

Article

Composite Indicators of Housing Market Pressures: How Well Do Single and Composite Indicators Align?

David Paul Gray 

Lincoln Business School, University of Lincoln, Lincoln LN6 7TS, UK; dgray@lincoln.ac.uk

Abstract

A claim made in 2020 that ‘something has gone fundamentally wrong with the housing system [in England]’ is considered using a coupling coordination-generated local authority district-based housing market ‘evaluation’ index and a Principal Components-generated alternative. It is argued that there is too much latitude granted to researchers in how the coupling coordination index is generated and applied. Indeed, its very construction presents problems for the language around it. Concluding that there is a balance system can be a result of which index is examined and how elements are included. Balance in one index could be associated with imbalance in another. Despite these issues, the latter composite is found to be no more closely associated with other, later period composites of stress and contemporaneous direct measures of housing affordability than the former. Furthermore, the language around a crisis and failure is perhaps overstated. Funding bodies were permitted to increase the amount of lending at high ‘affordability’ ratios in 2025. More appropriate language around lending and affordability multiples should be developed. Issues concerned with land directly include projecting where additional housing should be targeted, and those estimates are compared with the 2024 ones. Also, data on land values are found to be relatively linked to housing stress in accord with the view that they are intertwined.

Keywords: composite indices; housing unaffordability; coupling coordination; principal components; local authority districts

1. Introduction

There are various claims about a local housing system failure highlighting differing dimensions of housing, but at its heart is the assertion that England is facing an affordability issue. The Affordability Commission [1] in 2020 claimed that ‘something has gone fundamentally wrong with the housing system [in England] and what it offers local people’. A different ‘crisis’ entailed a rapid change in the costs of buying when, in just over 30 months to summer 2023, the Bank base rate rose 515 basis points to 5.25%. Five years earlier Jonathan Davidson, Director of Supervision—Retail and Authorisations, Financial Conduct Authority (FCA) [2], when outlining the regulator’s view of affordability, warned in 2018 that one in six would struggle if monthly rent or mortgage payments increased by more than £50. It was estimated that over 1.4 million households were facing the prospect of their low fixed rates ending and any new mortgage agreement being dramatically higher, with over half facing a possible doubling of their current fixed interest rate.

When national commentators claim that the housing system is failing, it has echoes of a system in a state of disorder: the latter being the sort of term used in information theory



Academic Editor: Piyush Tiwari

Received: 29 July 2026

Revised: 8 September 2026

Accepted: 14 September 2026

Published: 16 September 2026

Copyright: © 2026 by the author.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and conditions of the [Creative Commons Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

and entropy, which is the basis of the coupling coordination framework. Coupling is a concept drawn from physics that refers to a codetermined relationship between two or more subsystems, where the entropy weight method determines the weights of indicators of coupling coordination analysis. The degree of coupling coordination (CCD index) measures the concordance between the internal elements in the system. This method has had a rapid take-up, particularly among scholars of Chinese development [3], often with spatial clustering assessed for concentrations of hot spots.

Composite indicators are used in many areas as instruments to benchmark performance and monitor progress towards policy targets under such circumstances. A CCD index is a composite indicator, which should have a clear view of what is being measured [4]. An ‘evaluation’ index compiled using housing market indicators of housing supply and demand rates should be able to distinguish imbalanced or distressed areas or whether proposed house-building targets are distributed in such a way as to mitigate that housing stress. Often, the composite can be assessed against well-known and measured phenomena to which it is likely to be linked [4]. Hence, it is wise to confirm any coupling coordination index with others that measure similar phenomena. Commonly, there is no testing of how well the CCD evaluation indices are gauging the system. It is not always obvious that the composite indicator has a clear view of what is being measured. To address these issues a CCD evaluation index is generated using readily available housing indicators that, following what is found in the CCD literature, could be used as the basis for a composite. Using the same elements, principal component analysis (PCA) is used to compile a comparator index. This method is a widely used method for creating a composite index [4]. Additionally, both composites are assessed for their inference alignment with a battery of single indicators that measure: theoretical price drivers; supply of dwellings; housing market activity; housing underutilisation; tenure variables; and unaffordability across space. They are further assessed against two 7-point scales of housing stress variables, which explicitly include affordability in their construction; they are compared with national housing targets; and they are related to affordability measures commonly used in policy decisions, not least in the determination of the housing targets.

In assessing the evaluative qualities of the CCD housing index, the questions that are addressed are: what insights do the CCD evaluation index and the PCA index provide within the English housing market; does the distribution of the CCD evaluation index correspond with that of the housing market stress and other indices; does the CCD evaluation index offer a superior correspondence with that of housing market stress and other indices; and does the spatial distribution of the evaluation values correspond with those of the targets set recently by the governing party.

The paper is structured as follows. First, there is a discussion of housing affordability, which covers the contested terrain of housing distress in England assessments. This is followed by a theoretical frame based on a monocentric urban model, and various adaptations and the notion of relative city performance being slow-changing, where places can be trapped in persistent weak productivity growth, affecting the local housing market. This is followed by a discussion of supply constraints on adding dwellings. Methods and data sources are featured next, covering the two key composite generating processes of CCD and PCA. This includes an outline of CCD usage and various hazards of such an approach. The results section reports elements of the CCD and the PCA. This is done graphically, using maps and tabulations of ranked values subdivided by a north-south and an urban-rural divide. Correlations with single measures and composites reveal the usefulness of the evaluation index and its variants. There is then an analysis of affordability and Targets. It is shown that the evaluation index can be used to review localised housing targets and unaffordability.

2. Literature Review/Theoretical Framework

Wilson and Barton, when reviewing affordability for lawmakers, highlight three approaches to evaluating this concept [5]. The housing cost to income ratio (HCIR) is the proportion of a household's disposable income that is spent on housing. The housing price-to-earnings ratio (HPER) compares prices with gross earnings. The residual income approach defines housing as affordable if a household can meet their other essential needs after paying for their housing. For example, the Affordability Commission defines unaffordability as the point when rents or purchase costs exceed a third of net equivalised household income (accounting for related affordability issues, such as housing quality, overcrowding, adequacy of housing benefit, household size and regional variations). The Commission was amongst many commentators who believed before the pandemic that unaffordability was a serious concern. The Office for National Statistics (ONS), the body charged with providing national statistics, also covered perspectives on affordability. It used a HCIR threshold of 30% of disposable income. For renters, the ONS used gross income to rent, and a 30% marker [6]. Mahmoud and Beswick provide a household-based costing, whilst highlighting significant differences associated with land prices [7]. In local authority districts with lower land prices, a typical two-person family would only have to spend around 20% of their pre-tax income to rent a two-bed property; in the areas with higher land prices, this jumps to around 45–50%, and in the top 10 areas, this can cost up to 75% of their pre-tax income.

Even though house prices rose in both nominal and real terms, Table 2.5 of the Household Survey for 2023–24 reports that in 2015–16 mortgage payments as a proportion of household income was 17.7%, whereas for rent, the percentage is much higher, at 35%. By 2019–2020 the latter had dropped to 31.9% whilst the former had risen to 17.8%. Nevertheless, there was stability in these numbers from 2010–11 [8].

Rather than price levels, in effect the ONS and the Demographia International Housing Affordability Survey [9] deflate prices by the local wage. The house price-earnings ratio is derived by dividing the estimated house price by the earnings for the district concerned. The earnings are workplace-based (where people work) rather than residence-based (where they live). The median HPER is a standard measure for house purchase affordability across districts and countries. Demographia suggests dwelling purchases become unaffordable with an HPER above 3. It features only full-time employees on adult rates of pay. The earnings are gross (before tax) and do not relate solely to those who purchase a dwelling. They would include renters, existing homeowners, and other earners. Mortgage lenders have access to actual borrowers' data and would filter out some of the higher-risk borrowers. As such, their reported HPERs would be different from the ONS's.

A key cost to the house purchaser is servicing the mortgage, the setting of which is strongly influenced by the Bank of England's Bank Rate. Floating at less than 1% from 2009, it stood at 0.75% in 2019, dropping to 0.10% in 2020 at the outbreak of the pandemic. Post the Great Financial Crisis, there has been a preference for mortgages with fixed terms of 2 and 5 years. With the effective variable mortgage rate floating around 2.88% from 2016 to 2020, the proportion of borrowers on variable rates dropped from 49% to 26%, in part because the fixed rate of choice that lasted five years was no more expensive. The fixed rates for new mortgages for 2 [4] years dropped from 2.38% [2.8%] to 1.77% [1.89%]. Only 7% of new mortgages were at a variable rate (of 1.83%) by 2020. At the time, following around nine years of uninterrupted price growth, half of all mortgaged homeowners had at least 50% equity in their property, and a further third had between 25–50%. London and the southern regions particularly benefited, where up to 60% of borrowers owned at least half of their home's equity outright [10]. UK Finance felt confident in the housing market's robustness. The equity growth was based on the Bank Rate's real-term decline from 1985

to 2018, which accounted for the doubling of house prices relative to incomes over that period [11]. The Annual Survey of Mortgage Lenders' data on total mortgage payments as a percentage of income between 2009 and 2019 was steady at around 16.5%, with a new buyer paying around 1 percentage point above that [12], suggesting a stable proportion of income is spent on house acquisition over that time.

In 2023, over 1.4 million households were facing the prospect of renegotiating their low fixed interest rate mortgages in a dramatically changing environment. By summer 2023, wage and price inflation forced the Bank of England to raise the Bank base rate by 515 basis points in just over 30 months to 5.25%. The ONS surveys were showing that more than a third of those responsible for rent or mortgage payments in Great Britain were struggling to afford them. That rose to 17.9% in 2022 when the base rate was at 3.2%, and by 2024, when the base rate was 4.75%, the mortgage payment rate was 20.5%. This was when the effective mortgage rate for those with outstanding mortgages was 3.03% and 4.62% for new mortgages.

To assess the potential fallout of the mortgage rate rises, in April 2024, the ONS released two 7-point scales of housing stress: one based on the increase in monthly mortgage repayments for households who remortgaged in 2023 (the Mortgage Exposure Score or MES), whilst the other was based on the increase in monthly rental payments for households who experienced an increase in rental costs in 2023 the Private Rent Exposure Score or PRES) for 307 English districts for 2023 [13]. These are useful benchmarks for the work undertaken in this paper. Again, UK Finance [14] argued against there being a crisis, asserting that whilst higher than their previous fixed interest rate deals, the renegotiated mortgages were, on average, well below the stress test rates (3 percentage points higher than the contractual reversion rate) that their lender had previously assessed they would be able to afford. In other words, the members of UK Finance did not foresee mortgage delinquencies would follow in large measure. Indeed, in 2025, the FCA loosened its stress test rules so that the three percentage points could be reduced, leading to a possible increase in the number of First Time Buyers of 47,000–80,000 a year [15]. The number depends on how much new housing stock is delivered to meet the additional demand, to suppress the house price rise. Furthermore, the Bank of England's Prudential Regulation Authority relaxed the share of lending at high loan-to-income mortgages so that there could be more larger loans [16].

DiPasquale and Wheaton [16] spend chapters 2 to 5 developing a monocentric urban framework featuring markets, pricing, and rents. Within the monocentric urban area, dwellings closer to the central business district (CBD) command a higher rent or price, based on a locational monopoly. The rationale behind this declining price from the centre is the disutility of commuting, which is baked into the dwelling's rent or price. DiPasquale and Wheaton's model envisages that new dwellings are of the same size as existing dwellings but constructed at the outer edge of the city on undeveloped land. As they are furthest from the CBD, they will be the cheapest dwellings in the market. Assumptions can be relaxed. The number of dwellers can be increased without extending the boundary by raising the number of dwellers per dwelling and increasing the number of residential units on a plot of land. The high land prices encourage higher density so that there is an incentive for redevelopment and a greater number of dwellings per hectare. This is manifested in taller buildings and blocks of flats, which use land more intensely. Thus, approaching the CBD, land is more expensive; the density of population (number of dwellings per unit area and the number of people per dwelling) would be higher, but, although average housing price will be greater, there will be a non-linear relationship between that and land, related to a declining size of dwelling.

Other locational attractors can be envisaged. Agents could be attracted to amenities such as schools or green spaces, affecting local price. With the monocentric model, all receive the same wage. A wage compensation hypothesis predicts lower wages are associated with proximity to amenities; a non-pecuniary reward for working in a pleasant location. Lower affordability could be accounted for by both wages and house prices. So structural differences are baked into affordability that may be obscured by examining price alone.

A node's wage will be based on agglomeration/productivity effects. The evolution of a city's productivity will be affected by its host industries and their trajectories [17]. A spatial hierarchy of productivities will exist, but divisions will be mutable, changing slowly. In a path-dependent framework, geographically uneven productivity is associated with local histories and the concomitant development trajectories. An area can be locked into a favourable or unfavourable development path. This lock-in occurs when locally-specific characteristics make certain investments more attractive, which alter the terrain and relative competitiveness for other, later investments. Alternatively, by not having the right fit for a new technology, an area can be passed over for investment, and skills-based adaptation, affecting its draw on resources when another, associated, spatial round of investment occurs in the next innovation.

Housing theory posits that productivity will influence house price and rent averages across the districts under consideration. An asset-price model relates the price of the dwelling to the rental stream and the cost of capital. Absentee landlords would combine capital gains (growth in locational value) with rent when choosing where to invest. One can appeal to capital and labour movements to achieve some spatial equilibrium that provide the balance in a CCD systems sense. A local price-to-rent ratio will vary with the cost of capital, the size of the city, expectations of rental growth and distance to the CBD [16] (p. 51). A favourable development path which points to rising future locational value and hence growing rents [18–20] would encourage buyers to bid up current prices relative to current rents. By contrast, sluggish growth, which is associated with larger northern cities of the UK, deindustrialisation [21], declining populations both relatively and absolutely, and low-wage growth, would not be so favoured. The housing market has a bias. Local weak productivity growth is reflected more in declining prices than in falling population. Because dwellings are durable, these poor areas are more likely to feature old housing stock. If price falls below the cost of new construction, the construction industry may not engage in adding dwellings. Then the issue of rent covering maintenance costs arises. The likelihood of costs being covered by the rent is lower in poorer areas, resulting in a higher rate of vacancies.

Where the local price-wage combination is beyond the perceived going rate, DiPasquale and Wheaton posit that buyers will look elsewhere, leading to a quick correction. This leads to overspill where associated housing market areas have co-determined house prices. More broadly, agents move seamlessly within and between cities until a spatial equilibrium is achieved based on utility, which cannot be observed [22]. Seeing this, landlords may bid up prices, viewing the overspill as indicating the local housing is temporarily underpriced, pushing price levels to maintain a general structure over time in a local area and between areas. Such arbitrage is a force in a local environment that would induce investment return convergence. For Davis and Ortalo-Magné [23], a common proportion of income spent on housing (24% in the U.S.) offers a spatial equilibrium level. It is interesting to observe that this sort of proportion is found in many cost-affordability metrics mentioned above.

An alternative spatial equilibrating force is based on risk-adjusted returns to a dwelling purchase across space [24]. Mortgage-utilising buyers would be dependent on lenders'

views of future prices and the assessment of creditworthiness. There are lower agency costs to the lender in growing areas and with those with greater human capital. Under these circumstances, lenders offer greater mortgages for each unit of income. Duca et al. [25] assert that a striking aspect of recent research is a growing consensus that credit supply shifts are a principal driver of house prices. Great credit availability and risk appetite would have a feedback loop on demand and prices, particularly in growing areas. Thus, managing housing purchase demand and the locational premium is a concern [26].

DiPasquale and Wheaton [16] posit that positive price misalignments stimulate additional dwellings to be built above the replacement rate. The extent to which land is available, and additional dwellings follow rising demand to suppress price rises, will determine the balance of the increase in population and prices [20]. The implication of restricting additional dwellings can be seen in McCann [27]. It is shown that when productivity (income) rises, a node with constrained additional supply experiences a greater increase in the average locational rent premium. Assuming there is no change in the density of dwellers (densification), this sort of constraint points to the adjustment in price rather than a price rise and population growth.

McCann [27] reviews a housing market area where there are four income groups, which have different preferences for dwelling sizes and locations. The younger high-income group lives close to city amenities such as restaurants, probably in high-density dwellings, such as flats. The older high-income group are posited to be attracted to lower-density space and larger dwellings found at the edge of a housing market area. Importantly, low-density housing areas could be defined as part of a rural administrative district rather than an urban one, so that rural housing, at least the ‘commutable’ housing, is likely to be strongly linked to the local urban area. As such, the 2021 Urban-Rural designation for English districts uses commuting patterns in the assigning of the district, presenting different designations compared with the 2011 census. The low-income group could be limited to living in State-provided dwellings and/or renting. The public transport infrastructure, McCann [27] avers, will also constrain where such commuters reside. Subsidised transport is likely to be featured strongly in urban areas, which could restrict the locational choice of the low-income group further.

As a city expands, land that was developed some time ago within the urban area could be underutilising space, offering an incentive to redevelop the existing structure [16] (p. 83). Variants of land reuse include existing dwellings being converted, and commercial properties can be redeveloped as residential buildings. The former is classified as Conversions and the latter, Change-of-Use, in the accounting of net change of dwellings in the additional dwellings data collected by the ONS.

Recent national governments of both stripes have viewed the planning system as failing to provide the necessary numbers of additional dwellings. When the Affordability Commission was highlighting its concerns, the Conservative administration had published house building targets. Rather than assessing need as a function of household formation, the allocation of targets to local authority districts was based on HPERs. The target was 300,000 additional dwellings per year. The Labour administration of 2024, in their National Planning Policy Framework (NPPF) for England [28], imposed mandatory new targets on local housing planning authorities. It upped the target to 370,000, putting greater emphasis on housing affordability in assessing needs than the old targets.

A concern of various UK governments, explicit in the NPPF, is that there are regulatory constraints on new construction. Key elements of the supply of dwellings, the building industry and the implementation of land use planning are viewed as areas of failure. On a local basis, planning restrictions reduce the availability of land [29]. Over the period 2011 to 2019, a majority of neighbourhoods outside of city centres failed to build new houses.

To avoid being clogged in the planning system with high rates of planning objections, builders are limited to adding dwellings in the centres, or on the very edges of these cities. The Competition and Markets Authority (CMA) investigated the building industry [30] to establish whether house prices are held artificially high through restricting the supply of dwellings. Because of the bidding system for land, to avoid a loss, the CMA found that housebuilders tend to build at a rate that is consistent with the local absorption rates, i.e., the rate at which houses can be sold without needing to reduce their prices. Increases in demand are reflected in price rather than output. Decreased demand is addressed through incentives and increased marketing, rather than by cutting production [31]. Although this appears as a restrictive practice, the CMA did not impose any penalties.

Demographia argues that the widespread lack of intensification of land use is commonly traceable to regulatory limits on residential density or building height [9]. Land is 8 to 20 times more costly inside urban containment boundaries than outside. Lange et al. [32] claim there is a density gap in Britain's big cities relative to comparable French and Japanese cities over the decade to 2020–2022. British city centres have built almost as much as those in Japan and France, but at between two and six kilometres from the CBD the average French and Japanese big city built roughly twice as many homes. If the 62 biggest British cities and large towns had the same level of density as comparable French or Japanese cities, they would have 2.3–2.4 million more homes.

The Conservative administration of the 2010s sought to bypass local planning restrictions with the introduction of the permitted development right (PDR). While developers in England were previously required to submit detailed plans and apply for full planning permission for change of use, the changes meant they only had to notify the local planning authority of such a modification [33]. The majority of PDR conversions in England have been office conversions. It was hoped to boost repurposing commercial buildings for residential use in areas where planning agencies appeared unwilling to release sufficient land. There was also a relaxation of height restrictions.

The campaign group Empty Homes [34] highlights the underutilisation of properties with a view to bringing them back into use. It is most closely associated with residential dwellings that are classified as long-term vacant homes. The number of empty homes is captured by owners reporting their property has been empty for six months or more (i.e., unoccupied and unfurnished), for the purposes of assessing a Council tax liability. A six-month timeframe is largely acknowledged as being about right for those transitional transactions relating to property: such as a straightforward house sale; a period of putting in planning applications; the duration of refurbishing a property; or a house ensnared in probate. The Long Term Vacancy, which is a subset of vacancies, is a dwelling that is not available for current use. It may be unsellable in its current condition. A long-term vacancy (LTV) can be viewed as a dwelling that could be brought back into use outside of the planning process. A not dissimilar measure of housing underutilisation comes from the 2021 Census. Of the 1,507,100 unoccupied dwellings in England on Census Day, it is estimated that 89.7% were truly vacant and 10.3% were second homes. The latter includes non-commercial holiday homes, short-term lets, or another address while working away from home. Truly vacant homes could be a measure of frictions where the vendors sell their original abode after they have secured the new one, and the disposal of the surplus dwelling takes time. That may be the case in the U.S. where, much like unemployment, one means of assessing excess demand or supply in certain trading regimes is vacancies [35]. The emergence of elevated long-term vacancy that followed the financial crisis suggests structural over-supply to an excessive level in the U.S. [36]. In the UK, where house-switching is undertaken concurrently, the buyer engages in two trades simultaneously, selling their old abode on the day of completion of the purchase of their new one. A vacant

abode can still imply friction. Where there is a weak or cold market, the vendor may be too impatient to find a buyer and move to the new abode before selling the old residence, leaving them with two. This is expensive, possibly entailing a short-term bridging loan.

3. Materials and Methods

Loveridge et al. [37] outline 6 steps in constructing a composite index. Step 1 entails identifying candidate indicators, which is followed by Step 2, collecting the [survey] data. The process here entails using readily available data at the LAD level. Steps 3, 4 and 5 involve removing indicators that: give no helpful information on the variation; can be excluded from the composites without reducing its power; and duplicate other variables (which are identified as a correlation above 0.7). As indicated above, the approach here uses coupling coordination to generate an 'evaluation' index. To explore the usefulness of the indicators and their allocation to a subsystem, the same constituent variables are recombined using Principal Component Analysis. This rival index will have a data-driven approach that exposes the usefulness of the combination of sub-elements. Step 6: external validity consistent with theory. Nardo et al. [4] (p. 35) pose questions like: does the theoretically derived model provide a good fit to the data?; what does the lack of fit say about the composite?; and what concept would the available indicators be a good measure of? Composite indicators often measure concepts that are linked to well-known and measurable phenomena, which can be used to test the explanatory power of a composite [4] (p. 39). Step 6 is addressed using a series of correlations with single indicators and other composites.

3.1. Principal Component Analysis

A dataset x comprising $m = 1 \dots M$ districts and measured by $n = 1 \dots N$ housing indicators have the set of indicators simplified by Principal Component Analysis (PCA) which captures the largest variation in the data. The simplified scheme involves unobserved latent variables. The linear combinations produced by PCA are conventionally termed components. These components can be combined to generate indices of activity.

The dataset x in matrix form with dimensions $(M \times N)$ is transformed as a linear combination such that the transformed y is defined as $y = A'x$. One transformation of x is $y_1 = a_{11}x_1 + a_{12}x_2 \dots + a_{1N}x_N$, where $\sum a_{1n}^2 = 1$. The covariance matrix $Cov(x'x)$ can be expressed as $AA\Lambda A'$, where A is the eigenvector matrix, and Λ is a diagonal matrix comprising eigenvalues in order $\lambda_1 \geq \lambda_2 \geq \dots \lambda_N \geq 0$. $AA' = I$. With $x = Ay$, a bifurcated x can be expressed as $A_{(M \times G)} y_{(M \times G)} + A_{(M \times N-G)} y_{(M \times N-G)}$, where $A_{(M \times G)}$ are the retained eigenvectors, where there are G common component forces among N variables. The criteria for selecting the retained number of eigenvectors G include Kaiser's, used by default by SPSS (Version 30), which requires the corresponding eigenvalues to be 1 or above. Altering G and exploring whether the resultant factors provide any insight may be more useful. Selecting a high G can cause minor factors to appear to be important, whereas a low G can lead to a misinterpretation of the latent forces. With the thesis that there are G forces at work in the housing market, one could explore whether G is larger or smaller than that implied by a coupling method.

If $G > 1$, rotation is used to discriminate between components and improve interpretation. Varimax is an example of an orthogonal rotation that generates component loadings, based on the latent components being uncorrelated. Oblique rotation, such as Promax and Direct Oblimin, allows the G components to have non-zero correlations, implying latent force interdependence. The first principal component accounts for the largest proportion of the total variance in the set of indicators used. The second component accounts for the next largest amount of variance not accounted for by the first component, and so on for the higher-order components. When interpreting the G factors, largest loadings suggest the

latent variable g summarises n interrelated indicators well. There may be crossloadings so that an indicator can be associated with multiple latent components. Using the factor scores from the principal components as weights, a composite index can be constructed. Various factor composites can be aggregated by assigning a weight to each one of them equal to the proportion of the explained variance in the data set [4]. At the limit, one can just use the first component as the index, which as with [38], is taken to be households' 'socio-economic' score. Rather than the more traditional methods based on income and consumption expenditure to develop such a score, their work features durable asset ownership, access to utilities and infrastructure, and housing characteristic variables.

3.2. Coupling Coordination Degree

In information theory, entropy is a measure of the disordered state of a system. The entropy weight method, as used here, determines the weights of indicators in decision analysis of coupling coordination. Based on the distribution of the information (values) of different indicators, the values of N housing indicators can be investigated according to the idea of entropy. Coupling is a concept drawn from physics that refers to a codetermined relationship between two or more subsystems.

As guided by some overarching theoretical view of the indicators, allocate the $n = 1 \dots N$ housing indicators into groups, so that indicators 1 to n_1 are allocated to subgroup $g = 1$. Indicators $n_1 + 1$ to n_2 are allocated to group $g = 2$ and so on up to G groups of sub-systems. Indicators are winsorized, or standardised, so that they lie in the range of $[0, 1]$ after treatment. The standardisation of indicator n entails applying either.

$$r_{nm} = \frac{x_{nm} - \min\{x_{nm}\}}{\max\{x_{nm}\} - \min\{x_{nm}\}} \text{ or } r_{nm} = \frac{\max\{x_{nm}\} - x_{nm}}{\max\{x_{nm}\} - \min\{x_{nm}\}},$$

so that r_{nm} is the standardised value of x_{nm} , the value of the n th indicator in the m th group. This is then converted into a proportion using $f_{nm} = \frac{r_{nm}}{\sum_{m=1}^M r_{nm}}$. The information entropy model is used to calculate the degree of dispersion (e_n) of the n th indicator in the overall sample.

$$e_n = -\frac{1}{\ln(M)} \left[\sum_{m=1}^M f_{nm} \ln(f_{nm}) \right]$$

Calculation of information entropy redundancy entails subtracting e_n from unity. If the distribution is even, the redundancy is zero. The redundancy associated with the n th indicator is combined with others of a subgroup of indicators to determine the indicator weights for the subgroup. In the case of the weights of subgroup 1

$$w_n^1 = \frac{1 - e_n}{\sum_{n=1}^{n_1} (1 - e_n)}$$

The next stage entails multiplying the weights by the normalised values for each subgroup. In the case of subgroup 1 it is $H_m^1 = \sum_{n=1}^{n_1} w_n^1 r_{nm}$ and in the case of group 2 it is

$$H_m^2 = \sum_{n=n_1+1}^{n_2} w_n^2 r_{nm}.$$

Coupling Degree (C) reflects the degree of balance among the different subsystems within a system. The formula for estimating the coupling degree is

$$C_m = G \frac{\sqrt[G]{\prod (H_m^1, H_m^2, \dots, H_m^G)}}{H_m^1 + H_m^2 + \dots + H_m^G}.$$

The value of T represents the coordination degree. However, as will be discussed, it has been viewed as a total activity or development score [3]. The coordination degree is calculated using weights set by the researcher. Here, the weights α , β , δ in the three-subsystem scheme $T_m = \alpha H_m^1 + \beta H_m^2 + \delta H_m^3$ are chosen so that the subsystem values influence the overall index, appropriately. Given that the CCD could depend heavily on T and T on the structural components over the growth elements, the weights after some iterations are arranged 0.4, 0.4, 0.2.

The coupling coordination degree (CCD) provides a coefficient that represents the confluence amongst the subsystems within a system. The calculation for each LAD is $CCD_m = \sqrt[3]{C_m \times T_m}$. The value range of coupling degree, coordination degree and coupling coordination degree was all between 0 and 1.

It is common for CCD users to report spatial associations. Moran's I , a global measure of spatial association, involves correlating a variable with the spatially weighted average of itself, so that it can provide an indication of (dis)similar values across space. Moran's I is commonly used to test the null hypothesis of spatial randomness, ranging in value from -1 to $+1$. Spatial autocorrelation can be defined as $I = \frac{z_i' W z_i}{z_i' z_i}$ where $z_i = (x_i - \bar{x}) / \sigma$ and x_i is the local index or rate value. The local measure, Local Indicators of Spatial Association (LISA), makes up the components of Moran's I . A LISA can be defined as $I_i = z_i \sum_j w_{ij} z_j$ [39–41]. LISA maps offer 2×2 types of association: high–high (HH) or hot spots, low–high (LH), high–low (HL) and low–low (LL) or cold spots. HH implies districts with high rates or index values are collocated with others with high rates. LH and HL reflect outliers that are at odds with those locations. The measured association depends on the type of weight matrix. A nearest neighbour matrix can capture closely associated spaces limited to a certain number (here 10 is applied), where $w_{ij} = 1$ for a near-neighbour and 0 for a non-neighbour and $w_{ii} = 0$. To cater for multiple statistical comparisons, the level of significance is adjusted. Anselin [40] argues a Bonferroni adjustment is too conservative. Le Gallo and Ertur [42] recommend the adjustment be based on the number of near neighbours. As 10 is used here, the adjustment entails using a 0.5% pseudo-level, which corresponds with a false discovery rate of around 0.5%.

3.3. Data

The creation and examination of the CCD and PCAc indices utilise single housing measures that are collected under the headings: theoretic price drivers; supply of dwellings; housing market activity; housing underutilisation; tenure variables; targets; and unaffordability across space. There are two data repositories that are accessible to all researchers. The UK's Department for Levelling Up, Housing and Communities (formerly the Ministry of Housing, Communities and Local Government) hosts data on additional dwellings broken down into New Builds, Change-of-Use, Conversions and Demolitions. Collectively, these are components of the supply of dwellings. It is also the repository for the total number of dwellings and long-term vacancies. The ONS hosts population estimates, house prices, number of transactions (sales), rent, rent-to-earnings ratios, house price-to-earnings ratios and productivity data. The ONS also has some data that is available intermittently, such as those related to the Census of 2021, or specific reports. Cases in point are land values, first-time buyer mortgage sales and second and vacant home rates. The latter pair were derived from the Census. The price of a hectare of land for residential building is available for 2019. Details of the adjustments to data are to be found in Appendix A.

The entropic approach to a CCD composite would address the weighting of any included indicator. Demolitions, though, present empirical and theoretical difficulties. The logic for including Demolitions could be an extension of vacancies. Where there is an excess supply of dwellings, price and/or rent may fall below a level that covers the cost

of maintenance; the owner leaves it empty until it becomes unsafe, and it is scheduled for demolition. This implies a low demolition rate indicates a strong housing market. The alternative view is that, where land is scarce, demolitions could be a subset of land clearances with a view to repurposing the plot. This implies that a high level of demolitions indicates a strong housing market. Empirically, demolitions are positively correlated with all but vacancies, suggesting the latter outweighs the former, so are taken to rise with an increase in demand for local land, on average. In the process of analysis, particularly with the interpretation of PCA components, demolitions were found to be problematic. Rather than removing the variable, it was combined to construct ‘net new dwellings’, where the number of new dwellings is moderated by the loss due to demolitions. It has the advantage of being consistent with net conversions and change of use in examining the overall change in that category. Thus, all three supply of additional dwellings measures could be negative.

Table 1 reports winzorised data used for the CCD index. All the data are non-normal, as indicated by a Jarque–Bera test at the less than 0.1% level. The statistic, which is distributed as χ^2 with 2 degrees of freedom, is higher with lower means. For reference, the period the data covers is reported.

Table 1. Descriptive Statistics of Composite Winsorised Elements.

	Periods	Mean	SD	Skew	Kurtosis	J-B
Conversions †	2012–2013 to 2019–2020	0.266	0.136	2.708 **	9.64 **	1564 **
Change of Use †	2012–2013 to 2019–2020	0.118	0.081	4.638 **	45.067 **	27,081 **
New Dwell net †	2012–2013 to 2019–2020	0.350	0.182	1.015 **	0.906 **	63 **
Population Growth	2012:2019	0.462	0.127	0.392 *	1.584 **	40 **
LTVR †,††	2012–2013 to 2019–2020	0.704	0.153	−1.329 **	2.59 **	176 **
GVA/hour worked	2020	0.234	0.131	2.129 **	7.178 **	891 **
Pop/dwelling	2020	0.624	0.113	−0.284	4.189 **	229 **
Pop density	2020	0.115	0.166	2.666 **	8.384 **	1263 **
Earnings Growth	2012:2019	0.400	0.124	0.748 **	2.772 **	127 **
Price Growth	2012:2019	0.277	0.150	1.145 **	3.141 **	193 **
Price Level	2019	0.107	0.102	4.304 **	29.826 **	12,327 **

† Divided by the number of dwellings in the territory in 2020 and multiplied by 1000. †† This is standardised so its high values align with high values of other variables. * Significant at the 5% level
 ** Significant at the 0.5% level.

4. Results

4.1. CCD Indices

The median coupling value C_m is around 0.901, which is generally viewed as a high figure. The spatial boxplot map in Figure 1a reveals outliers, based on a 1.5 hinge. Urban areas have a higher level of coordination, particularly in the London area. Rural areas, particularly those at a great distance from an urban area, are poorly coordinated. Combined, the pattern shows dark brown surrounded by light brown or light blue, suggesting coupling fades with distance from a node. The arrangement is more in line with a core-periphery divide where the urban core is surrounded by an increasingly imbalanced rural hinterland. The LISA map Figure 1b reveals low–low (LL) combinations in the East Midlands, whilst high–low (HL) combinations appear to reflect urban punctuations in a rural canvas. An area to the west of the London area emerges as a hot spot. All maps are generated by GEODA and use the BGC projection.

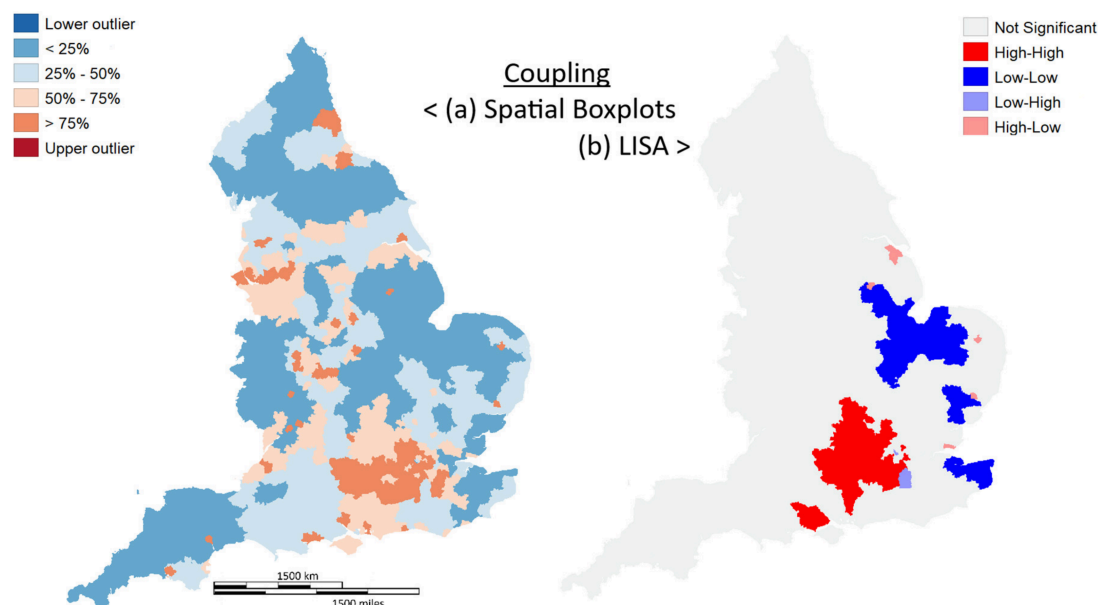


Figure 1. Coupling: Spatial Boxplot (a) and LISA maps (b).

The coordination values T , which have been viewed as the development indices, are found to be largest in the south-east of England, with the greatest in London. As Figure 2a shows, very few districts with high values are found in the north. As this combines growth rates of values such as population and number of dwellings with structural elements, such as price, this is taken to show that the value of activity (not the volume) is greatest where the highest prices are to be found. The LISA map Figure 2b reveals a much larger cold spot (LL combination) covering much of the north of England. The higher values in the south do not collocate to form a corresponding hot spot outside of the London area. This reveals that the north of England in general has a relatively low level of activity, combined with low property values.

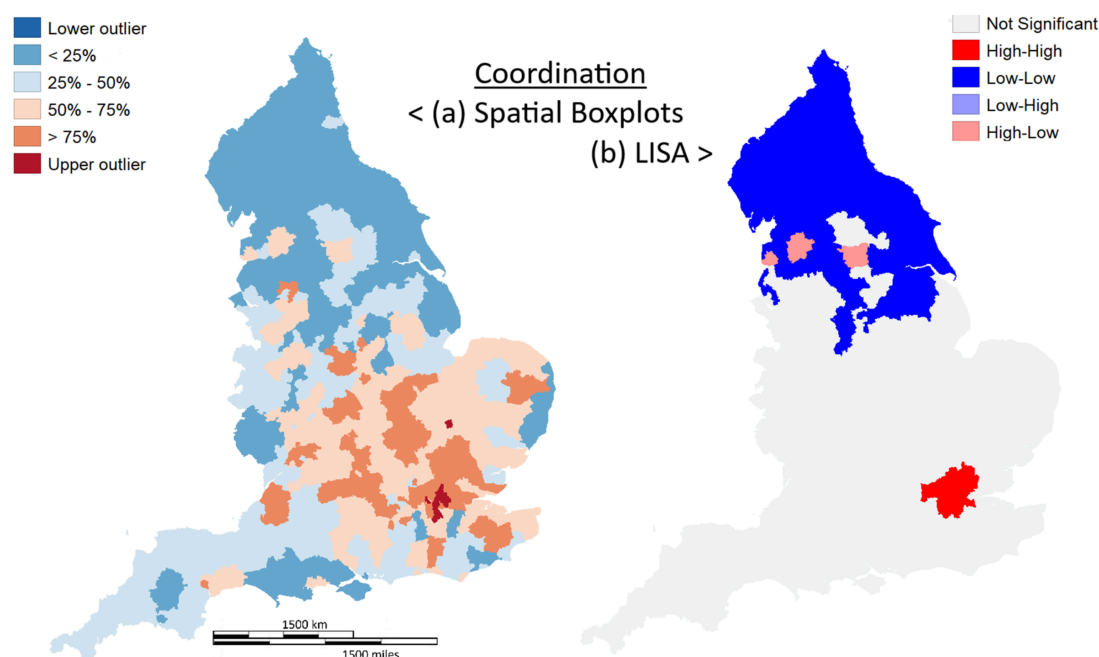


Figure 2. Coordination: Spatial Boxplot (a) and LISA maps (b).

An urban-rural and a north-south divide are explored. The urban and rural distinction is undertaken using the 2021 urban-rural classification of districts (Majority rural; Intermediate rural; Intermediate Urban; Major Urban). As these are generally defined, in effect, they are based on connectivity with urban areas: major rural is defined to capture more sparsely populated districts than Intermediate rural districts. Rather than a straightforward north-south divide, the groupings are more nuanced. Having said that, the delineations are in a natural order, akin to density of population, but not quite the same. Two areas with the same density can be at very different distances to a major population centre. The districts are aggregated into four super regions. The south of England excluding London consists of the South East, East of England and South West. London is a category of its own. The standard regions of the North West, Yorkshire and Humberside, and North East are labelled, collectively, as the North of England. The Midlands comprise East and West Midlands. One can view the four as being in an order based on distance from the highest house price region, London. At the very least, they are a more nuanced north-south distinction.

Using the 2021 urban-rural classification of districts, Median district population growth is lowest in Majority Rural and highest in Intermediate Urban. Majority Rural has the highest net additions rate of new builds, followed by Intermediate Urban, Intermediate Rural, and lastly Majority Urban. Population per dwelling and population density are highest in Majority Urban and Lowest in Majority Rural. Change of Use and Conversions are highest in Intermediate Rural, with the former lowest in Majority Rural whilst the lowest for the latter is found in Major Urban. Population growth is lowest in the North, followed by the Midlands and South, and highest in London. Population per dwelling follows this pattern, as do Conversions. Long-term vacancy rates (LTVR) follow the opposite pattern. The North has the lowest rate of all three forms of additions. The South East has the highest Change of Use rate, whereas the Midlands has the highest New Build rate.

The rural districts are characterised by the highest additions of dwellings and conversions, but the lowest population expansion. Combined with likely overspill between districts with, say, price and price growth, these differences in adding dwellings and population lead to imbalance in rural East Midlands-East Anglia. London has the highest rate of population growth and the lowest rate of newly built additions. This should point to an imbalance.

The issues raised by Figures 1 and 2 are explored using a North-South and an urban-rural grouping variable in a Kruskal-Wallis (K-W) test of difference and a Jonckheere-Terpstra (J-T) test of ordered alternative. Table 1 displays the mean ranks of the three subsystems of the CCD (H_S , H_D , H_L) and the two processes of the CCD (C_m , T_m).

The mean ranks for T confirm the discussion that coordination is lowest in rural areas. The no-difference null ($\theta_U = \theta_{UI} = \theta_{RI} = \theta_R$, where θ is the mean rank) is rejected (K-W $\sim \chi^2(3)$ 14 [0.003]) in favour of the alternative of $\theta_i \neq \theta_j$. Using the alternative that there is order in the mean ranks ($\theta_U \geq \theta_{UI} \geq \theta_{RI} \geq \theta_R$), T increases as the categories move toward the highest urban one (J-T $\sim N$ -3.5 [0.000]). The same cannot be said for H_S , H_D , and H_L , this is despite population density being an element of H_L , a circularity. Coupling in Figure 1a shows fading; a lower value with distance from a node. This is reflected in the Coupling values, which, when Urban, have the highest mean rank. There is a concentration of relatively low coupling in the East Midlands and East Anglia. It was suggested that T could be seen as a path-development measure.

Super-regional mean ranks are listed in Table 2b. Despite being classified as entirely urban, London in fact has a high additions rate. This is related to non-conventional additions. The population density is higher than elsewhere, as are productivity and price. London's H_S , H_D , and H_L are all high. As such, Coupling is also high. London's Coupling

mean ranks would feed into the Urban mean ranks in Table 2a. London has higher scores than any other sub-group, including H_S . The Midlands has low or imbalanced Coupling, with the South (excl. London) about the same as the North. Although the South's mean ranks for H_S , H_D and H_L are all above those for the North (i.e., θ_{No} , $\theta_{Mid} < \theta_{So}$, θ_{Lon}), there is some variation within the pairings.

The coordination values T , which have been viewed as the development indices, are found to be smallest in the North of England with the greatest in London. As with the Coupling values, with H_L , H_S , and H_D high, so will be the T coefficient. Imbalance should imply disequilibrium. However, relatively high supply does not mean sufficient supply to meet demand. Expanding the dwellings stock is more challenging in urban areas, particularly London. Hilber and Vermeulen [43] conclude that physical housing supply constraints are genuinely binding in densely developed areas, such as a London borough. They go on to suggest regulatory constraints are most important in a south-eastern city, such as Reading, whilst in the cities of Newcastle and Darlington in the north of England, house prices are comparably little influenced by supply constraints.

Figure 2b corresponds with the narrative that the North has adverse development path characteristics. There are very few high-value districts found in the North. In Table 2b, there is a strong relationship between distance to London and the development index. As this combines growth rates of values such as population and number of dwellings with structural elements, such as price, this is taken to show that the value of activity (not the volume) is greatest where the greatest prices are to be found.

Table 2. Subsystem Values by Spatial Subdivision.

a	Urban Rural					b	Regional				
	Mean Rank						Mean Rank				
	H_S	H_D	H_L	C_m	T_m		H_S	H_D	H_L	C_m	T_m
Urban (173)	156.4	156.3	147.5	202.3	168.6	North (72)	104.1	67.2	108.7	158.5	64.8
Urban Inter (47)	147.3	174.5	184.8	101.3	152.0	Midlands (65)	137.3	151.9	117.6	118.1	134.8
Rural Inter (37)	161.7	136.3	128.3	114.1	117.6	South (excl L) (138)	174.4	206.9	201.6	151.9	181.2
Rural (50)	146.2	140.0	166.6	66.1	132.1	London (32)	212.1	125.6	124.6	226.1	276.7
$\chi^2(3)$	1.1	5.3	10.7	124.2	14.0		46.0	121.1	73.0	32.0	149.9
p	0.776	0.149	0.014	<0.001	0.003		<0.001	<0.001	<0.001	<0.001	<0.001
J-T			1.0	−11.2	−3.5		6.8	7.9	5.5	2.8	12.9
p			0.295	<0.001	<0.001		<0.001	<0.001	<0.001	0.006	<0.001

Numbers in brackets = number of districts, H_L = Structural or persistent subsystem, H_D = Demand subsystem, H_S = Supply subsystem, T = Development index, C = Coupling index.

4.2. PCA Indices

The retained PCA components explain a high proportion of variation. Although it is usual to pay attention to the eigenvalues just below one to examine their utility, the usefulness was driven by the inferences one could draw from what emerged. Table 3 shows that a five-component solution is not unreasonable. The fourth component was found to link a high demolition rate with a slower rate of real wage growth, and the fifth linked a high rate of conversion with a greater population density. As a known component of additional dwellings, Demolitions was initially included in the CCD. It was found to be weakly correlated with all the variables used, including earnings growth. The

challenge was to explain how it is correlated with the fourth latent variable. The fifth component made more sense but provided little in the way of insight. A solution that retained Demolitions was to combine it with New Dwellings to create a net variable, Net New Dwellings. Rerunning the rotation with 11 rather than 12 variables did not affect the size of the fifth eigenvalue much, leaving a case for at least five components, yet the fourth and fifth components remained difficult to interpret. The factor loading on Conversions suggested that it was the only indicator strongly correlated with the last latent variable but not in combination with any other of the set. Without a clear theoretical justification for 5, 4 components among the 11 were settled on. The CCD was reconstructed to correspond with the same 11. The Varimax rotation method produced a Component Score Coefficient Matrix very similar to those when using Direct Oblimin and Promax rotations. As such, the case for non-orthogonal rotation could not be made. The rotation reduced the amount of variance explained by the first component by 30%. Thus, after many iterations, the data was reduced by selecting four components and rotating using the Varimax method.

Table 3. Eigenvalues and rotation loadings.

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings			
	Total	% of Variance	Cumulative %	Total Pre	Total Post	% of Variance	Cumulative %
1	3.36	30.52	30.52	3.36	2.33	21.19	21.19
2	1.71	15.53	46.05	1.71	1.89	17.16	38.35
3	1.26	11.48	57.54	1.26	1.86	16.93	55.29
4	1.02	9.26	66.80	1.02	1.27	11.51	66.80
5	0.97	8.79	75.59				
6	0.74	6.71	82.30				
7	0.64	5.77	88.07				
8	0.55	4.99	93.06				
9	0.33	3.02	96.08				
10	0.28	2.51	98.59				
11	0.16	1.41	100.00				
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.				0.621			
Bartlett's Test of Sphericity				$\chi^2(55) = 1102$ [000]			

In this analysis, the KMO value is 0.621, and Bartlett's test is significant ($\chi^2 = 1102$ [0.000]); therefore, PCA is appropriate. Bartlett's Test of Sphericity checks if the correlation matrix is significantly different from an identity matrix. As this coefficient is significant, it indicates that one can pursue a PCA reduction of the 11 variables into four combinations.

The results from the PCA are reported in Table 4 in three sections. The first displays the component loadings of the unrotated matrix, the second section shows the rotated components matrix, whilst the third displays the component score coefficient matrix. It appears that, following rotation, the second and third components switched in the Component Score Matrix.

The interpretation of the first component's factor loadings is that they are linked with structural or slow-changing variables. Agglomeration economies are posited to have higher productivity, great competition for land, rent and density of population. As land is at a premium, properties will be repurposed more readily, suggesting a high rate of change of use. Cities have high population intensities, the greatest of which is found in London. The loadings on the first latent variable on the rotated matrix are linked with structure. Population Density and Price have large factor loadings. Price growth also features.

Table 4. Component Values and Scores.

	Component Matrix				Rotated Component Matrix				Component Score Coefficient Matrix			
	1	2	3	4	1	2	3	4	1	2	3	4
Conversions net	0.375	−0.126	−0.167	0.811	0.076	0.036	0.069	0.911	−0.112	−0.119	0.021	0.801
Δ of Use net	0.476	−0.248	0.519	0.165	0.651	−0.227	0.249	0.218	0.322	−0.309	0.149	0.121
New Dwelling net	0.393	0.617	0.452	0.016	0.114	0.002	0.85	−0.066	0.031	−0.132	0.496	−0.088
Pop Growth	0.61	0.667	0.127	0.108	0.069	0.341	0.837	0.149	−0.075	0.07	0.438	0.067
LTVR	−0.615	−0.254	0.166	0.208	−0.241	−0.582	−0.342	0.005	−0.025	−0.296	−0.105	0.125
GVA/hw	0.688	−0.194	0.221	−0.346	0.74	0.29	0.179	−0.125	0.35	0.073	0.031	−0.268
Pop/dwell	0.477	0.372	−0.635	−0.074	−0.152	0.832	0.183	0.162	−0.232	0.518	−0.011	0.056
Pop density	0.613	−0.483	−0.268	0.157	0.529	0.385	−0.242	0.467	0.154	0.149	−0.229	0.289
Earn Growth	−0.201	0.209	0.33	0.324	−0.175	−0.42	0.275	0.126	−0.061	−0.307	0.23	0.193
Price Growth	0.768	−0.021	−0.144	0.014	0.46	0.52	0.223	0.283	0.107	0.203	0.03	0.11
Price Level	0.616	−0.536	0.253	−0.155	0.856	0.094	−0.082	0.075	0.419	−0.061	−0.101	−0.078

The indicators linked to the second latent variable are LTVR (negative), population/dwelling, earnings growth (negative) and house price growth. This is a combination of growth and structural variables. It was noted above when examining super-regions that Population growth, Population per dwelling and LTVR follow a pattern. Having an obverse relationship with price growth, LTVRs are likely to reflect [a weakness in] demand. Earnings growth should have a positive relationship with the latent variable.

The fourth component is correlated with Conversions and population density. Change of Use is linked to population density through the first latent variable. These forms of additions are more likely to be found in cities, with high-value land.

The third component is associated with new dwellings and population growth. The second latent variable has an association with vacancies, which could be viewed as potential additions. Thus, the latent variables could be viewed as revealing differing mechanisms behind additions. This is at odds with the CCD-based conjecture that supply variables form a subsystem and combine with other forces at the system level.

Combining the four factors retained using the corresponding variances in Table 3 as weights produces the Principal Components Analysis Composite (PCAc). The cartographical display of the boxplots and the LISA map for the PCAc (Figure 3) reveals that there is a blanket of low values over the north of England. This is supported by an LL patch over the north. High-value districts are found in the central Midlands and the South East of England, with lower values found in the South West and East Anglia. There is no corresponding large HH patch over the south.

Combining *C* and *T* produces the CCD index. The cartographical boxplots in Figure 4a strongly reflect *T* in Figure 2a. There are many examples of a fade from urban to rural. Again, a high number of coastal districts are found to be coloured blue, including those in the south. As with Figure 3b, there is no corresponding large HH patch over the south.

Following concerns about correlations with inputs [37], there is consideration of the CCD/PCAc composites and their elements. Comparing Figures 1 and 2 with Figure 4 suggests that coupling measure *C* has a much lower association than *T* has with the CCD. This is confirmed by Kendall's tau (0.288 ** vs. 0.835 **). It was projected that it is a strong possibility that the CCD index strongly reflects *T*. The association between CCD and PCAc is close (0.822 **).

Table 5 reports Moran's *I* for each variable and the composites. As noted above, prices are likely to be in a stable hierarchy, which should result in relatively high spatial autocorrelation values. Given the construction, this would feed through to the similarly high values for the composites (CCD 0.461 **, PCAc 0.514 **). Oddly, the productivity and earnings to pay for these should be these dwellings do not show up as spatially concentrated to the same degree. As Hamed [44] argues, [spatial] autocorrelation can inflate the variance of any test of difference. A possible way forward is to improve the

significance level. Assuming a variance inflation rate of two, due to spatial autocorrelation of 0.7 in one and 0.5 in the other variable, this can be accommodated by $\alpha \div 10$, resulting in a significance level of 0.5%.

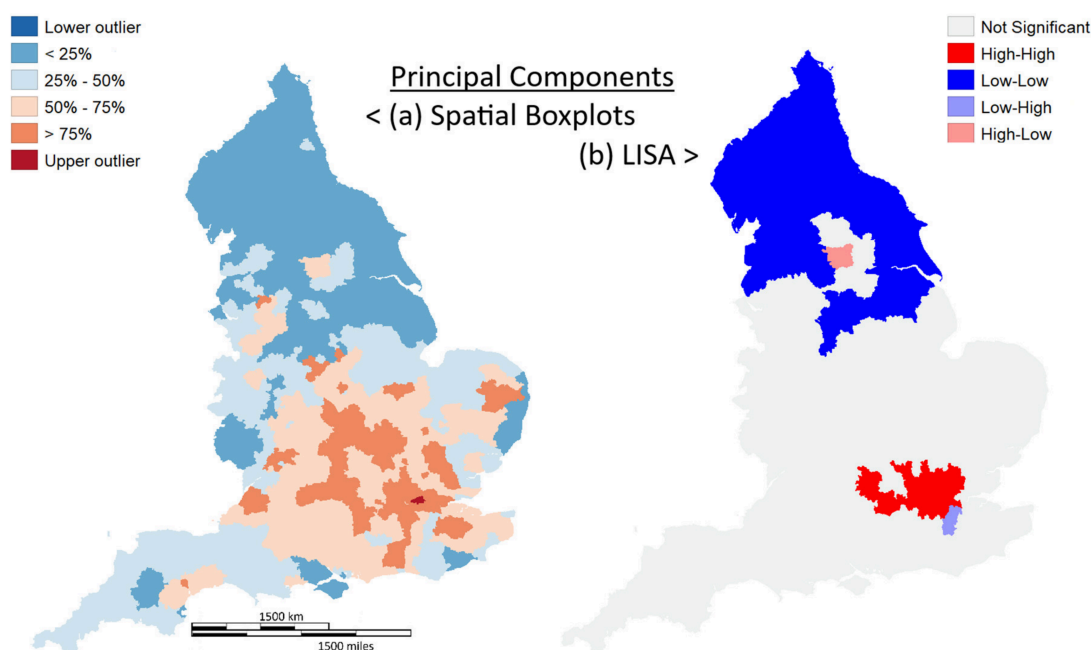


Figure 3. Principal Components Composite: Spatial Boxplot (a) and LISA maps (b).

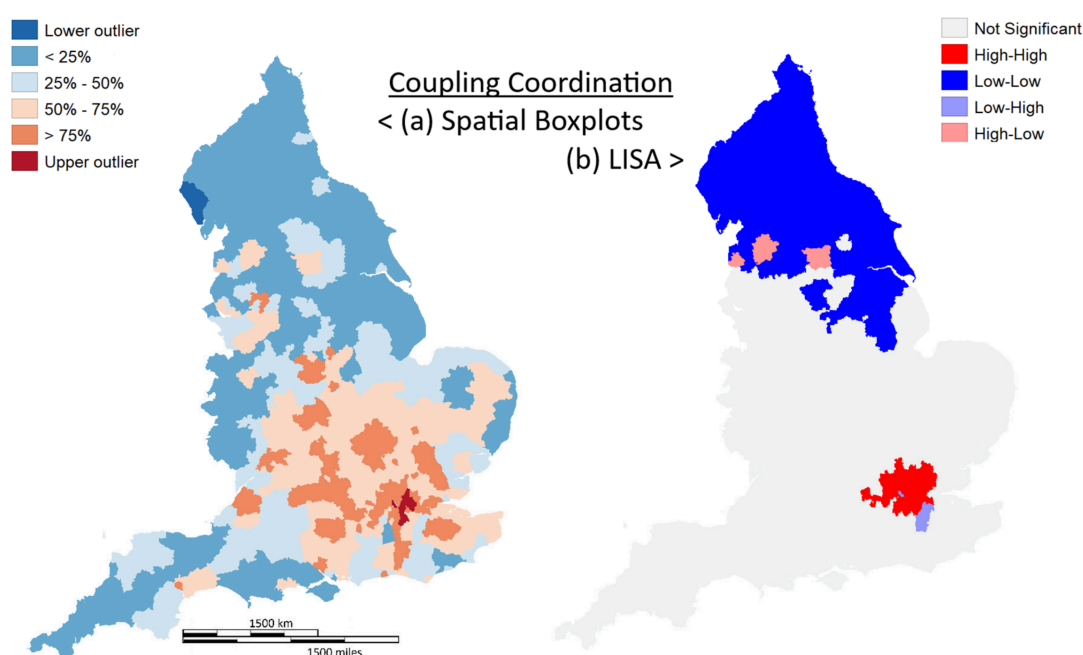


Figure 4. Coupling Coordination Degree: Spatial Boxplot (a) and LISA maps (b).

The Kendall tau equivalent of a rho of 0.7 is 0.49. The four highest correlations in Table 5 with PCAc pass this threshold, whereas only 1 does with CCD. To classify the associations between correlation coefficients, a second threshold of 0.37 which is significantly different from 0.49 at the 0.5% level. A correlation of greater than 0.37 is found between PCAc and CCD and six indicators (Price Growth, Price Level, LTVR, Population Growth, Population/dwelling, GVA/hour worked). The supply variables show similarly

low values, all lower than 0.3. Earnings Growth also fails to reach this modest level. Population density is on the cusp. Both the PCAc and CCD better reflect structural and demand components than supply elements. Generally, there is little to choose between them.

Table 5. Composite Internal Element Pairwise and Spatial Autocorrelation—Tau values.

	Composites			Exposure Scores	
	Moran's <i>I</i>	CCD 0.461 **	PCAc 0.514 **	Mortgage	Private Rent
Conversions	0.088 *	0.260 **	0.236 **	0.044	0.282 **
Δ of Use	0.108 *	0.295 **	0.293 **	0.186 **	0.321 **
New Dwell net	0.098 *	0.239 **	0.280 **	0.137 **	−0.062
Pop Growth	0.159 **	0.452 **	0.505 **	0.228 **	0.246 **
LTVR	0.352 **	−0.425 **	−0.519 **	−0.426 **	−0.343 **
GVA/hour worked	0.316 **	0.481 **	0.477 **	0.414 **	0.330 **
Pop/dwelling	0.254 **	0.447 **	0.484 **	0.412 **	0.368 **
Pop density	0.495 **	0.375 **	0.295 **	0.053	0.439 **
Earning Growth	0.018	−0.025	−0.088 *	−0.011	−0.087 *
Price Growth	0.494 **	0.566 **	0.537 **	0.377 **	0.449 **
Price Level	0.523 **	0.473 **	0.544 **	0.524 **	0.451 **
C	0.211 **	0.288 **	0.238 **	0.095 *	0.06
T	0.467 **	0.835 **	0.269 **	0.272 **	0.258 **

* Significant at the 5% level. ** Significant at the 0.5% level.

Table 6 also reports an additional series of correlations. First, a series of single housing indices. Second, as in Table 5, to assist with interpretation, there are comparisons with the ONS' indices of exposure to rising housing costs in 2023. Although these should reflect specific pressures of their time, the structural elements of the CCD/PCAc, which change slowly, should underpin exposures to changing housing costs. The MES and PRES are ordinal in nature, and range from 1 to 7, so that Kendall's tau is appropriate for correlation analysis, which is used throughout. If the four were functions of the same housing pressures in general, they would be closely associated.

PRES and MES are weakly associated (0.251), so they too are likely to provide different illustrations of distress. The correlations between CCD, PCAc and MES and PRES are higher than that, ranging from 0.408 to 0.538. Replicating the analysis using those single series elements of CCD/PCAc suggests that MES and PRES are less well associated with them compared with the PCAc and CCD, which could be a feature of the construction of the composites. One issue is how the four composites relate to an aggregated supply variable. Additional dwellings, a composite of all additional dwelling variables, still correlates at below 0.37, confirming a weak relationship with construction, pointing to the possibility that market pressures do not trump planning restrictions on where dwellings are to be built. By contrast, Price and Price Growth correlate highly with the stress scores. As factors that would increase stress for both the 2020 and 2023 versions of a crisis in housing, these findings are not inconsistent with the aims of the two stress indices.

Other measures of unaffordability that used are Land Values, Rent, Rent: Earnings, Price: Earnings, and Earnings Growth. Earnings Growth is shown not to be linked to stress. Theoretically, the locational price premium absorbs increases in income; the benefit of higher income is transferred into prices, rents and the mortgage burden. PRES, CCD and PCAc have correlation values with Rent level above those with the Price level. As Price level is an element of both CCD and PCAc, this is unexpected. Understandably, MES is more attuned to the Price Level. The unaffordability ratios in three of the four cases have slightly lower correlations. The MES is more aligned with HPER, and PRES is better allied

with Rents: Earnings, again, as one might expect. Finally, land costs, which offer a measure of the value in location, are correlated at similar levels to rents.

Table 6. External Indicator Comparators Pairwise and Spatial Autocorrelation—Tau values.

	Moran's	Composites		Exposure Scores	
	<i>I</i>	CCD	PCAc	Mortgage	Private Rent
MES		0.408 **	0.466 **		0.251 **
PRES		0.548 **	0.538 **	0.251 **	
Sales	0.223 **	−0.115 **	−0.085 *	0.111 **	−0.325 **
Price × Sales	0.365 **	0.365 **	0.437 **	0.534 **	0.277 **
FTB mortgage Sales	0.139 **	0.25 **	0.223 **	0.194 **	0.057
Second home	0.104 **	−0.067	−0.057	−0.160 **	0.089 *
Vacant home	0.230 **	−0.102 **	−0.133 **	−0.308 **	0.134 **
Mortgage % Owning	0.339 **	0.507 **	0.472 **	0.358 **	0.385 **
Renting privately %					
Renting	0.332 **	0.029	0.04	0.025	0.192 **
Returns	0.132 **	0.142 **	0.112 **	0.293 **	−0.057
Land values	0.496 **	0.533 **	0.573 **	0.484 **	0.558 **
Rent Level	0.597 **	0.584 **	0.631 **	0.481 **	0.614 **
Price: Earnings	0.628 **	0.451 **	0.530 **	0.495 **	0.453 **
Rent: Earnings	0.461 **	0.435 **	0.475 **	0.373 **	0.562 **
Oldtarget	0.475 **	0.541 **	0.586 **	0.369 **	0.546 **
Newtarget	0.527 **	0.399 **	0.476 **	0.471 **	0.423 **
Additions	0.117 **	0.307 **	0.356 **	0.185 **	0.055

* Significant at the 5% level. ** Significant at the 0.5% level.

The target variables point to a similarity of association with the affordability indices: the old targets favour those areas of rental stress whereas the spatial distribution of the new targets correlates with both stress indicators to the same degree. The CCD, PCAc and PRES favour the old targets whilst MES favours the new.

Activity measures involve sales, value of transactions and first-time buyer mortgage sales, which are purchase proxies. PRES is negatively associated with Sales, MES is weakly positive, but both CCD and PCAc are weakly negative. CCD, PCAc and MES indices have a weak link with FTB activity when PRES is not associated with FTB mortgages at all. The CCD, PCAc and MES have links with the value of transactions around 0.37 and above. The composites align more with MES than PRES on activity in general, but this is not significant.

Measures of housing underutilisation cover second home and vacant home rates. These denote vacant dwellings on the Census date in 2021, but the latter includes non-commercial holiday homes, short-term lets, or another address working away from home. The MES PCAc and CCD indices have negative associations with the two; MES correlations are significant. By contrast, LTVR is associated with MES, CCD and PCAc with tau of at least 0.425. The negative relationship with housing underutilisation could indicate that a low LTVR is consistent with a strong housing market. PRES correlations are weaker or at odds with the other three.

The theoretical price drivers of Population Growth and GVA/hw are included in the PCA and CCD. Population growth has a weaker association with stress measures than productivity. The PRES has a similar set of correlations with LTVR, Population/dwelling, and GVA/hour worked. These are lower than the equivalent ones with MES. It is noted above that the second latent variable is linked to LTVR and population/dwelling. Although the latter may indicate overcrowding in the district and so indirectly tie in with LTVR through demand for dwelling space, there could be a direct reverse link. Where vacancies

are high, there is, by definition, an absence of a population. This would apply to the Census' Vacancies and Second homes.

The last price driver, [Investment] Returns, is correlated with CCD, MES and PCAc. The positive sign suggests growth expectations affect the ratio. Assuming myopic expectations, this is only weakly supported. Neither price growth nor earnings growth are associated with Returns (0.006; 0.06), yet Mortgage exposure has the highest of the correlations, which is consistent with overstretched mortgagers bidding up price beyond that signalled by current rent [in 2020]. Given more affordable regions have seen a greater focus from landlords, one would expect a negative sign associated with PRES. The sign is appropriate, but the value is not noteworthy.

By construction, CCD, PCAc, C and T have the same elements, but as noted, C produces a different picture. In general, the other 5 have higher correlations with the indicators compared with the Coupling index.

Figure 5a shows the target additional rates subdivided into eight quantiles. In Figure 5b,c are the spatial patterns of the composites also arranged into 8 quantiles. From the shadings, if targets were based on the composites, there would be a greater emphasis on the midland and southern districts compared with the 2024 targets. There is some unanimity in the top and bottom quantiles. Of the 38 in the bottom quantile, 17 districts are common to all three lists. Where there is pairwise agreement only, it is mostly between the composites (13 of 17 cases). In the top quantile, the number is 14: all London boroughs. Greenwich, with the lowest target of 14 per 1000 existing dwellings, has an HPER of 15.3. Where there is pairwise agreement only, it is mostly between the composites (18 of 22 cases). Of the 18, 13 are London boroughs. Perhaps understandably, London dominates the top quantile as it does in the HPER hierarchy. Twenty-one of the 33 lowest-rate districts where there is agreement between the PCA and CCD would also be in the bottom quantile of the HPER hierarchy.

If all areas were targeted to expand in proportion, the same *rate* of additional housing would be found across regions and degrees of rurality. So rural and urban, north and south can have the same rates despite urban having a far larger number of dwellings. The mean ranks are reported in Table 7 by urban-rural (Table 7a) and north-south (Table 7b). The K-W and J-T tests, based on mean ranks, indicate that the null hypothesis that the scores of the MES are distributed evenly across the urban-rural classification is rejected (K-W 11.9 [0.008]). However, the alternative is not in an order akin to an urban-rural divide (J-T -1.1 [0.259]). The MES median indicates Intermediate Urban has the highest tensions. Table 7b shows increasing values with decreasing distance to London for all variables, which automatically supports a hypothesis of north-south schism in housing pressures.

Table 7. Target and Stress Projected Additions Rates by Spatial Subdivision.

a	Urban Rural					b	Regional				
	Newt	PCAc	CCD	MES	PRES		Newt	PCAc	CCD	MES	PRES
Urban	150.4	171.2	179.8	154.8	186.2	North	54.4	62.6	73.2	87.9	92.9
Urban Inter	150.5	149.1	140.0	175.6	136.0	Midlands	106.6	126.9	127.8	128.5	92.4
Rural Inter	155.5	128.9	112.8	169.6	105.9	South (excl L)	200.3	185.3	180.0	190.2	185.1
Rural	171.7	120.4	110.9	119.5	95.3	London	275.9	280.9	278.0	198.8	282.7
$\chi^2(3)$	2.33	16.7	35.4	11.9	59.0		207.6	165.9	140.5	78.9	153.7
p	0.51	<0.001	<0.001	0.008	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001
J-T		−4.1	−6.0	−1.1	−7.7		15.7	13.7	12.4	8.6	12.4
p		<0.001	<0.001	0.259	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001

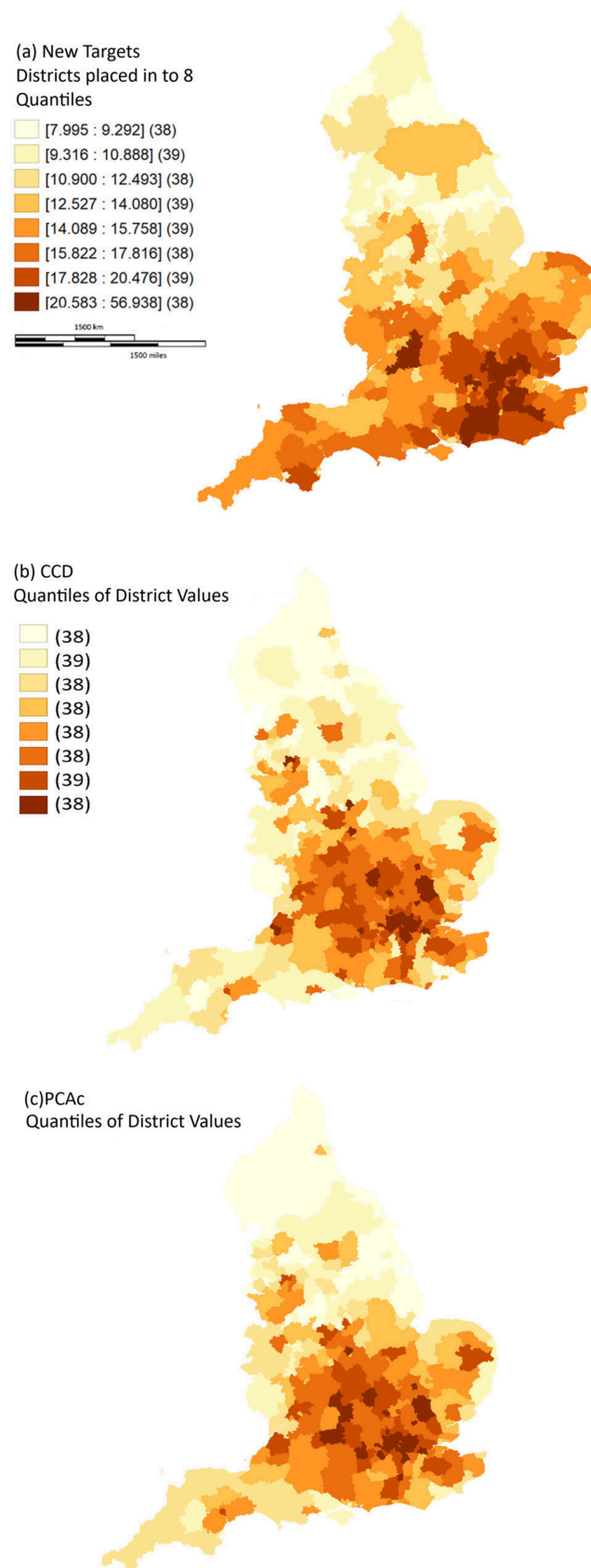


Figure 5. (a) Spatial Distribution: Housing Target. (b) Composite Spatial Distribution: CCD. (c) Composite Spatial Distributions: PCAc.

Tying together Table 7 with Table 6 and Figure 5, the medians and the K-W/J-T tests point to the distributions of PCAc and CCD following that of PRES: there are higher

pressures within the south than the north. MES favours Southern districts/intermediate urban. This is more in keeping with commuter land in the south-east. The New targets, statistically, are distributed at about the same rates across the four density categories, but the highest target rate is found in rural areas despite the impact of London weighing on the data.

Thresholds of rent and price unaffordability are used to develop two grouping variables. As outlined in Appendix B, Demographia [9], city HPERs are allocated into a collection of ranges up to 9. Demographia uses large urban spatial units. It was decided that that delineation was not ideal for districts, as there are 153 with an HPER greater than 9.0. Below 3 is ignored, and the lowest category includes seriously unaffordable dwellings. Severely Unaffordable was divided into two, as was Impossibly Unaffordable. For renters, the ONS applied a 30% threshold as affordable. Above and below that are divided into two. The Affordability Commission [1] used a third, but not of gross income. There are 123 districts with a gross rent-to-earnings ratio of over 30%.

The utility of these thresholds can be assessed by testing whether they reveal differences in the composites. The mean ranks of the HPER and Rent: Earnings data should be ordered $\theta_{<7} < \theta_{7-9} < \theta_{9-13} < \theta_{>13}$ and $\theta_{<0.25} < \theta_{0.25-0.3} < \theta_{0.3-0.33} < \theta_{>0.33}$, respectively. Furthermore, in a K-W context, a series of posterior pairwise tests such as $\theta_{<7} < \theta_{7-9}$ can be undertaken to confirm the thresholds are useful. Using a Bonferroni correction for multiple comparisons [45], it is found that all thresholds are useful.

Table 8 reports the mean ranks in the same format as Table 7. The MES has a wider range than the PRES with the HPER classifications, whilst the obverse is true with the Rent: Earnings ratio in Table 8b. The targets, the composites and the stress values all favour a higher rate of building in the more expensive, house-buying areas.

Table 8. Affordability Thresholds by Spatial Subdivision.

a						b					
	Newt	HPER					Newt	Rent:Earnings			
		PCAct	CCDt	MES	PRES			PCAct	CCDt	MES	PRES
<7 (87)	45.4	70.2	82.1	79.3	99.8	<0.25 (87)	72.6	87.1	92.0	101.0	83.9
7 to 9 (68)	125.0	137.9	137.6	129.9	120.3	0.25 to 0.3 (98)	133.2	142.2	141.1	144.9	135.1
9 to 12 (81)	194.2	183.9	179.0	187.9	168.8	0.3 to 0.33 (39)	179.1	172.5	174.2	171.3	163.1
>12 (72)	269.5	238.9	230.5	230.0	235.8	>0.33 (84)	252.8	230.4	225.7	212.1	245.5
$\chi^2(3)$	274.2	153.9	74.6	134.5	107.7		184.4	112.8	40	71.3	151.2
p	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001
J-T	19.5	13.2	8.2	12.0	10.4		14.6	10.9	6	8.5	12.5
p	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001

Using a Bonferroni correction for multiple comparisons, pairwise tests are used to consider what amounts to the inequalities of $\theta_{<7} < \theta_{7-9} < \theta_{9-12} < \theta_{>12}$. In the case of New Targets, MES and PCAc support all divisions. CCD supports $\theta_{<7} < \theta_{7-9} < \theta_{9-12}$. PRES, which is designed for renters, has mean ranks where $\theta_{<7} = \theta_{7-9} < \theta_{9-12} < \theta_{>12}$ are found. Switching to Table 8b, the order $\theta_{<0.25} < \theta_{0.25-0.3} < \theta_{0.3-0.33} < \theta_{>0.33}$ is not found. Rather in all cases $\theta_{<0.25} < \theta_{0.25-0.3} = \theta_{0.3-0.33} < \theta_{>0.33}$. So, the thresholds which distinguish groups in the data sets used are <7, 7–9, 9–12 and >12 using the HPER and <0.25, 0.25–0.33 and >0.33 with rent-to-earnings. Although there are 39 districts in the 0.3–0.33 bin, most are classified as impossibly unaffordable in the range of 9–12. From this, it is fair to conclude that divisions of affordability indices can add nuance to Demographia's [9] divisions at the top end of this UK data.

Altering the weights α , β , δ in the three-subsystem development index $T_m = \alpha H_m^1 + \beta H_m^2 + \delta H_m^3$ so that they were equal did make a difference. Saisana et al. [46] propose a mean rank average shift relative to a benchmark ranking. Using PCAc as the benchmark, and $\alpha = \beta = \delta$ as the initial weighting, varying δ from 0 to 0.45 whilst setting $\alpha = \beta$ reveals that 0.2 has the lowest mean rank average shift of 19.2 places. Setting $\delta = 0.2$ and varying α from 0 to 0.6 reveals that setting $\alpha = 0.45$ has the lowest mean rank average shift of 19.1 places. The initial setting of 0.4, 0.4, 0.2 has only a slight advantage over the equal or balanced setting. The correlation between the balanced CCD index and PCA (0.798), MES (0.399), and PRES (0.577) are very similar to the corresponding unequal ones. In general, the correlations with the unaffordability indices change by less than 10 percentage points, but the pattern of results is unaltered. The overall findings are found to be insensitive to weight alterations. Using a set that was of equal value would not have changed the inferences, which could be a feature of a subsystem with high coupling.

5. Discussion

Metrics which are used to implement and evaluate policies should have apposite features and reflect the appropriate concepts and policy scope [4,47]. Following Nardo et al. [4], there is a consideration of: the theoretical underpinnings; the usefulness of the elements; a consideration of the weightings both between the variables used and elements of the CCD; a review of a battery of correlations with well-known measures that capture similar phenomena.

First, the question of the theoretical driver behind the compilation. The CCD papers that are reviewed commonly propose policy solutions [in China] having highlighted some inequality black-spot, revealed by spatially autocorrelated CCD values. Where data is sparse or needs to be proxied, the scope for inapposite indices is great. As demonstrated in Appendix C, a compiler of a CCD evaluative index can take a broad view of the model behind the compilation of variables, including the number of subsystems and their constituents. This list is not commonly challenged. In the creation of the PCAc, it was necessary to review the benefits of the 4th and 5th Components and two variables. The decisions were made about how and what to retain. Demolitions are included in Net New Dwellings, so it was retained indirectly. Despite its poor showing, Real Earnings growth as a variable is retained. Theoretically, it is a strong driver of house prices and is indirectly featured in changes in affordability indices, but generally, the contributions of the two are difficult to confirm. The eigenvalues in Table 3 point to retaining 5 vectors, but the combinations of elements for the 5th are difficult to explain. This is also the case for the 4th, but losing both would represent more of an explanatory loss (58% vs. 76%).

Second, there is the assessment of the results. There are three subsystems assembled here: one that comprises all the constituents of Additional Dwellings; one that aims to capture demand for dwelling elements; and a third which features structural divides. The comparator index based on PCA Components presents a challenge of the underlying mechanism involved. Rather than in one supply subsystem, measures of additional dwellings are spread across the Components. As such, even if the selection is sound, the combinations of variables in a PCA Component could be seen as a subsystem of market forces. Some combine fast- and slow-changing indicators, much at odds with the posited CCD subsystems. One concludes that the mode of index compilation matters and, by implication, the weights apportioned to each element.

The interpretation of a CCD score, most logically with coupling, is of degrees of balance. It is argued that housing markets are likely to appear imbalanced in part because the economies upon which they are based are prone to imbalance, because the utility of a location is latent, or possibly there is a constrained supply problem. The LISA maps tend

to reveal hot spots around London and cold zones in the north of England. The spatial boxplots added more nuance to that. The fade is in keeping with locational premia and commuting across urban and rural districts. LISA is not designed to pick up the fade, so the two offer different pictures of the impact of spatial arbitrage. Rather than a clear northern periphery, Figure 1a reveals a rural periphery with the south-west, north-west, and east coast coloured dark blue (lower quartile). This fits the lowest C_m mean rank in Table 2a,b. The correlations between C_m and PCAc, MES or PRES reveal values below a 0.37 threshold. In other words, Coupling values show a weak association with measures of differential pressures.

It was posited that subsystems could be in balance as far as Coupling when the CCD could be imbalanced because of low T_m values. What is found is that C_m are generally high so that variations in CCD are mostly a function of T_m , as illustrated by the correlations between CCD, T_m and C_m in Table 5. The construction of C_m here, characterised as the ratio of two types of means, will lead to high values generally, suggesting it does not distinguish degrees of imbalance sufficiently.

Third, to gauge the relative usefulness, the composites are measured against other, similar indices. The inclusion of a variable in the composite is guided by theory. Almost half the included variables either turned out to be irrelevant or closely followed the composites. Dropping key variables would render the indices open to criticism about their credibility. A referee highlighted an inherent problem with developing an evaluation index with spatial data: one should be mindful of the testing data where the values are not independent. This can inflate the chance of a type 1 error [43] when testing composites and single variables. As discussed above, prices are expected to be in a hierarchy, locally, and be linked nationally by spatial arbitrage where capital and labour relocate until there is some sort of equilibrium. Competition for land in urban areas is posited to lead to a locational premium, a greater density of population and a more intense use of land. Moran's I for Price Growth, Price Level, CCD and PCAc are all at least 0.461. The former pair are elements of the latter composites. Three of the four correlations between the pairs are over 0.49, a level where one should be wary of the influence of a single variable on a composite. Moreover, the unaffordability indicators should also have the spatial concentration of high values. The tau correlations between the composites and the unaffordability indicators are around the same as the I values. One would be concerned about the composites if price was not found to be influential. By implication, dropping it from the composite would render the composite open to criticism of relevance. The type 1 error is addressed using a significance level of 0.1%. This has the advantage of keeping the analysis simple, but more sophisticated approaches to dealing with composites exist [46].

Based on what emerged, there is little to choose between the PCAc and CCD. Both better reflect structural and demand components than supply elements. Indeed, they are more closely associated with the HPER than with Rents: Earnings. PRES and MES are measures of stress in a slightly later period and focus on rising costs rather than price levels, yet all four are closely aligned with affordability measures. Interestingly, all four are more associated with the rent level rather than the rent-earnings ratio. Also, there is little to choose between their association with HPER and the price level.

Given the unaffordability emphasis, the CCD and PCAc are explored for their spread. It is shown that Demographia's [9] divisions could be reconsidered. Table 8a shows that the HPER boundaries of 7, 9, and 12 divide the four composites and the targets into reasonably equal groups. The rent-to-earnings measure is explored in Table 8b. Thresholds of 0.25 and 0.33 again divide the districts into 3 reasonably large groups.

Housing variables available intermittently, such as those related to the Census of 2021 or specific reports, do not necessarily correlate with the others considered. First-time buyer

mortgage sales and second and vacant home rates showed very little alignment with other similar variables. In other words, they do not offer much insight in the area of affordability. Land values, which offer a measure of the locational economic rent, are correlated with the four indices at similar levels to rents, making it a good indicator of unaffordability.

The geography of housing stress does not match the distribution of additional dwellings. The third PCA component shows a link between new build and population growth. These are in areas with neither the most nor least affordable districts. The extent to which land is available, and additional dwellings follow rising demand to suppress price rises, is posited to determine the balance of the increase in population and prices [20] and hence on unaffordability. In the literature, there is a strong emphasis on planning constraints influenced by local activists [29], and the limits on height in urban areas [34] to explain the shortage of dwellings where affordability is most acute. A less conventional explanation concerns the hoarding of land by landowners, which prefigures the ultimate housing and infrastructure outputs of private sector development [7] so house prices are a function of land prices. The CMA imply the causality is from housing price to land price [16,30], where land price is the residual after all other costs are met and the local house price is not depressed. This accepted practice implies that supply is not intended to depress price. Overall, it is difficult to escape the building land availability and deployment problem and the progress in this area.

The geography of the New Targets favours rural areas very slightly, whilst there is a relationship between distance from London and Targets, which is supported statistically. MES points to the greatest stress to be found in intermediate urban districts, but not significantly so. The distribution of PCAC and CCD values follows those of PRES, where urban areas are favoured over rural districts. Interestingly, the emphasis on rural areas for the 2024 targets places the issue of land availability into greater focus. The mandatory targets put pressure on local planners to supply additional accommodation again, which is focused on less than ideal locations. The enhancement of a development path of a highly productive node by reducing high house price impediment to attracting further high human capital is, in a sense, misplaced. The agglomeration benefits of large nodes are less likely to arise in less dense rural areas. That said, the focus on urban areas should intensify the need to adapt and repurpose existing buildings as a means of finding more scope to add dwellings locally. The failure to generate a large number of additional dwellings where planning restrictions and land ownership issues are likely to be less onerous is disappointing.

Some associations shed light on campaign goals, such as those of Empty Homes, who stress the need to reduce the number of empty homes and the number of demolitions. Demolitions were not found to be useful in the analysis of the supply or demand for dwellings. High LTVRs, which are found to be concentrated in northern regions [48], are posited to be a useful indicator of [lack of] demand, correlated with other measures of unaffordability. A cautionary tale emerged when using this variable. LTVRs, Vacancies, and second-home rates are negatively correlated with population per dwelling. Districts with a high rate of second and empty homes are likely to distort the population per dwelling measure downwards.

6. Conclusions

At its heart, this paper has two themes. First, an evaluation of a coupling coordination approach, which is used to generate a local authority district-based housing market 'evaluation' index. Second, the 2020 claim that 'something has gone fundamentally wrong with the housing system [in England]' is considered. The latter claim entails using local authority district data from that and other associated periods. The former, in conjunction with the

latter, evaluates the coupling coordination index by comparing it with the Principal Components alternative, two other ONS-produced stress indices, and a series of other single measures of the housing market. The questions that are addressed are: what insight does the evaluation index provide in terms of the balance within the English housing market; does the distribution of the evaluation index correspond with that of the housing market stress indices; does the spatial distribution of the evaluation correspond with those of the targets set recently by the two governing parties; and do the spatial distributions of the New targets, the evaluation and stress measures reflect the state of housing [un]affordability. Nardo et al. [4] also pose the questions: does the theoretically derived model provide a good fit to the data?; what the lack of fit says about the composite?; and what concept would the available indicators be a good measure of?

At the outset, the claims in various quarters that there were ‘crisis’ periods (2019/2020 and 2023) have not been corroborated by widespread, large-scale mortgage defaults. Lending bodies were sanguine about the state of the housing market and the low levels of defaults, pointing to their responsible lending practices. In the end, financial regulators were relaxing loan restrictions, implying that the mortgage levels borne by borrowers were not overburdensome and could be raised.

It is argued that the CCD approach to developing an evaluation index lacks rigour. Evaluation is a vague term. There is significant latitude granted to a compiler of a CCD evaluative index, including specifying the number of subsystems and their constituents and the variables deployed, perhaps obscuring what actually is evaluated. Although it is not uncommon to use the index for spatial policy, there is no systematic analysis of the input variables and their spatial dependence. Spatial autocorrelation is likely to be a property affecting any assessment of how the areal units interact. Spatial autocorrelation can lead to spurious conclusions about covariations. The CCD subsystem of market forces is posited to interact with others at the system level, which was not corroborated by the PCA Components. The mode of compilation matters, and, by implication, the weights apportioned to each element.

Despite the different weightings in their compilation, the CCD and PCAc are associated with other housing indicators to broadly the same degree. Both echo affordability measures better than other indicators. One should be mindful of the influence of Price on the indices, which might exaggerate the similarities. Alternative indices, MES and PRES, appear better attuned to the relevant mortgage and renting markets, whereas the PCA and CCD seem to be sensitive to affordability in housing in general. Linking the indices with the language of crisis is Demographia’s [9] housing unaffordability divisions. It is shown that dividing up their Severely Unaffordable and Impossibly Unaffordable classifications into more suitable HPER ‘bins’ can be determined. The CCD and PCAc indices and the stress measures can be allocated into these subdivisions in reasonably large numbers. Thresholds in rent-to-earnings data also chimed with these four composites. In light of the regulator allowing greater loans at higher HPERs, Demographia [9] might reconsider the language they apply to these ‘bins’. Indirectly, the UK regulator does not concur with the phrase Impossibly Unaffordable. Or does, but believes the solution is more lending.

Land values are relatively closely correlated with those benchmarks, especially HPER. It is not unlikely that there is two-way causality between housing price and land price [7,16,30]. Combining this with the recognition of the challenging nature of the planning process, and the use of mandatory targets, leaves one disappointed with the 2024 housing targets having more of a rural focus than the composite indicators suggest they should. The PCA points to a focus on urban areas, which has the theoretical advantage of potentially enhancing a development path of a productive node by reducing the impediment to attracting further high human capital that high house prices present. The

focus on urban areas should intensify the need to densify, adapt and repurpose existing buildings as a means of finding more scope to add dwellings locally. The relaxation of height restrictions under new PDRs echoes calls from commentators [9,34] about better land-use for affordability and productivity improvements. The failure of PDR conversions to generate a large number of additional dwellings when planning restrictions and land ownership issues are likely to be less onerous is, again, disappointing.

Looking at how things can be taken forward, there are technical issues with how one might approach assessing the qualities of the CCD. At the outset, it should be recognised that themes within the CCD application are flexibility and simplicity. There are more sophisticated approaches to dealing with composites [46], but demanding more work compiling the composite may undermine its very use. If nothing else, the playbook needs to be more robust. For example, the approach to the inclusion of key variables found in the articles considered here is rather broad. The inclusion of a variable in the composite is ‘guided’ by theory, but this can be thin or possibly misplaced. That variable could be found to be irrelevant to, or closely follow, the composite. If there were consideration of the veracity of an inclusion, the impact of spatial autocorrelation on a composite’s compilation is a complication.

The construction of one of the input indices, C_m , here is characterised as the ratio of two types of means. It led to high Coupling values, suggesting it does not distinguish degrees of imbalance sufficiently, and the CCD strongly reflected T_m values. This also leads to confusion around what should be targeted to balance. This is likely to be a general problem, which needs further attention. That said, it was anticipated that combining levels and growth variables would lead to imbalance by nature of their distributions. That did not materialise here, but it should be an area for further work.

A more considered approach to its application is also required. As a basis for policy intervention, imbalance implies some inequity or injustice. However, there are contested views on whether a regional system should be balanced. Building more rural houses to achieve some balance leads to a deagglomeration that possibly lowers productivity, combined with greater commuting, increasing the carbon emission problem. Therefore, potentially a misallocation of resources.

The assessment of the variables used here presented type 1 error issues, which were addressed using a higher significance threshold. Furthermore, there are two circularities in the work. Density of population and Price/price growth are included in the composites, which are then analysed by four rural-urban and four affordability divisions. These shortcomings could prove problematic and need further work.

Overall, one should be cautious about highlighting spatial injustices and promulgating policy initiatives on the basis of a CCD composite alone, following the procedures discussed in this paper.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are openly available at <https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/regionalgrossdomesticproductallnatslevelregions> (accessed on 1 January 2025). <https://www.ons.gov.uk/peoplepopulationandcommunity/housing/datasets/ratioofhousepricetoworkplacebasedearningslowerquartileandmedian/current> (accessed on 1 January 2025). <https://www.ons.gov.uk/peoplepopulationandcommunity/housing/datasets/numberofresidentialpropertysalesforationalandsubnationalgeographiesquarterlyrollingyearhpssadataset06> (accessed on 15 May 2026). <https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datas>

[ets/analysisofpopulationestimatestoolforuk](https://www.gov.uk/government/publications/land-value-estimates-for-policy-appraisal-2019) (accessed on 1 January 2025). Ministry of Housing, Communities & Local Government (2018 to 2021) Land value estimates for policy appraisal 2019 <https://www.gov.uk/government/publications/land-value-estimates-for-policy-appraisal-2019> (accessed 26 June 2026). Ministry of Housing, Communities and Local Government, Ministry of Housing, Communities & Local Government (2018 to 2021) Table 615: vacant dwellings by local authority district: England, from 2004. <https://www.gov.uk/government/statistical-data-sets/live-tables-on-dwelling-stock-including-vacants> (accessed on 15 May 2026). Ministry of Housing, Communities and Local Government, Ministry of Housing, Communities & Local Government (2018 to 2021) Table 125: dwelling stock estimates by local authority district <https://www.gov.uk/government/statistical-data-sets/live-tables-on-dwelling-stock-including-vacants> (accessed on 15 May 2026). Ministry of Housing, Communities and Local Government, Ministry of Housing, Communities & Local Government (2018 to 2021) Table 116: local authority dwelling stock, by district, England, from 1979 <https://www.gov.uk/government/statistical-data-sets/live-tables-on-dwelling-stock-including-vacants> (accessed on 15 May 2026). <https://www.ons.gov.uk/peoplepopulationandcommunity/housing/bulletins/privaterentalaffordabilityengland/2024> (accessed on 15 May 2026). <https://www.ons.gov.uk/peoplepopulationandcommunity/housing/methodologies/privaterentalaffordabilityenglandwalesandnorthernirelandqmi> (accessed on 15 May 2026). <https://www.ons.gov.uk/peoplepopulationandcommunity/housing/bulletins/privaterentalaffordabilityengland/2024> (accessed on 15 May 2026). <https://www.ons.gov.uk/peoplepopulationandcommunity/housing/bulletins/numberofvacantandsecondhomesenglandandwales/census2021> (accessed on 15 May 2026). <https://www.ons.gov.uk/peoplepopulationandcommunity/housing/datasets/percentageoftotalmonthlyhouseholdincomespentonprivaterentengland2012to2018> (accessed on 15 May 2026).

Conflicts of Interest: The author declares no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

CBD	Central business district
CCD	Coupling coordination degree
CMA	The Competition and Markets Authority
FCA	Financial Conduct Authority
FTB	First Time Buyers
H_L	Structural or persistent subsystem
H_D	Demand subsystem
H_S	Supply subsystem
HPER	House price Earnings ratio
LAD	Local authority district
LTV	Long-term vacancy
LTVR	Long-term vacancy Rate
MES	Mortgage exposure score
NPPF	National Planning Policy Framework
ONS	Office for National Statistics
PCA	Principal Component Analysis
PDR	Permitted Development Right
PRES	Private rent exposure score

Appendix A

As the temporal patterns can be erratic, the conversions, change of use, demolitions and new dwellings are averaged across 2012–2013 to 2019–2020 and divided by the number of dwellings in the territory in 2020 and multiplied by 1000 to generate added dwellings per 1000 dwellings. This is to standardise the district data, adjusting for the variety of

district sizes. First-time buyer mortgage sales per 1000 dwellings are most recently available in 2019.

Long-term vacancies are dwellings that are reported as being empty for six months or more (i.e., unoccupied and unfurnished) for the purposes of Council tax. Vacant homes and Second homes data are drawn from the 2021 census. All three sets are standardised by the housing stock for 2020. The Census definition of vacant is an unoccupied dwelling with no usual residents. A second home also has no usual residents but is a second address for a Census respondent, and it is occupied for more than 30 days per year. Long-term vacancies, in particular, are posited to be inversely related to indices of activity. The census and the council data definitions could lead to differing implications. Collectively, these are viewed as measures of housing underutilisation.

Earnings and price growth are measured as the ratio of the values in 2019 and the corresponding ones in 2012 so as to avoid unusual one-year blips and are calculated in real terms. Real earnings growth for many districts is negative over this period. The house price-earnings ratio is derived by dividing the estimated house price at the lower quartile and the earnings at the lower quartile for the district concerned. The lower quartile is more likely to reflect the earnings of the first-time buyer. The same approach is taken for rents but at the median. The earnings are workplace-based (where people work) rather than residence-based (where they live). It features only full-time employees on adult rates of pay. The productivity measure deployed here is gross value added per hour worked in the locale.

Price is used for calculating price growth and, when combined with the number of dwellings sold, provides a measure of the values of transactions ($= \text{Price} \times \text{Sales}$). [Un]affordability includes Price, Land Price, Rent, Rent: Earnings, Price: Earnings, Price Growth, Earnings growth. Activity measures involve sales, value of transactions and first-time buyer mortgage sales. In addition, the population measures of population density and population per dwelling are included in activity. The Census and rarely reported data fall within the 2019–2021 period, so they can be viewed as the same period.

The ONS released two 7-point scales of housing stress [13]. As well as using these directly, components are also utilised. With the data set provided, there are four tenure variables (the proportions of households owning-mortgage, renting privately, renting socially, and owning-outright). These are conflated into two, where the first is the number of owners-with-a-mortgage as a proportion of all owners, and the second is the number of private renters as a proportion of all renters. These cover stress scores of a period later than the 2019–2021 period used generally. That said, the structural or persistent elements should feed through. One would expect buyers in a less affordable area in 2020 to feature strongly in those who face potential mortgage stress with a jump in interest rates three years later.

House building targets, which were assigned to each district by both Conservative (Old-Targets) and Labour (New-Targets), are subject to the same adjustment as with other dwelling variables; divided by the housing stock for 2020, so providing a rate which is comparable across urban and rural districts. The 2024 targets were based on an average of the three most recent years for HPER data that was available, which, at the time, would cover 2020 to 2022.

A coupling coordination index is a composite of what are known as subsystems. These are defined by the researcher as separate but associated, interacting with others on an unspecified basis. Three subsystems are envisaged for the coupling analysis here. The first subsystem, H_L , collects structural or persistent elements of the density of population, the population per dwelling, productivity, median price of dwellings, and the rate of vacant dwellings, long term. In effect, this sets the relative prices between the two housing markets. The impact of the local development path provides the basis for measuring such

differentials at a point in time. The second subsystem is that of housing demand. H_D , the growth of demand as captured by price, income and population growth rates, i.e., incorporates both the increase in the local population and prices. The third subsystem, H_S , is the growth of the housing stock, as measured by new dwellings, demolitions (negative), conversions and change of use. This latter group are the same as those discussed in [49].

Excluding the Isles of Scilly, which have intermittent data, and on occasions City of London, for the same reason there are $N = 307$ districts with complete data sets. There are 26 indices, of which 11 are incorporated into the composites.

The nature of administrative space fits a monocentric urban model: rural areas tend to surround urban spaces. If the urban space is a single district surrounded by three rural districts, across the four, the urban is unusual. Agglomeration economies are based in part on a concentration of population. The density of population will be relatively high in urban areas. Normally, the urban district is a smaller space accommodating a greater population and a larger number of dwellings than the rural districts nearby. One would expect that the number of dwellings sold would be larger in urban areas. However, that does not mean the rate of sales is higher or lower in rural areas compared with urban. To accommodate for the variety of district sizes and populations, variables are adjusted. Many indicators are adjusted by the number of dwellings in the district, such as the number of new dwellings. Productivity as assessed by gross value added will be larger in urban areas. The measure is deflated by the number of hours worked. Data on earnings and price are already directly comparable.

Appendix B

Demographia [9] defines an HPER of: below 3 as Affordable; 3 to 4 as Moderately Unaffordable; 4 to 5 as Seriously Unaffordable; 5 to 9 as Severely Unaffordable; and above 9 as Impossibly Unaffordable. In 2020, Demographia was using four categories to analyse 92 metropolitan area housing markets of at least one million people across 8 nations. The terms were used to reflect the challenges to ‘middle-income’ households. In 2020, there were 36 Severely Unaffordable major housing markets. Including Hong Kong (20.7), Vancouver (13.0), Sydney (11.8) and Auckland (10.0). Recognising that unaffordability was becoming worse, for the analysis of the 2023 data, Demographia introduced ‘impossible’. In 2024, there were 12 Impossibly Unaffordable and 40 Severely Unaffordable markets across 95 markets, with Hong Kong (14.4), Sydney (13.8) and Vancouver (11.8), but Auckland (7.7) had improved. Table A1 illustrates the nature of urban affordability as presented by Demographia for 2020 and 2024. For example, of the 5 cities included from Australia, all were Severely Unaffordable in 2020. By 2024, all but one was classified as Impossibly Unaffordable. The HPER had risen by two incomes to 9.7 over four years.

Table A1. Affordability Scales as used by Demographia for 2020 and 2024.

2020 (92 Markets)		Australia	Canada	Hong Kong	Ireland	New Zealand	Singapore	United Kingdom	United States
Affordable	<3.1	0	0	0	0	0	0	0	4
Moderately Unaffordable	3.1–4	0	1	0	0	0	0	3	20
Seriously Unaffordable	4.1–5	0	1	0	0	0	1	9	17
Severely Unaffordable	>5	5	4	1	1	1	0	9	15
Total		5	6	1	1	1	1	21	56
Median HPER		7.7	5.4	20.7	5.4	10	4.7	4.8	4.2

Table A1. Cont.

2020 (92 Markets)		Australia	Canada	Hong Kong	Ireland	New Zealand	Singapore	United Kingdom	United States
2024 (95 markets)									
Affordable	<3.1	0	0	0	0	0	0	0	0
Moderately Unaffordable	3.1–4	0	1	0	0	0	1	2	11
Seriously Unaffordable	4.1–5	0	2	0	0	0	0	7	21
Severely Unaffordable	5.1–8.9	1	2	0	1	1	0	13	20
Impossibly Unaffordable	>9.0	4	1	1	0	0	0	1	5
Total		5	6	1	1	1	1	23	57
Median HPER		9.7	5.4	14.4	5.1	7.7	4.2	5.6	4.8

Appendix C

Nardo et al. [4] note that getting the theoretical model right is the main challenge of a composite (p. 35). Theory can be rather thin. In a sense, there is a premium based on balance. It is common with CCD to suggest that a high coordination degree means that the subsystems can work well together to jointly promote the overall activity of the system. In effect, a high value results from similar and high values. It is not unusual for the coupling degree, coordination degree and coupling coordination degree values to be placed into ranges. If in the interval (0.8, 1), there is high balance or coherence. There is a good-range if in the interval (0.6, 0.8), middle-range if in the interval (0.4, 0.60), low- range if in the interval (0.2, 0.4), and poor-range if in the interval (0, 0.2).

Although balance features strongly in the rhetoric, there is no explicit requirement to discuss equilibrium, yet imbalanced development corresponds with disequilibrium. The law of one price does not apply in spatial equilibrium in housing markets. Housing market theory, principally due to [16], predicts intra-urban prices to be in a stable hierarchy. Those ‘out-priced’ from the higher-priced market may opt to seek a dwelling in the lower-priced market. This implies that, in the face of increased demand in one, a price hierarchy is maintained through spillover between the two markets. Local house prices may then be out of line with the local level of productivity. Both areal units could appear imbalanced.

What is measured can affect ‘balance’. A wage compensation hypothesis predicts attractive amenities induce lower wages and/or costlier housing and so a less affordable area surrounding that amenity. The benefits of being closer to an amenity are baked into the price at the local level so that it is not clear that the resident is worse off than someone further out. The HPER is ambivalent on this matter.

A traditional core-periphery theory views urban-rural interaction as imbalanced. The ‘weak’ version of Thirlwall’s law has it that the growth rate of domestic income must equal the ratio of the growth rate of exports to the income elasticity of import demand [50], which implies that Thirlwall’s imbalanced growth model predicts rural growth to be constrained by urban growth, or a region with a low-income elasticity export portfolio be constrained by its ‘balance of payments’. Indeed, the New Economic Geography predicts that improved road links could have a negative impact on less developed regions [27]. Inter-urban differences, based on size and industrial mix, determine productivity. This mix, which is slow to change, can have long-term consequences, as envisaged by path dependency [17]. As such, differing parts of the economy could have a favourable or unfavourable structure and so levels of productivity which would affect locational choice, prices and rents over time. Path dependency theory does not project similar long-term growth. Given that

there are structural differences across housing markets which are likely to reflect wider economic differences, what constitutes an imbalanced system or a housing failure on a local or regional basis requires a strong narrative. Discordance amongst the subsystems within a system, which CCD has been used to assess, may not imply a tendency to converge on balance, but if the researcher projects the system should be pushed towards balance, then balance and equilibrium are synonymous, and superior to imbalance.

There is no guidance about the number of subsystems nor how they are combined. This can have consequences for interpretation and policy. Taking the constituents of the CCD in turn, the simplest form has two subsystems, such as Housing Demand H_D and Housing Supply H_S . One can write $C_m = 2 \frac{\sqrt{H_D \times H_S}}{H_D + H_S} \leq 1$. Take two cases: $H_D = 3 \times H_S$ and $H_D = H_S$. Assume the index values $H_D + H_S = 1$ and H_D and H_S have equal weighting in T_m (so the average of the two values). If $H_D = H_S$, $C_m = 1$, $T_m = 0.5$ and $CCD_m = \sqrt{0.5}$. If $H_D = 3 \times H_S$, $C_m = \sqrt{3} \div 2$, $T_m = 0.5$ and $CCD_m = \sqrt[4]{3}/2$. The balanced scheme produces the higher C_m and CCD_m values. Using the same two examples but with $H_S = 0.25$, C_m in the former = $2\sqrt{0.25} \div 0.5 = 1$, whereas the latter case remains the same by virtue of $H_D + 3 \times H_S = 1$. It is not the size, but the similarity of the elements that matters. As such, what ingredients there are ‘in the pot’ matters. That is based on $T_m (= 0.5)$ being the same. When $H_S = 0.25$, $H_D = 3 \times H_S$ results in $T_m = 2 \times H_S$ and $CCD_m = \sqrt[4]{3} \times T_m$, but when $H_D = H_S$, $T_m = H_S$ and $CCD_m = \sqrt{T_m}$. In other words, if $H_D > H_S$, $C_m < 1$, but T_m and CCD_m are greater than in the $H_D = H_S$ case. And if $H_D = H_S$, $C_m = 1$ and the CCD index is a non-linear function of the development index. The more balanced the Coupling, the more irrelevant Coupling is.

To illustrate some of the issues raised, there is a review of literature where CCD has been used. Tomal [3] observes that almost all available studies on the coordination degree of development concern China, its individual provinces, or cities. Interrogating the EBSCO digital journal repository, of the 3289 refereed academic journal articles written in English featuring the phrase ‘coupling coordination degree’, 2444 have a geographical subject of China and 40 cover Europe. None of those available featured solely European countries. Of those that did apply a CCD frame to European data, all applied it to China. For example, Li et al. [51] apply a CCD model to food security of 131 low- and middle-income countries. They found that the coupling degree was high across all regions, with values exceeding 0.80. Sub-Saharan Africa recorded $C = 0.83$. With a high balance, $CCD (= 0.48)$ would be a function of development levels ($T = 0.28$). The conclusion drawn was that fragmented aid is ineffective for Sub-Saharan Africa. Policymakers should implement comprehensive intervention packages in which economic transfers improve the ‘access’ subsystem, coordinated with investments in Water, Sanitation, and Hygiene infrastructure to enhance utilisation. Given the dominance of T , one could equally say it would benefit from greater economic development. Not unsurprisingly, Europe and Central Asia exhibited the highest level of T and CCD.

Tang et al. [52] apply CCD to the level of regional economic resilience and digital finance. They draw on Martin and Sunley’s [53] path-dependency-based discussion of economic resilience, with digital finance deemed as the other subsystem. An odd combination.

Kong et al. [54] posit three housing subsystems (population growth, land use and housing supply) based on 172 cities in 11 urban agglomerations from 2014 to 2017. Housing includes average price, sales and completions in value terms. Land includes average land price, and population includes density and growth rate, plus average salary and disposable income. The coupling coordination degree is examined for positive spatial correlation. Land and house prices could be spatially autocorrelated, so a type 1 error is possible.

He et al. [55] compile an evaluation index to assess the coordination degree of population urbanisation and affordable housing land supply. The population urbanisation subsystem is a combination of the urban population as a proportion of the total population,

and the number of employees in the secondary and tertiary industries as a proportion of the total employees. The affordable housing subsystem melds land supply area for affordable housing as a proportion of the total residential land area, and local government expenditure on affordable housing as a proportion of the total general budgetary expenditure. There is no direct measure of unaffordability in the collection of indices. For example, there is no mention of house price- or rent-to-earnings ratio.

In his work, Tomal [3] considers six subsystems (environment, demography, economy, infrastructure, housing and society), but like almost all other studies, assumes that each dimension contributes equally to the local development index. Tomal's indicators are not independent.

Wang et al. [56] generate a coupling-based index of urban–rural integration in the Yellow River Basin. The four dimensions of integration are spatial, captured by the density of the road network in urban and rural areas, which complements the number of buses per 10,000 people (social integration). Economic integration is measured by ratios of consumption, income, industry, and employment, whilst ecological integration includes the proportion of GDP spent on investment in environmental protection. These, when combined, provide a level of integration that is coupled with an economic development measure (GDP per capita only). Urban areas, theoretically, should have higher productivity levels. Wang et al. [56] assert that the smaller the difference, the higher the level of economic integration. Core-periphery and Economic Geography models would predict that a higher density of the road network between urban and rural areas should imply a higher the level of integration leads to a larger not smaller difference.

In their coordinated development of urban-rural integration, Zhan et al.'s [57] subsystems are Life, Production and Ecological functions. Their network emphasis is rural water and electricity infrastructure. Production includes measuring income of the collective economy/Total rural land area and the proportion of non-agricultural land area/Total rural land area and Production land area/Total rural population—a different set of measures for broadly the same investigation as Wang et al. [56].

References

1. Affordable Housing Commission. Making Housing Affordable Again: Rebalancing the Nation's Housing System Affordable Housing Commission. 2020. Available online: <https://nationwidefoundation.org.uk/publications/ideas-to-change-the-housing-system/making-housing-affordable-again-rebalancing-the-nations-housing-system/> (accessed on 1 January 2026).
2. Davidson, J. Getting Affordability Right in Consumer Credit Financial Conduct Authority 15 March 2018. Available online: <https://www.fca.org.uk/news/speeches/getting-affordability-right-consumer-credit> (accessed on 1 January 2026).
3. Tomal, M. Evaluation of coupling coordination degree and convergence behaviour of local development: A spatiotemporal analysis of all Polish municipalities over the period 2003–2019. *Sustain. Cities Soc.* **2021**, *71*, 102992. [CrossRef]
4. Nardo, M.; Saisana, M.; Saltelli, A.; Tarantola, S.; Hoffmann, A.; Giovannini, E. *Handbook on Constructing Composite Indicators: Methodology and User Guide*; OECD Publishing: Paris, France, 2008. Available online: <https://publications.jrc.ec.europa.eu/repository/handle/JRC47008> (accessed on 15 August 2025).
5. Wilson, W.; Barton, C. What is Affordable Housing? House of Commons Briefing Paper 07747 2019 December. Available online: <https://commonslibrary.parliament.uk/research-briefings/cbp-7747/> (accessed on 1 January 2025).
6. ONS. Research Output: Alternative Measures of Housing Affordability: Financial Year Ending 2018. Available online: <https://www.ons.gov.uk/peoplepopulationandcommunity/housing/articles/alternativemeasuresofhousingaffordability/financialyearending2018> (accessed on 1 January 2026).
7. Mahmoud, S.; Beswick, J. What Lies Beneath: How to Fix the Broken Land System at the Heart of Our Housing Crisis. New Economics Foundation. 17 July 2018. Available online: <https://neweconomics.org/2018/07/what-lies-beneath> (accessed on 28 July 2025).
8. Ministry of Housing, Communities & Local Government, English Housing Survey 2023 to 2024: Headline Findings on Demographics and Household Resilience. Available online: <https://www.gov.uk/government/statistics/annex-tables-for-english-housing-survey-2023-to-2024-headline-findings-on-demographics-and-household-resilience> (accessed on 4 January 2026).

9. Demographia International Housing Affordability Survey. 2024. Available online: <https://ti.org/pdfs/dhi2024.pdf> (accessed on 13 September 2026).
10. Miles, D.; Monro, V. *UK House Prices and Three Decades of Decline in the Risk Free Real Interest Rate*; Staff Working Paper No. 837; Bank of England: London, UK, 2019.
11. UK Finance. Household Finance Review—Q1 2021. Available online: <https://www.ukfinance.org.uk/sites/default/files/uploads/Household-Finance-Review-2021-Q1-FINAL.pdf> (accessed on 4 January 2026).
12. Bank of England. Record of the Financial Policy Committee Meeting on 27 June 2025. 9 July 2025. Available online: <https://www.bankofengland.co.uk/-/media/boe/files/financial-policy-committee-record/2025/fpc-record-july-2025.pdf> (accessed on 1 January 2026).
13. ONS. Who Is Most Exposed to Rising Housing Costs in England and Wales? Available online: <https://www.ons.gov.uk/peoplepopulationandcommunity/housing/articles/whoismostexposedtorisinghousingcostsinenglandandwales/2024-04-25> (accessed on 1 January 2026).
14. UK Finance. Household Finance Review—Q2 2025. Available online: <https://www.ukfinance.org.uk/system/files/2025-09/Household%20Finance%20Review%202025%20Q2.pdf> (accessed on 4 January 2026).
15. Rath, N. Building the Mortgage Market of Tomorrow, Financial Conduct Authority. 11 November 2025. Available online: <https://www.fca.org.uk/news/speeches/building-mortgage-market-tomorrow> (accessed on 1 January 2026).
16. DiPasquale, D.; Wheaton, W. *Urban Economics and Real Estate Markets*; Prentice Hall: Englewood Cliffs, NJ, USA, 1996.
17. Martin, R.; Sunley, P.; Gardiner, B.; Evenhuis, E.; Tyler, P. The city dimension of the productivity growth puzzle: The relative role of structural change and within-sector slowdown. *J. Econ. Geogr.* **2018**, *18*, 539–570. [CrossRef]
18. Coulson, N.E.; Liu, C.; Villupuram, S. Urban economic base as a catalyst for movements in real estate prices. *Reg. Sci. Urban. Econ.* **2013**, *43*, 1023–1040. [CrossRef]
19. Glaeser, E.; Gyourko, J. Urban Decline and Durable Housing. *J. Political Econ.* **2005**, *113*, 345–375. [CrossRef]
20. Van Nieuwerburgh, S.; Weill, P. Why Has House Price Dispersion Gone Up? *Rev. Econ. Stud.* **2010**, *77*, 1567–1606. [CrossRef]
21. Pike, A.; MacKinnon, D.; Coombes, M.; Champion, T.; Bradley, D.; Cumbers, A.; Robson, L.; Wymer, C. Uneven Growth: Tackling City Decline. Joseph Rowntree Foundation. 2016. Available online: <https://www.jrf.org.uk/report/uneven-growth-tackling-city-decline> (accessed on 8 August 2023).
22. Roback, J. Wages, rents, and the quality of life. *J. Political Econ.* **1982**, *90*, 1257–1278. [CrossRef]
23. Davis, M.; Ortalo-Magne, F. Household Expenditures, Wages, Rents. *Rev. Econ. Dyn.* **2011**, *14*, 248–261. [CrossRef]
24. Sinai, T. Feedback Between Real Estate and Urban Economics. *J. Reg. Sci.* **2010**, *50*, 423–448. [CrossRef]
25. Duca, J.; Muellbauer, J.; Murphy, A. What Drives House Price Cycles? International Experience and Policy Issues. *J. Econ. Lit.* **2021**, *59*, 773–864. [CrossRef]
26. Szumilo, N. The spatial consequences of the housing affordability crisis in England. *Environ. Plan. A* **2019**, *51*, 1264–1286. [CrossRef]
27. McCann, P. *Modern Urban and Regional Economics*, 2nd ed.; Oxford University Press: Oxford, UK, 2013.
28. Ministry of Housing, Communities and Local Government, National Planning Policy Framework. 2024. Available online: <https://www.gov.uk/government/consultations/proposed-reforms-to-the-national-planning-policy-framework-and-other-changes-to-the-planning-system/proposed-reforms-to-the-national-planning-policy-framework-and-other-changes-to-the-planning-system> (accessed on 1 January 2025).
29. Breach, A.; Magrini, E. Sleepy Suburbs: The Role of the Suburbs in Solving the Housing Crisis. Centre for Cities. March 2020. Available online: <https://www.centreforcities.org/publication/sleepy-suburbs-housing-crisis/> (accessed on 3 March 2025).
30. Competition and Markets Authority. Housebuilding Market Study Final Report. 26 February 2024. Competition and Markets Authority. Available online: https://assets.publishing.service.gov.uk/media/65d8baed6efa83001ddcc5cd/Housebuilding_market_study_final_report.pdf (accessed on 15 June 2025).
31. Adams, D.; Leishman, C.; Moore, C. Why not build faster? Explaining the speed at which British house-builders develop new homes for owner-occupation. *Town Plan. Rev.* **2009**, *80*, 291–314. [CrossRef]
32. Lange, M.; Breach, A.; Kovacevic, L. Flat Britain: The Urban Density Gap and How to Close It Centre for Cities. November 2025. Available online: <https://www.centreforcities.org/publication/flat-britain-the-urban-density-gap-and-how-to-close-it/> (accessed on 4 December 2025).
33. Rankl, F. Planning in England: Permitted development and change of use. In *House of Commons Library*; Research Briefing; House of Commons Library: London, UK, 2023.
34. Empty Homes in England. Action on Empty Homes. @emptyhomes. 2016. Available online: www.actiononemptyhomes.org (accessed on 1 January 2024).
35. Zabel, J. A Dynamic Model of the Housing Market: The Role of Vacancies. *J. Real. Estate Financ. Econ.* **2016**, *53*, 368–391. [CrossRef]
36. Molloy, R. Long term vacant housing in the United States. *Reg. Sci. Urban. Econ.* **2016**, *59*, 118–129. [CrossRef]

37. Loveridge, R.; Sallu, S.; Pasha, I.; Marshall, A. Measuring human wellbeing: A protocol for selecting local indicators. *Environ. Sci. Policy* **2020**, *114*, 461–469. [\[CrossRef\]](#)
38. Vyas, S.; Kumaranayake, L. Constructing socio-economic status indices: How to use principal components analysis. *Health Policy Plan.* **2006**, *21*, 459–468. [\[CrossRef\]](#)
39. Anselin, L. An Introduction to Spatial Data Science with GeoDa. Exploring Spatial Data 2023. Volume 1. Available online: https://lanselin.github.io/introbook_vol1/ (accessed on 7 September 2024).
40. Anselin, L. Local Indicators of Spatial Association—LISA. *Geogr. Anal.* **1995**, *27*, 96–115. [\[CrossRef\]](#)
41. Anselin, L.; Syabri, I.; Kho, Y. GeoDa, an Introduction to Spatial Data Analysis. *Geogr. Anal.* **2006**, *38*, 5–22. [\[CrossRef\]](#)
42. Le Gallo, J.; Ertur, C. Exploratory Spatial Data Analysis of the Distribution of Regional per Capita GDP in Europe, 1980–1995. *Pap. Reg. Sci.* **2003**, *82*, 175–201. [\[CrossRef\]](#)
43. Hilber, C.; Vermeulen, W. The impact of supply constraints on house prices in England. *Econ. J.* **2016**, *126*, 358–405. [\[CrossRef\]](#)
44. Hamed, K. Effect of persistence on the significance of Kendall’s tau as a measure of correlation between natural time series. *Eur. Phys. J. Spec. Top.* **2009**, *174*, 65–79. [\[CrossRef\]](#)
45. Siegel, S.; Castellan, N. *Nonparametric Statistics*; McGraw-Hill: New York, NY, USA, 1988.
46. Saisana, M.; Saltelli, A.; Tarantola, S. Uncertainty and Sensitivity Analysis Techniques as Tools for the Quality Assessment of Composite Indicators. *J. R. Stat. Soc. Ser. A Stat. Soc.* **2005**, *168*, 307–323. [\[CrossRef\]](#)
47. Black, J.; Connolly, K.; Davidson, S.; Spowage, M. The use and misuse of regional data: Perspectives, challenges and policy implications from across the UK. *Reg. Stud.* **2025**, *59*, 2464102. [\[CrossRef\]](#)
48. Gray, D. The Measurement of Intra-Distributional Mobility: An Investigation of District Long-Term Housing Vacancies. *Land* **2024**, *13*, 1898. [\[CrossRef\]](#)
49. Gray, D. A Spatial Analysis of the Components of Change of the Housing Stock in England: Will Alternative Means of Adding Dwellings Make a Difference? *Sustainability* **2025**, *17*, 7431. [\[CrossRef\]](#)
50. Blecker, R. The debate over ‘Thirlwall’s law’: Balance-of-payments-constrained growth reconsidered. *Eur. J. Econ. Econ. Polic. Interv.* **2016**, *13*, 275–290. [\[CrossRef\]](#)
51. Li, N.; Song, X.; Liu, M.; Hao, Y.; Liu, J.; Liu, Z.; Zhang, Y.; Wang, M.; Ren, M. A Multidimensional Assessment of Food Security in Low- and Middle-Income Countries: System Performance and Interdimensional Coordination. *Nutrients* **2026**, *18*, 1432. [\[CrossRef\]](#)
52. Tang, D.; Zhao, Z.; Li, J.; Boamah, V. Research on coupling coordination degree of digital finance and economic resilience in the Yangtze River Economic Belt. *Nat. Hazards* **2024**, *120*, 14279–14309. [\[CrossRef\]](#)
53. Martin, R.; Sunley, P. On the notion of regional economic resilience: Conceptualization and explanation. *J. Econ. Geogr.* **2015**, *15*, 1–42. [\[CrossRef\]](#)
54. Kong, Q.; Kong, H.; Miao, S.; Zhang, Q.; Shi, J. Spatial Coupling Coordination Evaluation between Population Growth, Land Use and Housing Supply of Urban Agglomeration in China. *Land* **2022**, *11*, 1396. [\[CrossRef\]](#)
55. He, C.; Li, D.; Yu, J. Quantifying the Spatial-Temporal Variation of Population Urbanization and Affordable Housing Land in China. *Land* **2022**, *11*, 259. [\[CrossRef\]](#)
56. Wang, X.; Wang, W.; Wang, C.; Jiao, X.; Teng, C. The Spatial Relationship Between Urban–Rural Integration and Economic Development: A Case Study of Urban Agglomeration in the Yellow River Basin. *Sustainability* **2025**, *17*, 1438. [\[CrossRef\]](#)
57. Zhan, L.; Wang, S.; Xie, S.; Zhang, Q.; Qu, Y. Spatial path to achieve urban-rural integration development—Analytical framework for coupling the linkage and coordination of urban-rural system functions. *Habitat. Int.* **2023**, *142*, 102953. [\[CrossRef\]](#)

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.