infty$, and $L(t) = \log(t + 1)$ as it produces the best test power. Equation (3) ensures that for all $\alpha \geq 0$, δ_{it} converges to δ_i. In this setting, Phillips and Sul develop a test of the null hypothesis of convergence:

$$H_0{:}\delta_i = \delta \text{ and } \alpha \geq 0, \tag{4}$$

$$H_A{:}\delta_i \neq \delta \text{ for all } i \text{ or } \alpha < 0. \tag{5}$$

The empirical testing is conducted as follows. As the first step, a cross-sectional variance ratio H_1/H_t is constructed:

$$H_t = \frac{1}{N}\sum_{i=1}^{N}(h_{it} - 1)^2, \tag{6}$$

where h_{it} is the relative transition parameter, tracing out a transitional path of regional house price relative to the panel average, and specified as:

$$h_{it} = \frac{X_{it}}{N^{-1}\sum_{i=1}^{N} X_{it}}. \tag{7}$$

Equation (7) indicates that the cross-sectional mean of h_{it} is unity, such that $h_{it} \to 1$ and thus $H_t \to 0$ as $t \to \infty$ under the condition of convergence. In the second step, the hypothesis in equations (4) and (5) can be implemented through the following log t regression model:

$$\log\left(\frac{H_1}{H_t}\right) - 2\log L(t) = a + b\log(t) + \varepsilon_t,$$

$$\text{for} \quad t = [rT], [rT] + 1, \ldots, T \quad \text{with } r > 0. \tag{8}$$

Depending on the sample size, r is suggested to be from 0.2 to 0.3 based on Monte Carlo experiments. Phillips and Sul show that $b = 2\alpha$ and equation (4) can be conveniently tested through a one-sided t-test. The null hypothesis of convergence is rejected when $t_b < -1.65$ (5% significance level).

To identify convergence clubs, the algorithm involves four steps, sketched as follows:

- Step 1 is to create the order of the panel members according to the last period house price observations.
- Step 2 is to form the core group of regions on the basis of the maximum $t_k > -1.65$, from the sequential log t regressions based on the k highest members where $2 \leq k \leq N$.
- Step 3 is to establish the club membership. The region outside the core group is added and evaluated for the membership in this group. The new region is added if the associated t-statistic is greater than 0.
- Step 4 is to form another group of members if the regions are not selected in step 3. If the null of convergence is not rejected for this new group, a second convergence club is formed. If rejected, steps 1–3 are repeated to identify sub-convergence clusters. In step 2, if there is no k for which $t_k > -1.65$, the remaining regions do not form a convergence group, suggesting a divergent behaviour in these regions.

5. DATA

Following Abbott and De Vita (2013), Cook and Watson (2016) and Gray (2018), we employ the regional house price index from the Nationwide Building Society, which is available across all UK regions since 1973:Q4. The 13 regions used in this study include East Anglia, East Midlands, London, Northern Ireland, North, North West, Outer Metropolitan, Scotland, South East, South West, Wales, West Midlands, and Yorkshire and Humberside.

The main sample period used in this study is over 1973:Q4–2008:Q2. The house price index is only available from 1973:Q4, thus restricting this study from performing an earlier analysis. Following the prior work (e.g., Lin, 2022), we drop the post-GFC observations to avoid the exceptional circumstance. The sample ends at 2008:Q2, as the Lehman Brothers filed for bankruptcy protection on 15 September 2008.

Panel A in Table 1 presents the descriptive statistics for nominal house prices before and after the introduction of inflation targeting in 1992:Q4. Overall, house prices are higher in London compared with anywhere else in the UK between the two subsamples; for example, Northern Ireland is about half of London's prices. Following Montagnoli and Nagayasu (2015), the house price inflation is defined as the annual growth rate of house prices by the first difference of the natural logarithm over four quarters.

Consistent with Montagnoli and Nagayasu (2015), the results in panel B in Table 1 show differences in house price inflation across regions. However, as expected, we find that the house price inflation is systematically higher across all the UK regions in the non-inflation-targeting regime except for Northern Ireland. This phenomenon can be explained by the fact that the housing market in Northern Ireland during the period 2001–11 experienced

Table 1. Summary statistics of house price and house price inflation.

Variable	Mean	SD	Minimum	Maximum
Panel A1. Non-inflation-targeting regime: house price				
East Anglia	34,239	21,226	9998	78,846
East Midlands	27,740	16,468	8637	60,538
London	46,063	28,177	12,848	97,667
North	24,038	12,820	7713	48,794
North West	25,982	15,341	8020	55,795
Northern Ireland	22,871	6997	7952	33,280
Outer Metropolitan	45,944	27,951	12,863	99,979
Scotland	28,054	12,891	8972	52,346
South East	37,225	22,727	10,871	83,901
South West	33,709	20,155	9605	73,112
Wales	27,379	14,364	8953	54,349
West Midlands	29,248	17,176	9388	61,290
Yorkshire and Humberside	29,937	16,052	9517	64,936
Panel A2. Inflation-targeting regime: house price				
East Anglia	101,842	47,977	50,609	183,815
East Midlands	87,675	41,771	45,341	156,924
London	158,516	78,475	66,573	303,739
North	73,989	34,889	41,884	134,534
North West	87,549	40,847	48,841	159,062
Northern Ireland	85,456	52,383	33,603	227,970
Outer Metropolitan	145,642	66,443	69,042	259,160
Scotland	80,428	32,998	50,519	152,479
South East	117,985	57,150	53,820	215,375
South West	110,298	54,134	52,545	204,447
Wales	82,810	40,459	45,037	154,969
West Midlands	94,857	42,494	51,144	165,094
Yorkshire and Humberside	83,958	40,346	46,498	156,429
Panel B1. Non-inflation-targeting regime: house price inflation				
East Anglia	7.03%	10.14%	−21.52%	35.62%
East Midlands	7.09%	8.64%	−10.66%	37.79%
London	7.05%	9.14%	−15.66%	24.38%
North	7.38%	6.72%	−5.77%	30.32%
North West	7.82%	7.11%	−4.18%	29.93%
Northern Ireland	5.59%	6.75%	−6.54%	21.80%
Outer Metropolitan	7.15%	8.95%	−14.40%	25.84%
Scotland	7.10%	5.26%	−4.09%	20.62%
South East	6.88%	9.68%	−14.80%	26.56%
South West	7.16%	8.93%	−11.15%	34.29%
Wales	6.90%	8.28%	−11.83%	35.37%
West Midlands	7.25%	8.18%	−6.93%	35.48%
Yorkshire and Humberside	6.98%	8.86%	−18.29%	33.57%
Panel B2. Inflation-targeting regime: house price inflation				
East Anglia	5.57%	6.30%	−11.22%	20.69%
East Midlands	5.34%	6.39%	−8.96%	20.94%
London	6.70%	6.23%	−9.26%	18.76%

(*Continued*)

Table 1. Continued.

Variable	Mean	SD	Minimum	Maximum
North	4.95%	7.77%	−7.39%	24.02%
North West	4.97%	6.60%	−6.86%	21.28%
Northern Ireland	8.72%	8.58%	−21.71%	34.38%
Outer Metropolitan	5.89%	5.95%	−7.15%	20.56%
Scotland	5.14%	5.22%	−6.88%	18.30%
South East	6.11%	6.00%	−8.28%	22.74%
South West	5.99%	5.93%	−6.90%	22.13%
Wales	5.29%	7.13%	−7.76%	23.64%
West Midlands	5.02%	5.96%	−8.61%	21.04%
Yorkshire and Humberside	5.00%	7.44%	−7.25%	26.53%

Note: The non-inflation-targeting regime is from 1973:Q4 to 1992:Q3, while the inflation-targeting regime is from 1992:Q4 to 2008:Q2. The annual house price inflation is calculated as $\ln(P_t/P_{t-4})$, where P_t is the house price at time t.

extreme changes relative to the rest of the UK, partially due to the speculative boom in the Republic of Ireland and some local factors (Paris & Frey, 2018).

6. EMPIRICAL ANALYSIS

6.1. Preliminary investigation

Our empirical investigation starts with the correlation analysis. Comparing the correlation result of house price inflation across regions between the inflation and non-inflation-targeting regimes in Table 2, the correlation values across regions have appeared to systematically increase for most areas, providing preliminary evidence of convergence among regional markets. For example, in the Yorkshire and Humberside region, its correlation with East Angelia increases from an initial value of 0.59 to 0.79 in the inflation-targeting regime. Interestingly, we also find the existence of ripple effects, the value of correlation seems to be highly correlated with geographical proximity to the region. For instance, South East has the lowest correlation with Northern Ireland in two subsample periods, and as expected, the correlation increases in the inflation-targeting regime.

Turning to the unit root testing, all regional house price indices are found to be difference-stationary based on the augmented Dickey–Fuller (ADF) (Dickey & Fuller, 1981) testing reported in Table 3.[3] If non-stationary variables are integrated of the same order, it indicates that the non-stationary variables may share a common trend in the long run. Thus, we next analyse the long-run convergence among UK house prices via the standard pairwise unit root testing.

Following Holmes and Grimes (2008) and Gray (2018), we concentrate on the deviations of regional house prices from the UK national house prices. If the deviation is stationary, regional house prices are concluded to converge to the national house prices. Comparing the results of pairwise unit-root testing between the inflation and non-inflation-targeting regimes in Table 4, it appears that stationarity is revealed in more regions in the inflation-targeting regime, regarding regional house price differentials with the nation, pointing to a direction of stronger regional convergence since the implementation of inflation targeting.

As the univariate unit root test may suffer from low test power (e.g., Holmes & Grimes, 2008), we further complement the findings with conventional Levin et al. (2002) and Im et al. (2003) panel-data unit-root tests. Results in Table 5 show that in both inflation and non-inflation-targeting regimes, the null hypothesis of all the panels containing a unit root can be rejected based on the results of Levin et al. (2002), suggesting a long-run convergence in UK housing markets. However, comparing the test statistics between the two subsample periods, the tests by Levin et al. (2002) and Im et al. (2003) systematically show that the support for regional convergence moves to a higher level of statistical significance in the inflation-targeting regime. Altogether, our preliminary analyses suggest that regional housing markets may be more integrated in the inflation-targeting regime.

6.2. Convergence clubs

Following recent studies (e.g., Apergis et al., 2015; Blanco et al., 2016; Holmes et al., 2019; Kim & Rous, 2012; Montagnoli & Nagayasu, 2015), we next employ a log t-test developed by Phillips and Sul (2007). In contrast to the conventional approach, one key strength of Phillips and Sul's clustering algorithm allows modelling of long-run equilibrium within a heterogeneous panel and therefore can investigate the presence of convergence clubs.

Panel A of Table 6 shows that in the non-inflation-targeting regime, London and Outer Metropolitan (the two most expensive areas in the UK) form a convergence club, and a t-statistic is insignificant, indicating that the null hypothesis of regional convergence in one club cannot be rejected and house prices in Central and Greater London areas differ from the rest of the UK. Summing up the results in panel A of Table 6 before the inflation-targeting regime, three convergence clubs (named clubs 1–3) are found, along with two non-convergent areas: club 1 is composed of London and Outer Metropolitan; club 2 of North West, South East, South West and West

Table 2. Correlation of house price inflation across regions.

	East Anglia	East Midlands	London	North	North West	Northern Ireland	Outer Metropolitan	Scotland	South East	South West	Wales	West Midlands	Yorkshire and Humberside
Panel A. Non-inflation-targeting regime													
East Anglia	1.00												
East Midlands	0.80	1.00											
London	0.83	0.72	1.00										
North	0.23	0.58	0.32	1.00									
North West	0.36	0.71	0.43	0.89	1.00								
Northern Ireland	0.14	0.16	0.31	0.40	0.31	1.00							
Outer Metropolitan	0.90	0.76	0.96	0.33	0.42	0.29	1.00						
Scotland	0.20	0.46	0.34	0.83	0.72	0.62	0.34	1.00					
South East	0.96	0.84	0.93	0.33	0.46	0.22	0.97	0.30	1.00				
South West	0.95	0.88	0.84	0.33	0.49	0.18	0.89	0.30	0.96	1.00			
Wales	0.61	0.89	0.62	0.76	0.83	0.32	0.65	0.66	0.70	0.73	1.00		
West Midlands	0.80	0.93	0.68	0.55	0.72	0.19	0.73	0.41	0.82	0.87	0.84	1.00	
Yorkshire and Humberside	0.59	0.87	0.60	0.74	0.78	0.29	0.62	0.69	0.67	0.68	0.93	0.80	1.00
Panel B. Inflation-targeting regime													
East Anglia	1												
East Midlands	0.90	1.00											
London	0.82	0.66	1.00										
North	0.69	0.85	0.41	1.00									
North West	0.80	0.91	0.51	0.88	1.00								
Northern Ireland	0.23	0.18	0.32	0.16	0.22	1.00							
Outer Metropolitan	0.84	0.76	0.89	0.51	0.61	0.25	1.00						
Scotland	0.50	0.61	0.28	0.70	0.75	0.48	0.41	1.00					
South East	0.92	0.85	0.88	0.64	0.72	0.24	0.90	0.43	1.00				
South West	0.92	0.89	0.79	0.74	0.79	0.24	0.84	0.55	0.93	1.00			
Wales	0.74	0.86	0.49	0.88	0.93	0.24	0.54	0.72	0.67	0.76	1.00		
West Midlands	0.88	0.95	0.67	0.86	0.88	0.18	0.74	0.59	0.85	0.91	0.85	1.00	
Yorkshire and Humberside	0.79	0.92	0.52	0.90	0.92	0.24	0.62	0.70	0.72	0.78	0.90	0.89	1

Table 3. Unit root testing on stationarity of house price.

	Non-inflation-targeting regime		Inflation-targeting regime	
	Level	First difference	Level	First difference
East Anglia	−0.67	−4.25***	0.83	−6.35***
East Midlands	−0.11	−4.14***	0.88	−5.43***
London	−0.81	−3.09**	1.15	−6.52***
North	0.47	−6.56***	1.07	−6.76***
North West	1.46	−4.27***	1.35	−4.31***
Northern Ireland	−1.86	−6.24***	0.73	−5.69***
Outer Metropolitan	−0.72	−3.08**	1.05	−4.77***
Scotland	0.53	−6.36***	2.95	−6.76***
South East	−0.75	−2.93**	0.95	−5.86***
South West	−0.51	−3.94***	1.28	−5.95***
Wales	0.20	−4.20***	0.98	−6.19***
West Midlands	0.36	−5.67***	0.87	−5.34***
Yorkshire and Humberside	−0.23	−4.27***	1.15	−5.90***

Note: *** and **Significance levels at 1% and 5%, respectively. The null hypothesis of the augmented Dickey–Fuller (ADF) testing is that the variable of interest is non-stationary. If the null hypothesis is rejected, then the variable is concluded to be stationary.

Midlands; club 3 of East Midlands, North, Scotland, Wales, and Yorkshire and Humberside; two non-convergent areas namely East Anglia and Northern Ireland.

Interestingly, the clustering seems to be spatially distributed. For instance, in club 1, London lies inside Outer Metropolitan, while in club 2, North West, West Midlands, South East and South West are geographically adjacent. Overall, the results of grouping in the non-inflation-targeting regime present spatial patterns in the UK regional housing markets, which can be possibly explained by migration in Meen (1999), as households use differences in regional house prices and move between appealing locations nearby (Giussani & Hadjimatheou, 1991).

The presence of three convergence clubs in the non-inflation-targeting regime support the findings of Montagnoli and Nagayasu (2015) that multiple equilibria (i.e., convergence clubs) exist across regional markets in the UK. It is thus important to consider the number and composition of each convergence club for clustering analysis. Yet, we further complement that convergence under the assumption of a single steady state can be possible, especially when the government strives to stabilise prices in goods and services. Since the adoption of inflation targeting, there is a significant change of convergence clustering among regions. The result in panel B of Table 6 shows that all the areas in the UK converges into one club, displaying significant equilibrium correction for all regions. In contrast, we find higher levels of heterogenous dynamics across UK regions in the non-inflation-targeting regime.

While we argue the reduction of spatial arbitrage is a key force for integration in the inflation-targeting regime, common trends or other factors contributing to the integrated systems shall be acknowledged. To demonstrate, interestingly, Northern Ireland, the most geographically disconnected region from the UK, moves into integration in the inflation-targeting regime. Coinciding with the inflation-targeting regime, the Belfast Agreement in

Table 4. Pairwise unit root testing.

	Non-inflation-targeting regime	Inflation-targeting regime
East Anglia	−1.23	−1.86**
East Midlands	−0.67	1.10
London	−0.86	−0.70
North	−0.94	−0.65
North West	−1.39	−1.72**
Northern Ireland	−0.54	−2.85***
Outer Metropolitan	−0.36	−0.92
Scotland	−1.49	−1.60
South East	−1.58	−1.34
South West	−1.03	−0.50
Wales	−0.89	−1.15
West Midlands	−1.77	−0.36
Yorkshire and Humberside	−1.12	−1.40

Note: We perform the unit root testing on the deviations of regional house prices from the national house prices. The null hypothesis of the testing is that the variable of interest is non-stationary. *** and **Significance levels at 1% and 5%, respectively.

Table 5. Panel data unit root tests.

	Non-inflation-targeting regime	Inflation-targeting regime
Levin et al. (2002)	−3.84***	−9.45***
Im et al. (2003)	−0.60	−4.67***

Note: The null hypothesis in Levin et al. (2002) and Im et al. (2003) is that all the panels contain a unit root. *** and **Significance levels at 1% and 5%, respectively.

Table 6. Convergence club classification.

	Log *t* regression Club composition	Coefficient for *b* (*t*-statistics)	Average price
Panel A. Non-inflation-targeting regime			
Club 1	London, Outer Metropolitan	−1.92	£46,003
		(−1.54)	
Club 2	North West, South East, South West,	−0.15	£31,541
	West Midlands	(−0.18)	
Club 3	East Midlands, North, Scotland, Wales,	0.06	£27,430
	Yorkshire and Humberside	(0.13)	
Non-convergent group	East Anglia, Northern Ireland	−6.45***	£28,555
		(−8.20)	
Panel B. Inflation-targeting regime			
Club 1	East Anglia, East Midlands, London,	−0.28	£100,847
	Northern Ireland, North, North West,	(−1.43)	
	Outer Metropolitan, Scotland, South		
	East, South West, Wales, West Midlands,		
	Yorkshire and Humberside		

Note: The results are based on the log *t*-test developed by Phillips and Sul (2007). The results are estimated based on equation (8). The null hypothesis is the existence of convergence in a club. *** and **Significance levels at 1% and 5%, respectively.

1998 can contribute to the process of convergence, as the agreement improves the political stability. In a successful inflation-targeting regime, private investment is particularly promoted; thus, a stable Northern Ireland is appealing to investors, leading to the reduction of spatial arbitrage. Collectively, the findings are consistent with our hypothesis that the adoption of inflation-targeting policy that fosters private investment will affect regional house prices to move towards a long-run equilibrium systematically.

We further investigate the housing convergence since the GFC with results reported in Table 7. Since the GFC, there is a significant change of convergence clustering among regions. The results show three club clusters and one group of non-convergent areas. More clubs are formed in this case which can be possibly explained by the fact that inflation-targeting policy is less successful since the GFC. Therefore, the reduction of spatial arbitrage opportunities are limited.

The clustering appears spatially distributed. Interestingly, some of the non-convergent areas are particularly subject to global investment flow, since the GFC. For instance, Scotland is ranked as the UK's most attractive foreign direct location with cities including Aberdeen, Edinburgh and Glasgow for attracting both inward and outward investment (The Scottish Government, 2022). London, typically found to be distinctive in the literature (e.g., Gray, 2018) and known for attracting foreign investment, is confirmed to be divergent. This can be speculated to have ripple effects on adjacent regions such as Outer Metropolitan and South East. While the neo-classical theory suggests the long-run convergence, the complexity of global factors adds the limit to the theory and explains the potential divergence across regions.

Table 7. Post-crisis convergence club classification.

	Log *t* regression Club composition	Coefficient for *b* (*t*-statistics)	Average price
Club 1	East Angelia, South West	0.19	£202,016
		(1.05)	
Club 2	East Midlands, West Midland	−0.01	£161,706
		(−0.03)	
Club 3	Northern Ireland, Wales, Yorkshire and Humberside	0.68	£139,315
		(3.35)	
Non-convergent	North, North West, South East, Outer Metropolitan,	−1.12***	£221,173
group	London, Scotland	(−34.81)	

Note: The results are based on the log *t*-test developed by Phillips and Sul (2007) over 2008:Q3–2020:Q4. The results are estimated based on equation (8). The null hypothesis is the existence of convergence in a club. *** and **Significance levels at 1% and 5%, respectively.

Moving from one club cluster into three clusters and one group of non-convergent areas in the post-GFC period, it appears that the Greater South East is more divergent and divided from the rest of the UK. This implies that during a successful inflation-targeting regime between 1992 and 2008, all regions have a tendency to converge to a similar price level, integrating the Greater South East with the rest of the UK. Interestingly, further contrasting the post-GFC result against that in the non-inflation-targeting regime, the convergence club membership changes. While this research focuses on the reduction of spatial arbitrage as the driver for house price convergence in a successful inflation-targeting regime, further research on investigating the changes of convergence in subgroups is encouraged.

6.3. Implication

Analysis on regional housing price convergence can help policymakers alleviate regional imbalances and institutional investors formulate portfolio diversification strategies (Antonakakis et al., 2018). From the finance perspective, diversification benefits are limited when regional housing prices converge (Gholipour & Lean, 2017). Our finding of one club formation for all regions in the inflation-targeting regime suggests fewer diversification benefits for holding a property portfolio.

From the policy perspective, analysis of housing convergence offers policymakers information about the temporal and geographic diffusion of macroeconomic shocks and national policy (Cotter et al., 2015). Investigating housing convergence across the UK is important, since policymakers aim to restructure the housing finance system and mitigate catastrophic risk in dreadful housing downturns. Thus, a higher level of regional housing convergence in the inflation-targeting regime suggests a more even geographical diffusion to the national policy.

Moreover, as argued by Churchill et al. (2018), convergence of house prices in the long-run suggests that the wealth is more spatially distributed. Thus, a higher level of housing price convergence during inflation targeting would allow households to more easily move across regions and improve labour market efficiency, achieving a more balanced development.

7. CONCLUSIONS

We extend the literature by linking regional house price convergence to the change of monetary environments. Using the UK inflation-targeting policy in October 1992 as a natural setting for the structural change, results by a log *t*-test developed by Phillips and Sul (2007) show three house price convergence clubs in the non-inflation-targeting regime, but only one club for all regions in the recent inflation-targeting regime until the GFC. The findings affirm our hypothesis that a successful inflation-targeting policy that promote private investment can accelerate house price convergence across regions.

The results provide important implications for balanced national development and portfolio diversification benefit. It is of key interest for the government to maintain a balanced housing development in a country. From the policy perspective, the findings suggest that the adoption of inflation-targeting policy helps housing price converge. This can further improve distribution of wealth, migration movements, and labour market efficiency, achieving a more balanced national development. However, from the investment perspective, a higher degree of integration of housing markets in the inflation-targeting regime indicates markets move more closely together. Thus, there are fewer diversification benefits for institutional investors holding a property portfolio. Therefore, a need for agents in housing markets to understand the change of monetary environments is evident.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

NOTES

1. Test statistics = 37.05 and p-value = 0.00. The null hypothesis of no structural break is rejected and the testing suggests an estimated break year in 1992.
2. See the cited literature about the model description.
3. Other types of unit root tests such as Phillips and Perron (Phillips & Perron, 1988) and the modified Dickey–Fuller testing (Elliott et al., 1996) are conducted as well. The results and conclusion remain consistent.

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