



Homes England – Measuring Social Value

Paper 7: Housing Affordability and Productivity

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List of Abbreviations

Abbreviation	Full Term
ASHE	Annual Survey of Hours and Earnings
BIC	Bayesian Information Criteria
CEBR	Centre for Economics and Business Research
GDP	Gross Domestic Product
GVA	Gross Value Added
HHI	Herfindahl-Hirschman Index
HMA	Housing Market Area
IRTS	Increasing Returns to Scale
IV	Instrumental Variable
LA	Local Authority
LSOA	Lower Super Output Area
MHCLG (DLUHC)	Ministry of Housing, Communities and Local Government (formally Department for Levelling Up, Housing and Communities)
NERA	National Economic Research Associates
NHS	National Health Service
NPPF	National Planning Policy Framework
OBR	Office for Budget Responsibility
ONS	Office for National Statistics
QCA	Qualitative Comparative Analysis

1. Foreword

The building of new homes will have a direct impact on Gross Domestic Product (GDP), whether through new construction activity or the services provided by the assets once built. However, building the right homes in the right places can also have a longer run impact on economic activity by facilitating labour mobility, enabling a better matching of workers to jobs, supporting agglomeration economies and so improving overall productivity growth. This is highlighted in the extract from the 2025 Spring Statement¹ relating to the National Planning Policy Framework (NPPF) below:

“Not only do housing services and construction sector productivity continue to contribute to growth, in the long run, building more houses in the most productive parts of the country also generates growth benefits by enabling these areas to expand. Giving more people access to higher-wage, higher-productivity jobs enhances labour mobility”.

And the corresponding extract from the Spring 2025 OBR Economic and Fiscal Outlook:²

“In addition, further increases to potential GDP from labour mobility and agglomeration effects may become more material over time”.

Developing our understanding of the role of housing in supporting the economy through productivity growth is important. It will ensure we are both able to fully articulate the expected impact of individual projects but also to understand the circumstances that are most likely to lead to these impacts so that investment can be targeted appropriately.

This paper presents the outputs from two interrelated studies that have sought to explore the role of housing in improving productivity. One of these studies focuses on a quantitative approach and the other uses qualitative methods. Combining the conclusions from each of these studies provides valuable new insight, demonstrating that building new homes close to productive economic clusters can have a material impact on productivity.

The work sits as part of a broader programme of research the Agency has been undertaking, working in close collaboration with colleagues in the Ministry of Housing, Communities and Local Government (MHCLG) and in consultation with HM Treasury, focused on strengthening Homes England’s ability to measure and assess the full social value delivered through our housing and regeneration activities. All research published under the Homes England measuring social value series is available at www.gov.uk/government/collections/homes-england-measuring-social-value.

I would like to thank Alma Economics for their work on both studies. I would also like to thank the many colleagues within Homes England, MHCLG and HM Treasury for their input to the work. In addition, I would like to thank Dr Melvyn Weeks from the University of Cambridge, who provided peer review support on the quantitative study.

Andy Wallis

Chief Economist, Homes England

¹ HM Treasury Spring Statement 2025

https://assets.publishing.service.gov.uk/media/67e3ec2df356a2dc0e39b488/E03274109_HMT_Spring_Statement_Mar_25_Web_Accessible_.pdf

² OBR (2025), Economic and Fiscal Outlook March 2025

https://obr.uk/docs/dlm_uploads/OBR_Economic_and_fiscal_outlook_March_2025.pdf

2. Executive Summary

Research Background and Approach

1. The affordability of housing in the UK has increasingly become a challenge for households in recent decades, characterised by escalating house prices which are outpacing wage growth. For example, the average cost of a home in England was over 4.5 times the average annual salary in the year 2000, however this has since increased to over 10 times the average salary.³ The increasing unaffordability of housing is more acute in London and the South East, with house-prices to salary ratios more than doubling in London from 6.2 in 2000 to 14.3 by 2022. Accelerating housing costs impact the wider economy by reducing the ability of employers to access the right talent, while also constraining household budgets. In this context, building more homes in the right areas can support wider economic growth objectives.
2. To further understand the role of housing affordability in the context of economic growth and productivity, this report presents the outputs of two interrelated studies undertaken by Alma Economics on behalf of Homes England:
 - **Study 1: Econometric analysis of housing and productivity.** This study quantitatively explores the impact of housing affordability on regional productivity in England using econometric methods. It builds on a similar study produced by NERA⁴ by exploring alternative modelling strategies to assess the robustness of its findings, as well as extending the analysis to consider whether affordability impacts can be observed outside the Greater South East region.
 - **Study 2: Case study analysis of housing and productivity.** This study combines qualitative and quantitative analysis deep-dives on local areas to provide further evidence on the how housing unaffordability may affect economic outcomes at a local level, including exploration of the mechanisms underpinning this relationship. This research employs Qualitative Comparative Analysis (QCA) and utilises a mixed-methods case-study approach of local areas.

Summary of findings

3. The results from the econometric analysis are summarised as follows:
 - **There is a statistically significant impact of rising housing costs and affordability challenges on the productivity of London and nearby regions.** The baseline model indicates that a 10% increase in housing costs relative to incomes in the Greater South East leads to a 3.1% decline in productivity, a greater impact than that reported by NERA.
 - **The results imply that a 5% increase in housing stock (equivalent to 187,000 new homes in London) would be associated with a 10% reduction in house prices and a 3.1% increase in productivity.** This is based on analysis by MHCLG (2018) which indicates that a 1% increase in housing stock leads to a 2% reduction in house prices.
 - **Outside the Greater South East, the study finds little evidence of a relationship between housing affordability and productivity from the econometric analysis, although this is revisited in the case study analysis with techniques better suited to smaller geographies.** In all regional groups examined, except the

³ This is based on data on house prices and earnings, sourced from the Office for National Statistics. Refer to the next section and the Appendix for more details on data definitions and sources.

⁴ NERA (2024) Housing Affordability and Economic Productivity Estimating the Effect of Housing Affordability on Economic Productivity in the Greater London Area, <https://www.london.gov.uk/sites/default/files/2024-11/240927%20GLA%20Housing%20Productivity%20-%20Report%20FINAL.pdf>

Midlands, there are statistically insignificant relationships. For the Midlands, the results indicated a statistically and economically significant impact. However, the results are sensitive to different model assumptions, making the evidence relatively weak.

- **Despite the lack of significant findings outside the Greater South East, productivity effects may still exist in other regions.** If industrial clusters are confined to relatively small areas within a region, the econometric approach adopted would not be able to detect statistically significant effects⁵. The insights from the Greater South East analysis could be extrapolated to clusters in other regions that face affordability challenges. This hypothesis is supported by the case study analysis carried out in the next section of this report, which identifies smaller clusters outside the South East where growth in housing supply could support economic growth.
4. The findings from the case study analysis of local clusters supplement these findings by exploring the mechanisms in which housing can support productivity growth:
- **Industrial clusters are important for driving productivity growth. However, these clusters inherently rely on local conditions.** The case study analysis found evidence of agglomeration effects associated with local industrial clusters which are responsible for driving productivity growth of the region, such as professional services, health and life sciences and manufacturing sectors. However, these clusters are place-based and require the right local conditions to thrive, including having access to the right talent which in turn requires affordable housing to be available to workers.
 - **Building houses in locations where there are growing industrial clusters that benefit from agglomeration effects is important.** As shown through the case studies, productivity growth of key sectors is associated with greater inward migration, leading to greater housing demand and a reduction in affordability. The study found evidence that the unavailability of affordable housing could be constraining future sector expansion and therefore additional productivity growth. Across the case studies, stakeholders highlighted that unavailability of housing was a key push factor for some businesses deciding whether or not to relocate or stay in the area. Business representatives noted that when housing was scarce, it was difficult to recruit skilled workers which potentially may constrain future growth. Building more homes in areas with growing sectors benefitting from agglomeration effects could support future growth.
 - **It is important to consider both housing that is affordable, as well as affordable housing programmes.** Evidence has been found of affordability challenges for workers on medium-to-low incomes, even for those who are not eligible for affordable housing programmes. This implies that housing unaffordability is a challenge not just for those on the lowest incomes. It will also have implications for inequality within local areas as households become priced out of urban centres. Building more houses needs to be done in tandem with other policies to support urban expansion, such as to address inequality concerns and transport policies to overcome congestion issues.

Policy implications

5. Together, these studies find evidence that building houses in the 'right' places can drive productivity growth. The analyses suggest that new housing can enhance productivity when located in areas where there are growing industrial clusters benefitting from agglomeration and require having access to a local supply of skilled workers. While this is most relevant to London, it also applies to smaller clusters across the UK, especially in localities facing affordability challenges. If policymakers aim to develop and expand growth clusters, providing sufficient affordable housing can help drive productivity growth.
6. The relatively fixed supply of workers at the national level means that simply improving housing affordability to attract workers may not necessarily drive economic growth at the national level. Instead, housebuilding should

⁵ London's scale has likely enabled the detection of a statistically significant impact within the Greater South East region. As other clusters may not be dominant within their regions, it is likely that statistical methods like the one used in this research are unable to capture similar effects.

be targeted at areas with promising industrial clusters that benefit from agglomerations, where increasing unaffordability could be constraining further sector expansion. Focussing on local industrial agglomerations will result in the inward migration of labour to the local area to be productivity-enhancing at the national level rather than causing displacement. However, it should also be recognised that supporting the movement of workers in this way will also have implications for the areas from which these skilled workers are moving from.

7. The analysis also highlights the importance of house building policies to be coupled with wider local economic growth policies to reduce the risk of adverse consequences from rapid expansion of local populations. This includes transport infrastructure investment to support commuting patterns, as well as addressing overcrowding concerns.

Part 1

Econometric analysis of housing and productivity

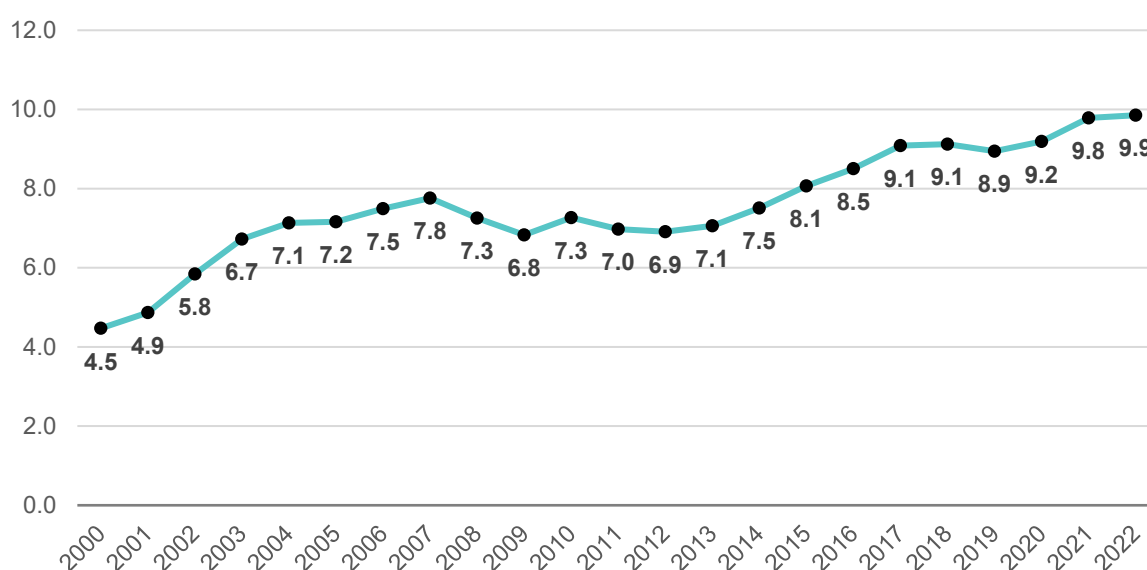
3. Introduction to econometric analysis

8. Alma Economics was commissioned by Homes England to examine the relationship between housing affordability and economic productivity. The central question is to what extent rising house prices relative to incomes hinder productivity growth. This is explored quantitatively through econometric analysis, as outlined in this section.

Background

9. There are two main channels through which housing affordability could affect productivity.
- **Skill shortages:** High housing costs prevent workers from relocating closer to high-productivity jobs and/or force them to leave expensive cities, reducing the local supply of skilled workers, which is particularly important for productivity growth.
 - **Investment Diversion:** High property costs may discourage investment or divert capital from high-yield assets to lower-yield assets, hampering productivity growth.
10. This impact of housing affordability on productivity is particularly important given three key stylised facts. Firstly, **rising house prices:** House prices in England have grown significantly over time, making homeownership increasingly difficult. In 2000, the average home in England cost approximately 4.5x the average salary. In recent years, this ratio has more than doubled to around 10x the average salary⁶. This is based on data across all English regions, with significant variability within England.

Figure 1: House price to earnings ratio, England

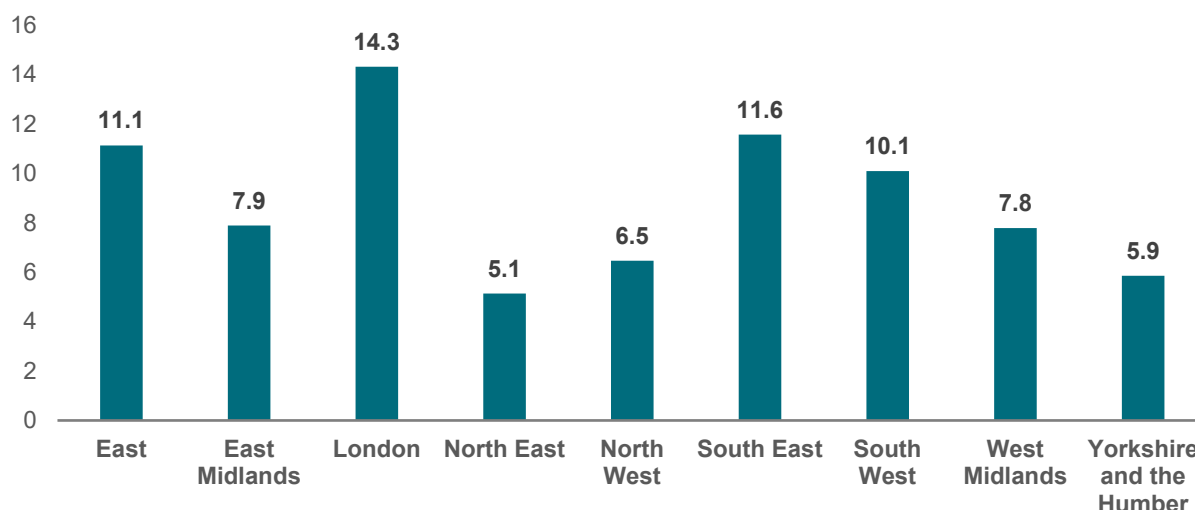


Note: House prices are the median price paid for residential property across all residential property types; earnings is a workplace-based estimate of the median gross annual earnings for full-time employees; calculated using the median value across all English local authorities; Source: Office for National Statistics and Alma Economics calculations

11. Secondly, regional challenges: Housing affordability is a challenge across several English regions, but it is particularly severe in London, where house prices are 14x the average London income.

⁶ Recent [data](#) shows that wages grew more quickly than house prices in 2023 and 2024, bringing the house price-to-earnings ratio back to pre-pandemic levels. Notwithstanding this, the ratio remains significantly higher than in previous decades.

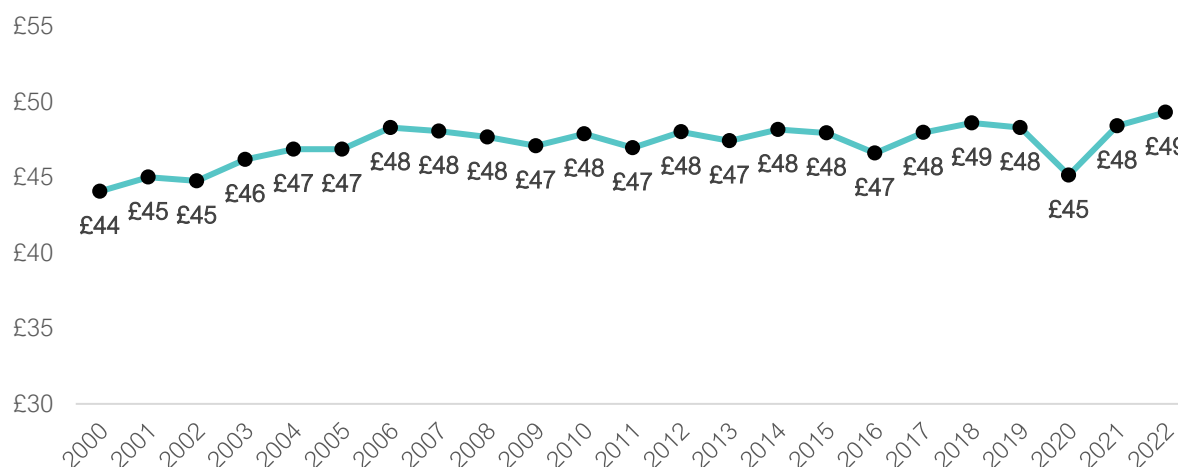
Figure 2: House price to earnings ratio, 2022



Note: House prices are the median price paid for residential property across all residential property types; earnings is a workplace-based estimate of the median gross annual earnings for full-time employees; calculated using the median value of the ratio in local authorities within regions; Source: Office for National Statistics and Alma Economics calculations.

12. Thirdly, **sluggish productivity growth**: Productivity in England has stagnated, showing no material improvement since 2007.

Figure 3: Productivity (000s), England



Note: Gross Value Added per job in 000s; calculated using the median value across All English LAs; Source: Office for National Statistics and Alma Economics calculations.

13. Given these challenges, the key policy question is to what extent a national or regional housing policy aimed at mitigating high housing costs could support much-needed productivity growth.

Objective

14. NERA recently published an econometric study^{Error! Bookmark not defined.} exploring the link between productivity and housing affordability in London, South East, and the East of England (Greater South East region). The study found that rising housing costs in London and surrounding areas have a statistically significant impact on regional productivity. Specifically, it was found that a 10% increase in housing costs relative to average income reduces regional productivity by 1.4%.

15. The NERA study focuses on London, South East, and the East of England and uses econometric techniques, including Instrumental Variables (IV), to identify the impact of affordability on productivity.
16. This study extends the NERA study in two directions. First, it uses alternative modelling strategies to evaluate the robustness of the NERA study's findings. Second, it examines whether similar affordability impacts can be observed outside the Greater South East region.

Structure of this report

17. The remainder of this report is structured as follows:
 - **Section 3** discusses the data and methodology.
 - **Section 4** presents the findings.
 - **Section 5** outlines of the conclusions of the econometric analysis.
18. Methodological details and additional findings are presented in the Annex at the end of this document.

4. Data and methodology

19. This section details the methodology and data sources underpinning the analysis.

Data

20. All data used were available at the local authority (LA) level and over time. The sample included 279 English LAs from 2000 to 2022.

21. Labour productivity was calculated as Gross Value Added (GVA) per job filled. The affordability measure is the ratio of house prices to earnings – the higher the value of the ratio, the lower the affordability.

22. The measures used are similar to those employed by NERA. The main difference is that this study uses real GVA (GVA in constant prices) to calculate productivity, whereas NERA used nominal GVA (GVA in current prices). Real GVA excludes the impact of price inflation and is therefore the preferred measure for productivity calculation. Details about the data definitions and sources are provided in the Annex.

Overarching approach

23. This study builds on NERA’s approach, applying panel data econometric techniques to model productivity as a function of affordability. The primary estimation method relied on panel fixed effects; however, some panel instrumental variable regressions were also used (see below).

24. The model exploits the panel structure of the dataset, i.e., data across LAs and over time, and controls for LA fixed effects and common time trends. LA fixed effects were included to capture unobserved effects that vary across LAs but remain constant over time (e.g., capital endowment). Time effects were included to capture unobserved factors that vary over time but are common across LAs, such as unobserved technology shocks that affect all LAs’ productivity in a similar way. A technical description of the model is provided in the Annex.

Figure 4: Econometric model



25. The treatment of time fixed effects is critical. In principle, many variables affect productivity, including innovation and technology adoption, knowledge and skills, and investment and capital stock. These variables are challenging to control for at the LA level. Data might be available at the national level but not at the LA level. Time fixed effects were included to capture these unobserved or difficult-to-measure time-varying factors. Failing to sufficiently control for these factors could severely bias the model estimates.

Local authority groups

26. Separate models were estimated for different groups of LAs. The aim was to balance three key challenges.

- First, sufficient sample sizes were needed and data variation to detect effects. The larger the sample size, the greater the power of the statistical tests to accurately estimate the impact of affordability on productivity.
- However, pooling all LAs together and estimating a single model for all English LAs might not be appropriate. If LAs in different regions experience different unobserved productivity shocks, the time-fixed effects may not sufficiently control for these, potentially biasing the model estimates.
- Additionally, pooling may be unsuitable if there is heterogeneity in the impacts. Specifically, if the effect of affordability varies by region due to differences in the level of affordability, population density, and/or the nature of the labour market, the model estimates could be biased.

27. To address these challenges, regions were grouped into five groups, some of them overlapping, using two criteria: the industry composition and the level of housing affordability. The underlying assumption is that regions with similar industry structures would experience similar productivity shocks—allowing time-fixed effects to capture these shocks—and that regions with comparable house price-to-earnings ratios would exhibit elasticity homogeneity.

28. For instance, regions in the Midlands and the North derive approximately 15% of their output from manufacturing, which is considerably higher than the share in London or the South East. In contrast, London and the South East have a larger proportion of output stemming from Information and Communication, as well as Professional, Scientific, and Technical activities, compared to the rest of the country (detailed data on regional industry composition can be found in the Annex).

29. Also, the impact of affordability in London and the South East, where the house price-to-earnings ratio is the greatest, could be very different from that in the North, where affordability challenges are less severe (see Figure 2).

30. The table below displays the five groups of LAs used, along with the rationale for their grouping.

Table 1: Local authority groups

Group	Number of LAs	Regions	Rationale
Greater South East	138	London, South East, and East	Industry composition: They have the lowest Manufacturing share compared to regions in Midlands and the North. House price-earnings ratio: They display the highest house price-earnings ratio compared to other English regions.
North	56	North East, North West, Yorkshire and The Humber	Industry composition: Similar industry structure, e.g., Manufacturing accounts for c.15% of the total output. House price-earnings ratio: These three regions have the lowest house price-earnings ratios compared to

other English regions, ranging from 5.1 to 6.5 (See Figure 3).

Midlands	63	East Midlands and West Midlands	Industry composition: Similar industry structure. House price-earnings ratio: Similar house prices-earnings ratio (7.8 in East Midlands and 7.9 in East Midlands – see Figure 2).
North and the Midlands	119	North East, North West, Yorkshire and The Humber, East Midlands, and West Midlands	Combined the two previous groups to increase the sample size. Industry composition: Similar industry structure. House price-earnings ratio: These five regions have the lowest house price-earnings ratios compared to the other four regions (London, South East, South West, and the East—see Figure 3).
Midlands and South West	85	West Midlands, East Midlands, South West	Added South West to the Midlands group to increase the sample size based on the house price-earnings ratio.

Dynamics

31. The impact of affordability on productivity is expected to occur with a time lag. Changes in house prices and affordability do not immediately influence productivity. For instance, individuals do not relocate instantly in response to a change in house prices and the level of housing affordability. A decline in affordability today is likely to gradually affect skill supply and investment, which will, in turn, progressively influence productivity over the coming years.
32. To account for both short-term and long-term effects, dynamic models were estimated that consider both contemporaneous and lagged effects of affordability. This deviates from NERA's approach, which used only contemporaneous effects.

Endogeneity

33. In principle, there might be a “feedback” relationship between productivity and affordability⁷. Housing affordability may affect productivity, but productivity may also influence affordability. An increase in productivity could lead to higher real incomes, which in turn could increase the demand for housing, resulting in higher housing prices. If the increase in house prices outpaces the rise in earnings, housing affordability may decrease. This potential feedback effect could bias the estimates if not accounted for⁸.
34. A statistical test was used to assess this premise. The tests suggested that affordability is exogenous—there is no feedback relationship. However, due to the limitations of the test, the possibility that the test could be misleading was considered (i.e. incorrectly suggesting exogeneity) and an IV approach was used in addition to more conventional panel estimation methods⁹. The exogeneity tests and the IV estimates are provided in the Annex.

⁷ In technical terms, productivity and affordability may be part of a system of simultaneous equations.

⁸ This bias is known as the simultaneous equation bias.

⁹ The Wu-Hausman test was conducted to evaluate the null hypothesis that affordability is exogenous. The failure to reject the hypothesis could suggest that affordability is truly exogenous, or it may indicate a Type II error, where the analysis incorrectly failed to reject the null. This could be due to model misspecification or weak and invalid instruments—for example, see [Guo et al., \(2018\)](#). To address the possibility of a Type II error IV estimation has also been considered.

Geographical area to measure affordability

35. Following NERA, an average affordability measure was calculated by taking the mean affordability of nearby LAs. "Nearby" is defined as LAs within a 20km radius, using the centroids of the LAs to define LA distance. The rationale is that employees are typically willing to commute between LAs, provided commuting times are not excessive. Housing costs in an LA, as well as those in surrounding LAs, provide a good approximation of housing affordability, as this captures broader commuting zones. The sensitivity of the results was tested using different zones.

Box 1: Differences between Alma Economics' and NERA's methodologies

Alma's data and methodology align closely with those used by NERA. However, there are key differences: as discussed above, Alma used real GVA to calculate productivity, rather than nominal GVA, the sample was slightly larger and included LAs outside the Greater South East region, and, unlike NERA, lag effects were incorporated to account for time lags in the underlying relationship.

Additionally, Alma employed extra instruments in the IV estimation. In addition to the share of green belt land, the planning application refusal rate and the share of planning applications decided on time was used. The advantage of these instruments is twofold. First, the planning application instruments vary over time, eliminating the need to impose an arbitrary linear trend, as is done for the green belt instrument (see NERA for the rationale).^{*} Second, the additional instruments facilitate testing for instrument exogeneity, which requires more than one instrument.^{**}

Methodical aspect	Alma Economics	NERA
Sample	Greater South East regions from 2000 to 2022; separate models for other regions were estimated	Greater South East regions from 2002 to 2021
Productivity measure	Real GVA per job filled	Nominal GVA per job filled
Dynamics	Yes	No
Instruments	Three instruments: (1) Share of green belt land times a time trend; (2) Planning application refusal rate; and (3) Share of planning applications decided on time	One instrument: Share of green belt land times a time trend

Alma also attempted to replicate NERA's analysis using nominal GVA, with a sample and data that closely align with NERA's specification. While Alma managed to obtain the productivity measure used by NERA (matching the data vintage), this was not possible for the affordability measure – the affordability measure appears to differ from NERA's, as evidenced by the summary statistics reported by NERA, potentially reflecting different data vintages. Moreover, Alma's dataset contained five fewer LAs than NERA's. Using the closest approximation of NERA's data, Alma were unable to replicate NERA's results or identify statistically significant effects of affordability on productivity.

^{*} All instruments pass the relevance test (the results are provided in the Appendix).

^{**} When there is one endogenous regressor, at least two instruments are required to test for overidentifying restrictions and instrument exogeneity.

5. Findings

36. This section provides a summary of the findings, organised into two main parts. The first part outlines the results for the Greater South East area, while the second part covers the results for the remaining group of LAs outside the Greater South East.

Greater South East

37. The following table presents the panel fixed effect estimates for the Greater South East using different lag structures. In all models, the dependent variable is productivity, while the independent variable is housing affordability (using contemporaneous and/or lagged values). The first model includes no lags, assuming that affordability has an immediate (same-year) effect on productivity, whereas the remaining models incorporate lag effects. The coefficients represent the elasticity of productivity with respect to affordability. The total impact, comprising both short-run and long-run effects, is calculated by summing the statistically significant coefficients of all contemporaneous and lagged values.

38. Assuming no lag effects, this analysis found that a 10% increase in the house price-to-earnings ratio leads to a 1.9% decrease in productivity (Model 1). However, the analysis indicates the presence of significant lag effects. First, the lag values appear to be statistically significant, while the Bayesian Information Criterion (BIC), which assesses model fit, suggests that Model 5 provides the best approximation of the dynamic relationship. Model 5 indicates that a 10% increase in the house price-to-earnings ratio leads to a 3.1% decrease in productivity in the long run¹⁰.

39. Interestingly, all models that incorporate lag effects (Model 2 to Model 6) produce a consistent long-run elasticity of approximately -0.31¹¹. In contrast, Model 1, which does not account for lag effects, appears to significantly underestimate the impact of affordability on productivity, suggesting an elasticity of -0.19. The static model's estimate is similar to NERA's baseline elasticity of -0.14, roughly half of this study's own estimate.

40. The econometric estimates indicate not only a statistically significant but also an economically significant impact of the house price-to-earnings ratio on productivity. The findings suggest that policies aimed at increasing the housing supply in London and improving housing affordability would also enhance regional productivity¹².

¹⁰ This model is the result of a general-to-specific model reduction starting with a general model (Model 2) and gradually deleting the most insignificant variables.

¹¹ The higher the house prices relative to earnings, the lower the productivity.

¹² If the loss of productivity from London is offset by gains in other English regions, i.e., a zero-sum game, there would be no overall productivity gains for England. This is difficult to determine and requires a qualitative assessment, such as evaluating the extent of agglomeration economies, the importance of international talent and London's ability to attract global talent, and whether London's output (e.g., financial services, professional, scientific, and technical activities) can be substituted by other regions.

Table 2: Panel fixed effects estimates, Greater South East

Model	1	2	3	4	5	6
Affordability (t)	-0.190 ^{***}	-0.007	-0.007	-0.007		-0.088 [*]
	[0.064]	[0.056]	[0.056]	[0.056]		[0.052]
Affordability (t-1)		-0.111 ^{**}	-0.111 ^{**}	-0.101 [*]	-0.107 ^{**}	
		[0.046]	[0.046]	[0.053]	[0.054]	
Affordability (t-2)		0.015	0.016			
		[0.046]	[0.041]			
Affordability (t-3)		0.002				
		[0.050]				
Affordability (t-4)		-0.206 ^{***}	-0.205 ^{***}	-0.200 ^{***}	-0.199 ^{***}	-0.223 ^{***}
		[0.057]	[0.054]	[0.054]	[0.052]	[0.054]
Total (sum of statistically significant contemporaneous and lag effects)	-0.190	-0.32	-0.32	-0.30	-0.31	-0.31
N	2,622	2,622	2,622	2,622	2,622	2,622
BIC	-5,111	-5,142	-5,150	-5,158	-5,166	-5,163

*Notes: Estimated by panel fixed effects; Common time fixed effects are included; The dependent variable is productivity; Both productivity and affordability are in natural logs; Affordability is measured using the "20km buffer" approach; The sample includes London, the East, and the South East from 2000 to 2022; N represents the sample size—a common sample is used to ensure BIC comparability between models; BIC refers to the Bayesian Information Criterion, where lower values indicate a better fit; Cluster (LA) standard errors are shown in brackets; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Source: Alma Economics analysis.*

41. A series of sensitivity checks were conducted by varying:

- The LAs and time periods included in the estimation sample,
- The buffer zone used to calculate affordability – the baseline model applies a 20km zone, but alternative levels have also been tested, and
- The treatment of fixed effects – using a linear time trend instead of time-fixed effects and allowing time-fixed effects and/or time trends to vary by region or LA.

42. The lag structure of the models remained unchanged – the optimal lag structure (lag 1 and lag 4) identified in the baseline model was used.

43. The results of the sensitivity analysis, as outlined in Table 3 below, suggest that:

- The impact of affordability is negative and statistically significant in all models except those that include region- or LA-specific time effects. This is likely to be due to insufficient variation in the data, making it difficult to separate the impact of affordability from other time-varying effects¹³.
- The greater the buffer zone, the larger the estimated coefficient. For example, in the model with no buffer zone, the total impact is -0.19, increasing (in absolute terms) to -0.34 when a 30km buffer is applied. This may reflect measurement error when relevant commuting areas are measured more accurately by considering nearby LAs, more accurate estimates are obtained.

44. Overall, the results of the sensitivity check suggest that, although the estimated impact of affordability on productivity varies, it remains statistically and economically significant in the majority of the sensitivity checks.

¹³The statistically insignificant results could also suggest that, once the analysis control for LA- or region-specific unobserved time effects, the impact of affordability disappears. In other words, the results could be explained by (a) a lack of sufficient variation, (b) the true model having region- or LA-specific effects, and failure to capture them biases the affordability estimates, or (c) both (a) and (b). Alma lean towards (a) A lack of sufficient variation is most likely, given that variation within regions is low, making it difficult to isolate affordability from region-specific time effects. Also, the inclusion of region- or LA-specific effects is likely to result in overfitting and may therefore not be the most appropriate approach. Moreover, it is reasonable to assume that unobserved productivity shocks are similar between London, the South East, and East of England, meaning that region- or LA-specific time-fixed effects are not required—a model with common Greater South East or common London/South East time effects (Model 2) is well-specified. This is also supported by the case study analysis in Part 2 where evidence of a relationship with productivity outside of London and the South East has been found.

Table 3: Sensitivity analysis, Greater South East

Model	1	2	3	4	5	6	7	8	9	10
Sensitivity check	Baseline	Exclude East	Linear trend	No buffer	10km buffer	30km buffer	London-specific time-fixed effects	Region-specific time trends	LA-specific time trends	Exclude 2020-2022 data
Affordability (t-1)	-0.107** [0.054]	-0.111 [0.067]	-0.106*** [0.037]	-0.114** [0.047]	-0.111** [0.048]	-0.103 [0.063]	-0.029 [0.078]	0.01 [0.037]	0.017 [0.029]	-0.085 [0.056]
Affordability (t-4)	-0.199*** [0.052]	-0.317*** [0.066]	-0.053** [0.026]	-0.077** [0.038]	-0.131*** [0.043]	-0.232*** [0.071]	-0.029 [0.064]	0.024 [0.025]	0.034* [0.021]	-0.110** [0.048]
Total (sum of contemporaneous and lag effects)	-0.31	-0.43	-0.16	-0.19	-0.24	-0.34	-0.06	0.03	0.05	-0.20

Notes: The dependent variable is productivity. Both productivity and affordability are in natural logs. Affordability is measured using the "20km buffer" approach, unless stated otherwise. The sample includes data from London, the East, and the South East LAs from 2000 to 2022, unless stated otherwise. All models have been estimated using panel-fixed effects with time-fixed effects, unless stated otherwise. Clustered (LA) standard errors are shown in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Model 1: Baseline model. Model 2: Uses London and South East LAs—East of England LAs are excluded from the sample. Model 3: Replaces the time-fixed effects with a linear trend. Model 4: Uses an affordability variable without a buffer zone adjustment. Model 5: Uses a 10km buffer zone instead of a 20km buffer zone. Model 6: Uses a 30km buffer instead of a 20km buffer zone. Model 7: Uses common time-fixed effects for East and South East LAs, and a London-specific time-fixed effect. Model 8: Replaces time-fixed effects with Regional-specific time trends. Model 9: Replaces time-fixed effects with LA-specific time trends. Model 10: Excludes the 2020–2022 (COVID-19) period from the sample.

Rest of England

45. Table 4 displays the model estimates for the remaining four regional groups. It includes two sets of estimates, each based on a different lag structure¹⁴. In most cases, the impact of affordability is statistically insignificant. The only exception is in the Midlands, where the impact is statistically significant, suggesting that a 10% increase in housing affordability improves local productivity by approximately 1.5% (a material effect). This impact may be driven by the Birmingham, Coventry, and Wolverhampton “cluster”.
46. Notwithstanding this, a series of sensitivity checks, detailed in the Annex, yield estimates that are often statistically or economically insignificant. For instance, when the last three years of the sample are excluded (due to the impact of COVID-19), the effect becomes significant only at the 10% level. Most importantly, when either no buffer zone or buffer zones of 10km and 30km are applied, the affordability coefficient becomes statistically insignificant. This indicates that the baseline results using the 20km buffer zone may have occurred by chance.
47. The results presented in this section should be interpreted with caution. While it is possible that productivity gains associated with affordable housing exist outside London, these may not be able to be identified econometrically if they are present in small clusters within regions. If business clusters in other regions face housing affordability challenges, it is likely that they would benefit from policies aimed at alleviating these challenges. In other words, the insights from the Greater South East analysis could be extrapolated to clusters in other regions.

¹⁴ These lags structures were the results of a general-to-specific model reduction approach.

Table 4 Panel fixed effects estimates, Outside Greater South East

Model	1	2	3	4	5	6	7	8
Region	Yorkshire and The Humber; North West; North East	West Midlands; East Midlands	Yorkshire and The Humber; North West; North East; West Midlands; East Midlands	West Midlands; East Midlands; South West	Yorkshire and The Humber; North West; North East	West Midlands; East Midlands	Yorkshire and The Humber; North West; North East; West Midlands; East Midlands	West Midlands; East Midlands; South West
Affordability (t)	0.014	0.035	0.02	0.107				
	[0.114]	[0.082]	[0.077]	[0.073]				
Affordability (t-4)	0.012	-0.177**	-0.085	-0.110*	0.016	-0.172**	-0.083	-0.091
	[0.089]	[0.082]	[0.054]	[0.063]	[0.102]	[0.084]	[0.055]	[0.067]
N	1064	1197	2261	1615	1064	1197	2261	1615

Notes: The dependent variable is productivity; Both productivity and affordability are in natural logs; Affordability is measured using the "20km buffer" approach; All models include time-fixed effects; N represents the sample size; Cluster (LA) standard errors are shown in brackets; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Source: Alma Economics analysis.

6. Econometric Analysis Conclusion

48. This study examined the impact of housing affordability on regional productivity using econometric models and data from English LAs over the past 20 years.

49. The findings of this study can be summarised as follows.

- There is a statistically significant impact of rising housing costs and affordability challenges on the productivity of London and the surrounding regions. The baseline model indicates that a 10% increase in housing costs relative to incomes in the Greater South East leads to a 3.1% decline in productivity, a greater impact than that reported by NERA.
- To achieve a 10% reduction in house prices and a 3.1% increase in productivity, a 5% increase in housing stock – equivalent to 187,000 new homes in London – would be needed. This is based on the MHCLG rule of thumb, which indicates that a 1% increase in housing stock leads to a 2% reduction in house prices.
- Outside the Greater South East, little evidence was found of a relationship between housing affordability and productivity. In all regional groups examined, except the Midlands, statistically insignificant relationships were found. For the Midlands, the results indicated a statistically and economically significant impact; however, the results are sensitive to different model assumptions, making the evidence relatively weak.
- Despite the lack of significant or robust findings outside the Greater South East, productivity effects may still exist in other regions. If industrial clusters are confined to relatively small areas within a region, the econometric approach would not be able to detect statistically significant effects¹⁵. The insights from the Greater South East analysis could be extrapolated to clusters in other regions that face affordability challenges.

50. The findings suggest that new housing to improve affordability can enhance productivity when located in the right areas. While this is most relevant to London, it also applies to smaller clusters across the UK.

¹⁵ London's scale has likely enabled the detection of a statistically significant impact within the Greater South East region. As other clusters may not be dominant within their regions, it is likely that statistical methods like the one used in this research are unable to capture similar effects.

Part 2

Case study analysis of housing and productivity

6. Introduction to Case study Analysis

Background and Approach

51. Alma Economics was commissioned by Homes England to explore the relationship between housing and local economic performance, primarily productivity, and how this differs across areas of England as a result of local contextual factors such as geography, demographic makeup, and industry mix.
52. The specific objectives of the research (as set out by Homes England) were to:
1. Gain insight into the relationship between housing and local economic outcomes to inform the development of new housing strategies;
 2. Provide evidence on the scale of local economic impacts linked to housing development;
 3. Develop a qualitative and quantitative research methodology to investigate the relationship between housing and economic performance at the local level; and
 4. Test this research methodology with a set of case studies, examining relationships between housing and economic performance in specific local areas with a greater level of detail.
53. The current research builds on a literature review written by Jacobs and commissioned by Homes England in 2021, focused on what empirical and theoretical evidence exists regarding the relationship between new housebuilding and productivity growth.
54. Firstly, a short literature review was carried out, building on the 2021 work, to investigate theoretical evidence on the relationship between housing growth and local economic development. Available data was explored, including timeliness, frequency, and granularity (e.g., geographical area covered). Following the review, the relationship between housing stock and economic performance in local areas using Qualitative Comparative Analysis (QCA) was analysed. For each case study¹⁶ (i.e., areas with above-average productivity growth and above-average housing stock), QCA looks to identify patterns across case studies to understand common relationships. QCA identified a series of localities which meet this combination of conditions (i.e. demonstrating a relationship between housing and economic performance).
55. These localities were then taken forward, examining the extent to which the characteristics identified in the QCA were present at the local level in five local authorities: Cambridge, Wokingham, Bolsover, South Derbyshire, and Rushmoor. Findings from each of the case studies were informed by qualitative and quantitative research activities, including a desk-based review of relevant planning documents and grey literature for each area, analysis of local authority and lower-super output area level data on relevant indicators, and interviews with local authority staff, business representatives, and academics.

Structure of this report

56. The remainder of this report is structured as follows:
- **Section 7** summarises the methodology and approaches used in the research.
 - **Section 8** details the findings from the QCA and summarises the rationale for the choice of case study areas.
 - **Section 9** summarises the findings from the case study analysis, collating themes from each case study.

¹⁶ Each local authority area in England served as one case study.

- **Section 10** provides implications for future housing policy, and recommendations for future research.

7. Methodology

57. This section summarises the methodology for the case study analysis.

Literature review

58. A focused literature review was conducted, to examine existing hypotheses on the relationship between productivity and housing supply. The literature review follows on from previous work commissioned by Homes England, conducted by Jacobs in 2021. Reviewing the economic literature aided in the selection of explanatory variables by:

- Providing insight into which variables are likely to have a significant impact on productivity and therefore should be included in the model;
- Producing a framework for interpreting findings in a meaningful way by providing additional context and explanation; and
- Sense-checking any quantitative results against existing literature and well-established hypotheses.

Qualitative Comparative Analysis

59. QCA is a research method that was developed initially by Charles Ragin in 1987 to enable analysis of data sets with too few observations for robust regression analysis but too many for simple thematic analysis of case studies to be carried out by hand.¹⁷ QCA is a suitable analytical technique as it allows us to systematically explore patterns and combinations of characteristics in a large number of case studies (i.e. localities) which exhibit a relationship between housing and economic performance. Whilst the QCA approach does not provide quantitative estimates of these relationships, it has been used to identify a smaller number of case studies that possessed the characteristics of interest to be explored in more detail later on.

60. The first step of QCA is to identify the set of case studies for analysis. In the QCA results presented in Section 8, each case study is comprised of one English local authority. The set of case studies included are based on the following criteria:

- All English local authorities for which data on all variables is available; and
- Those that make up a meaningful unit of observation, independent of its relationship with neighbouring local authorities. For example, the effects observed in the wider literature as drivers of productivity growth should apply within a single local authority, rather than a group of local authorities, thus making the relationship between housing and productivity easier to observe.

61. On this basis, Greater London has been excluded from the analysis, as individual local authorities within London are unlikely to make up a unit of observation themselves, instead operating as part of a larger economy with other local authorities, which would be too complex to assess in this analysis. This approach is also in line with the econometrics analysis which identifies London as a single large cluster. Other large English cities (e.g., Birmingham and Manchester) map more closely to single local authorities, so they have been included in the analysis.

62. The second step of QCA is to define an outcome of interest. In the current research, the outcome of interest for each case study is whether the combination of strong performance in housing supply growth and strong performance in labour productivity growth was observed. To include this in QCA, a long-time horizon of 10 years was chosen to allow for long and variable lags for how changes in housing supply influence productivity. For

¹⁷ Ragin, Charles C., 1987, The Comparative Method: Moving Beyond Qualitative and Quantitative Strategies.

housing supply, the most recent 10-year window available at the time of the analysis was 2012 to 2022. For labour productivity, 2022 data was not yet available during the research, so the average compound growth rate from 2012 to 2021 was used as a proxy estimate for 2012 to 2022. The outcome variable is binary and takes the value of 1 where a local authority saw the combination of both above-average housing supply growth and above-average labour productivity growth and zero otherwise.¹⁸

63. The third step of QCA is to identify a set of conditions (variables) that will be explored as explanatory factors for observing the outcome of interest. Based on the review of the literature on key drivers of productivity, administrative data on these factors have been collated to feed into the QCA. The starting level of some variables (e.g., data from 2011 or 2012) was used in the QCA to better understand growth over time and the extent to which starting conditions impact current productivity, based on the starting endowments hypothesis in the literature. For example, some areas may have had high levels of starting productivity, but relatively little growth within the ten-year period.
64. All data used in the QCA is considered at the local authority district level, using 2023 boundaries. As data from multiple years was used, data recorded using previous local authority boundaries was matched to the current boundaries using Office of National Statistics (ONS) lookups, which relate different ONS geographies to one another. Key variables as identified in the literature review in Chapter 2, and how they were measured, are provided below.
 - **Initial skills endowment:** Initial skills endowment was derived using ONS data on the highest level of qualification of all usual residents aged 16 and over based on the 2011 census. Within the analysis, initial skills endowment was measured using the number of residents with at least a Level 3 educational attainment in 2011 scaled by the number of dwellings in the local authority.¹⁹
 - **Initial productivity endowment:** The 2012 level of labour productivity, captured using ONS data on the average Gross Value Added (GVA) per hour worked by local authority district.
 - **Initial housing stock endowment:** The 2012 number of dwellings as captured by the former Department for Levelling Up, Housing and Communities (DLUHC) and the now Ministry of Housing, Communities and Local Government (MHCLG) estimates on dwelling stock per local authority district.
 - **Initial level of deprivation:** Captured using MHCLG deprivation score for the 2010 Indices of Deprivation. Data aggregated at the Local Authority level provided by the NHS has been used.
 - **Initial industry concentration:** Measured by the Herfindahl–Hirschman Index (HHI) of concentration using 2012 GVA by local authority by sector.²⁰ The HHI was computed after excluding certain sectors unlikely to experience increasing returns to scale (IRTS), specifically: (a) basic industries (agriculture, mining, electricity, gas, water and waste),²¹ (b) GVA from imputed rents from owner-occupiers (a component of the National Accounts but not an industrial sector), and (c) wholesale activities.
65. For each of the conditions (variables) above, these were included in the QCA with the value of 1 where the variable was above-average for the sample and a value of zero otherwise.
66. The fourth step in QCA is to conduct analysis, starting with listing the local authorities with the relevant explanatory conditions, and counting the number of cases where the conditions hold (e.g., having high starting

¹⁸ In the spirit of QCA, which is a hybrid qualitative/quantitative technique, “near misses” (defined as only 0.1 standard deviations away from being above-average) were coded as 1s rather than zeros.

¹⁹ See [here](#) for further detail on definitions, including an ONS caution about the reliability of using Level 4 qualifications.

²⁰ The HHI is the sum of the square of activity shares for different sectors. The maximum possible value, representing a perfectly concentrated area with activity all in one sector would be 100² and the theoretical minimum would be zero if an area was spread equally over an infinite number of industry sectors.

²¹ This exclusion is because “basic industries” are unlikely to experience agglomeration effects based on spatial proximity in the same way that other industries will have. For example, there is a geographical limit to having an increasing concentration of farms and mining quarries that would otherwise yield agglomeration effects.

housing stock, high starting productivity, high skills endowment, high industry concentration). For each of these combinations for which there are observations, the percentage of cases where high housing supply is coupled with high productivity has been recorded.²²

67. The final step is to set a probability cut-off or threshold (or multiple cut-offs) for the percentage of cases in which the outcome of interest is observed for any given combination of conditions. The output of the QCA is then a list of combinations of starting conditions (e.g., high starting productivity combined with high deprivation) that are associated with a high probability of observing high housing supply growth coupled with high productivity growth.

Linear Probability Model re-statement of QCA results

68. Following QCA estimation, it is possible to re-state the results using regression analysis that maintains the binary nature of both the dependent and explanatory variables as well as including variables to incorporate the combinations identified during QCA. A Linear Probability Model has been used for ease of interpretation. This option for presenting the results is likely to be more intuitive for readers with experience of regression output but not of QCA.

Analysis of mixed methods case studies

69. To begin an in-depth analysis of the local areas, data available at the local level on key explanatory factors identified by the QCA has been analysed. Data included in each case study varied to some extent by local area, but broadly included:

- **Productivity growth to confirm the productivity-related findings**, and examine whether there were spikes in productivity in any years over the period of interest;
- **Housing growth, to confirm housing-related findings**, and examine whether there were spikes in housebuilding in any years over the period of interest;
- **Sectoral composition and productivity** across sectors, as measured by the share of GVA and output per hour worked to assess the extent to which industry concentration or clustering is occurring in case study areas;
- **House price to earnings ratios**, to examine how changes in housing demand and productivity are driving house prices;
- **Local deprivation**, as measured by deprivation decile at the LSOA level to examine the effect (if any) of productivity growth on deprivation across the area;
- **Skill level, inward migration and population growth** to understand the extent to which starting endowments impact productivity growth, and to examine how much the composition of the area has changed over time.

70. Following the analysis of secondary data, key planning documents and local grey literature was reviewed to provide additional local context. Where relevant, academic literature was also reviewed but there was very little in the way of relevant papers. Key documents reviewed included Local Plans governing the time period of interest, Housing Market Needs Assessments, transport strategies, and previous reviews or evaluations relevant to the local economy. The period of interest for both the QCA and data analysed for the case studies was 2012-2022. In keeping with this, the majority of planning documents and grey literature analysed were from this period or earlier. In some cases, older documents were also reviewed if they provided a forward view of the period of interest or provided context on the starting levels of key factors. For example, the Cambridge Local

²² There are a variety of software options for doing this and all should return identical results. Alma used fsQCA version 4.1, available to download [here](#) along with a user manual.

Plan published in 2006, governs the period up to 2016. The work cited is focused on setting out progress and priorities from this time period to provide context on any observed housing supply growth, rather than seeking to validate whether any housing targets or ambitions were met.

71. Findings from the desk-based review and analysis of secondary data informed the recruitment of stakeholders for interviews, and material included within interview guides. Interviews sought to obtain a local perspective on enabling factors, barriers, and challenges to productivity growth, and the role that housing plays in each area. While specific questions were tailored to the interview participant's area of expertise and experience within the area, key topics included:
- Rationale for recent housebuilding programmes, such as whether there was a specific strategy in mind and whether it sought to address specific challenges or opportunities.
 - Experiences of recent housebuilding programmes, including whether they met the aims of any underlying strategies, as well as whether it resulted in any unintended challenges or positive outcomes.
 - The role of industry in supporting productivity growth, including the 'pull and push' factors for businesses to be located in each case study area and what this means in terms of housing and workers coming into the area.
 - Factors, barriers and challenges to supporting housing growth in the area.
72. In total, 17 interviews were conducted across all areas, four relating to Cambridge, four relating to Wokingham, six across Bolsover and South Derbyshire,²³ and three relating to Rushmoor. Stakeholders included local authority representatives, local councillors, academics, business representatives, and individuals representing third sector organisations and chambers of commerce. Most interviewees participated on the basis of remaining anonymous.
73. Interviews were then analysed to identify key themes within and across case studies and provide additional context to quantitative findings from the research.

²³ South Derbyshire and Bolsover are in the same county, so many stakeholders Alma spoke to were able to speak to themes in both areas.

8. Findings from Qualitative Comparative Analysis

74. QCA was used to identify a set of case study areas experiencing above-average growth in housing and above-average growth in productivity. The QCA was used to reveal factors or combinations of factors that were associated with both high housing growth and high productivity growth. These factors, which included industry specialisation, skills endowment, and deprivation, were informed by a targeted review of the literature. The results of the QCA were used to select a series of case studies to explore in further detail the relationship between productivity growth and housing growth.

Literature review

75. A focused literature review on the economics of productivity has been undertaken. The literature review identified three primary hypotheses relating to starting endowments, industry specialisation, and demand channels, which are discussed as follows.

Starting endowments

76. Starting endowments refer to the assets, skills, or resources possessed by an area at the beginning of a given period of time. In summary, the evidence suggests that while starting endowments may impact future productivity growth, the empirical and theoretical literature indicates that the impact is ambiguous, with some studies finding a positive relationship, and others finding a negative one.
77. For example, low starting endowments may offer greater potential for growth. The Solow Growth Model²⁴ suggests that areas which begin with low levels of endowments (i.e. capital) will experience faster growth than similar areas starting with higher levels of endowments. This is explained by decreasing returns to scale, in which the additional output generated by each additional unit of capital decreases over time, and so regions with lower starting endowments (e.g., lower levels of capital) will grow more quickly, eventually catching up with regions with higher starting endowments (Kane 2001).
78. However, high endowments could also be crucial for attracting skilled human capital, with areas with higher skill levels drawing more highly skilled workers. The literature shows an overwhelmingly positive relationship between skill endowment and productivity. Theoretically, higher levels of education and skills increase productivity by expanding the set of an individual's capabilities. Increased skills can also increase productivity through indirect mechanisms such as innovation and technological diffusion. Rincon-Aznar et al. (2015) noted that growth accounting studies²⁵ have found that skill improvements have tended to directly account for a fifth of the growth in labour productivity in the UK in recent decades. Further, Holland et al. (2013) found that a one-percent increase in the share of the workforce with a university degree raises the productivity level by 0.2-0.5 percent in the long run, indicating a high-potential of education and skills to contribute to economic growth.
79. A high concentration of skilled workers may in turn attract more skilled workers. In an evidence review on regional productivity differences, Zymek and Jones (2020) found that "sorting", or the tendency of similar types of people to live and work near one another, is a powerful explanatory factor for regional differences in productivity. Therefore, if an area has a large number of highly skilled workers, more highly skilled workers are likely to gravitate there as a result. Zymek and Jones (2020) noted that because sorting is self-reinforcing, small differences in regional areas may, in time, grow into large differences in productivity. Sorting may also exacerbate other preexisting inequalities, with highly skilled workers being more likely to move to areas with higher starting levels of capital or a greater number of highly productive firms.

²⁴ The Solow Growth model (1956) is an economic model explaining how population growth, technology, and savings contribute to productivity growth in the long run. In short, the model predicts that economic growth will diminish over time, even with high levels of capital input, unless there is a technological advancement.

²⁵ Growth accounting is a technique used to explain the contribution of different factors (labour, capital, etc.) to economic growth.

80. With regards to housing stock specifically, Meen and Nygaard (2010) argued that because housing stock is spatially fixed and long-lasting (compared to other assets or capital), any changes happen slowly over time, placing more weight on the starting housing stock of an area. Investment in housing such that skilled workers are closer to jobs that match their specialisations and are closer to other workers with whom they can exchange knowledge, could lead to increased local productivity. Conversely, a lack of affordable or good quality housing supply could discourage or prevent workers from relocating, limiting productivity gains (MacLennan et al. 2019).
81. Based on the hypotheses presented above, the starting endowments of a local area could have bearings on the area's productivity growth, and housing stock growth. As a result, factors related to starting endowments should be included in the exploration of this relationship.

Industry specialisation

82. Industry specialisation occurs when several firms (or firms in the same industry) are concentrated in a geographic area. When specialised firms are located in one area, these areas can benefit from agglomeration. Firms do not need to be based in an urban area or large population centre to benefit from agglomerations, as a relatively small number of highly specialised firms can still generate productivity benefits (Zymek and Jones 2020).
83. Agglomeration may increase productivity through several channels. Areas with a high degree of industry specialisation have a larger pool of skilled workers. This allows firms and workers to take advantage of "matching" benefits, where firms and workers benefit from sharing specialised labour resources, and workers can more easily find jobs to suit their specialist skills (MacLennan et al. 2019). This lowers the probability of labour shortages for firms, and unemployment for workers (Krugman 1991). Firms can also take advantage of sharing benefits, where they can capitalise on a common pool of resources, infrastructure (MacLennan et al. 2019) and information spillovers, giving clustered firms a better production function than sole producers (Krugman 1991). Finally, firms within industry clusters can take advantage of reduced communication and transportation costs (Glaeser 2010). Using evidence from Australia, Nygaard et al. (2021) found that a doubling of industry specialisation of an area (relative to the state as a whole) was associated with 4-10% higher wages.
84. Housing market dynamics can influence the development of agglomeration economies and can also be driven by their development. A lack of suitable housing supply may require adjustments from workers (e.g., increasing travel to work time) and deter firms from relocating, discouraging the formation of productive clusters (MacLennan et al. 2019). Further, productive clusters or agglomeration economies may cause housing costs to increase. Nygaard et al. (2021) found that despite workers within specialised clusters having higher wages, workers on the lower end of the wage distribution tend to benefit less than higher wage earners. High housing costs within agglomeration economies can further exacerbate these inequalities.
85. There is some evidence that clusters are more likely to occur in some industries than others, and as a result those industries are more likely to drive productivity growth. Cortright (2006) differentiates between traded and non-traded industries. Traded industries are those which sell goods and services in competition with businesses located in other regions or countries, while non-traded businesses serve the demand of the local population and include businesses such as retail, personal services, local government, and most healthcare. Traded industries are typically where clusters occur and are more likely to generate productivity gains. As non-traded sectors are typically geographically dependent on the local population, they are unlikely to expand disproportionately unless an area experiences large population growth. The distinction between traded and non-traded industries explains why manufacturing or IT clusters may drive productivity gains, but healthcare clusters may not.
86. The hypotheses above suggest that areas with clusters or high-industry concentrations, especially within traded industries such as manufacturing or IT may experience high rates of productivity growth. Therefore, industry concentration, or a similar proxy for regional clusters, should be included in the analysis of a region's productivity growth. Additionally, a supply of suitable housing in an area could aid in the development of regional clusters by creating additional incentives for firms and workers to relocate, indicating a relationship with housing growth.

Demand channels

87. For some areas, the act of building could be transformative in terms of the level of new investment to the area. The housebuilding industry makes significant contributions to the local economy in the form of direct and induced employment²⁶, and financial contributions to local authorities and local areas, generating increased demand and keeping local areas competitive.
88. As reported in the 2023 Annual Employee Estimates from the ONS (2024), the housebuilding industry directly employed an estimated 285,100 people in Great Britain, equating to 18% of total construction sector employment. Further, housebuilding and the construction sector more generally offer a crucial labour market entry point for young workers or workers with lower levels of skills, as well as those moving out of unemployment. A sample survey of housebuilding firms carried out by the House Builders Federation (2018) found that across England and Wales, there were approximately 4,300 apprentices, 525 graduates, and 2,900 trainees employed within the industry.
89. Outside of those working directly on-site within housebuilding projects and for housebuilding firms, on behalf of the National Housebuilding Foundation, the Centre for Economics and Business Research (CEBR) found that for every job in the construction industry, 1.5 indirect and induced jobs are created elsewhere in the economy (National Housebuilding Federation, 2018). Based on this evidence, the act of housebuilding itself has the potential to increase employment and raise productivity especially in areas where there may be low starting levels of skills and high rates of unemployment.

Summary

90. Concluding, the literature establishes that local productivity can be impacted by a range of factors, including resource and skill endowment, the formation of clusters or industry agglomeration, and increasing demand through housebuilding itself. Therefore, when exploring the relationship between housing stock growth and productivity growth and what drives this combination of factors, these elements should be considered.

Results from the QCA

91. The results of the QCA show that local authorities that had high starting skills endowments, high starting productivity, high levels of industry concentration, and low levels of starting housing stock, were more likely to have experienced both high housing stock growth and high productivity growth.
92. Specifically, QCA revealed that the combination of starting conditions associated with observing a very high probability of both above-average housing stock growth and above-average productivity growth from 2012-2022, referred to in QCA as the "primary combination", were:
- Above-average starting skills endowment
 - Above-average starting productivity
 - Above-average industry concentration (after excluding primary, industry, wholesale, and retail activities)
 - Above-average starting housing stock endowment (although this condition appears to be least important)
93. Out of the sample of 252 local authorities, there were eight local authorities that possessed this combination of conditions (e.g., high skill levels, high starting productivity, high industry concentration and high housing stock endowment): Cambridge, Hart, Reading, Runnymede, Rushmoor, South Derbyshire, Surrey Heath, and Wokingham. Of these local authorities, all of them also had both high housing stock growth and high

²⁶ Direct employment refers to employment within the housebuilding industry specifically, where induced employment refers to employment created as a result of housebuilding activity generating additional income for households to spend on goods and services in the economy.

productivity growth, apart from Reading which exhibited above-average housing stock growth, but below average productivity growth from 2012-2022.

94. The QCA also uncovered that local authorities that had both above-average starting levels of deprivation and above-average starting levels of productivity also were associated with a higher probability of having high housing stock growth and high productivity growth. Bolsover exhibited this combination of factors.

Results from the Linear Probability Model

95. An alternative way to display the findings of the QCA is to include the set of conditions in simple Linear Probability Model²⁷. Each of the five yes/no conditions included in the QCA is included in Specification 1 below. The variable QCA combination of conditions is a dummy variable equal to one if a local authority possesses all the conditions identified in the primary combination (above-average starting skills endowment, below average starting housing stock endowment, above-average starting productivity, and above-average industry concentration), and zero otherwise.
96. Specification 2 carries out step-wise removal of variables that are statistically insignificant to simplify interpretation of the model and hone in on the most significant factors, resulting in the inclusion only of the starting level of skills, the starting level of productivity and the primary combination of conditions identified by QCA. Alongside those five individual conditions, the primary combination of starting conditions for a high probability of success (described in the QCA results above) is included as an additional dummy variable. Table 5 shows the full results from both specifications.

Table 5: Results from the Linear Probability Model

Variable	Specification 1	Specification 2
Above-average starting skills	0.092	0.120*
Above-average starting housing stock	0.099	1.2
Above-average starting productivity	0.121*	0.162*
Above-average starting industry concentration	0.080	-
Above-average starting deprivation (IMD)	-0.078	-
QCA combination of conditions	0.580*	0.593*

**denotes 5% level of statistical significance based on robust standard errors. N=252*

97. The table above shows the probability of having the combination of high housing growth and high productivity growth, based on the factor given in the column “variable”. For example, an area with an above-average starting productivity is 12 percentage points more likely to also have the combination of above-average housing and productivity growth than an area with a below average level of starting productivity, according to the first specification.
98. Key findings from the linear probability model match those from the QCA. Specifically, local authorities that had above-average starting skills, above-average starting housing stock, above-average starting productivity, and above-average starting industry concentration were associated with a higher probability of experiencing high

²⁷ The Linear Probability Model conducts Ordinary Least Squares regression analysis with a binary dependent variable.

housing growth and high productivity growth, as compared to local authorities who had below average levels of those factors. The variable “QCA combination of conditions” which includes interactions between the factors identified in the primary combination from the QCA had the strongest association with high housing growth and productivity growth.

99. After removing insignificant variables, Specification 2 demonstrates that local authorities that have an above-average starting skills endowment, and an above-average level of productivity are significantly associated with having high housing growth and high productivity growth, as compared to local authorities with below average starting skill endowments. As with the first specification, the primary combination of conditions had the strongest association with the combination of housing growth and productivity growth, increasing their probability by around 59%.

100. It should be noted that the independent variables presented in the table above and explored in the QCA only represent the association between the combination of high housing stock growth and productivity growth and the factors explored above, and do not imply a causal relationship. Therefore, the analysis above alone cannot establish that the combination of high housing stock growth and high productivity growth is caused by any of the factors above, or that any of the factors above are caused by high housing stock growth and high productivity growth, as the relationship may be influenced by other, unexplored factors. In order to explore these relationships in more detail, a smaller number of detailed case studies have been undertaken, informed by analysis of both qualitative and quantitative data.

Rationale for the selection of case study areas

101. Based on the QCA and LPM analysis, a long list of 9 local authorities has been established to examine in more detail as case studies. While quantitative analysis of data from a large number of areas can uncover what factors are associated with housing growth and productivity, detailed case studies, drawing on both qualitative and quantitative data can shed more light on why these relationships exist, and how they might vary from area to area. At this point, areas have been prioritised where (a) the extent to which the main town or city is well contained in one local authority, making it a meaningful cluster or unit of analysis, (b) there is a specific industry concentration, that may lend itself to productivity gains and (c) no area is too close to any other long-list case study options (as it may violate its ability to be analysed independently) and (d) is not within the area of Greater London, as these local authorities are unlikely to make up a meaningful unit of analysis independent of their surrounding LAs.

102. These factors will allow us to create a list of case studies informed by economic theory and the high-level analysis that are likely to yield the most useful set of lessons learned from the case study analysis.

103. The local authorities taken forward as case study areas are:

- **Cambridge LA**, which is a well-known case of high housing supply growth being coupled with high productivity growth and appears to be a well-defined cluster.
- **Wokingham LA**, which appears to be a well-defined cluster with a focus on ICT and a single largest town (Wokingham).
- **South Derbyshire LA**, which has a concentration of local manufacturing businesses and has a large single urban area (based around Swadlincote).
- **Bolsover LA**, which is a well-defined cluster around a single town (Bolsover) and a case of successful growth in housing supply and productivity despite a high starting level of deprivation.
- **Rushmoor LA**, a relatively well-defined ICT cluster with two towns (Farnborough and Aldershot).

104. From the long list of case studies, the following options were excluded:

- **Reading LA**, which, is included within the long list as it possesses the primary combination of QCA conditions (e.g., high starting skills endowment, above-average starting housing stock, high industry concentration, and high levels of productivity). However, it is the only LA that didn't experience the combination of above-average housing supply growth and above-average productivity growth. It is excluded from the short list on the basis that it may be less comparable with other LAs and is less likely to generate useful lessons on economic growth.
- **Runnymede LA**, which is very close to Greater London and therefore not a good candidate to consider as a cluster, (based on the reasons provided above).
- **Hart LA**, which is not well-defined as a cluster and situated next to Rushmoor LA, indicates that any effects observed in Hart may be influenced by activity in the surrounding areas, making it difficult to analyse as an independent unit.
- **Surrey Heath LA**, an acceptably well-defined manufacturing cluster with a single largest town (Frimley). Surrey Heath is not included in the short list as it is less well-defined as a cluster relative to other long-list options, based on it being less clearly centred around one town or centre, and its proximity to London.

9. Findings from analysis of local case studies

105. Based on findings from the QCA, five case study areas were identified to further investigate the relationship between productivity growth and housing growth. These five case studies include: Cambridge, Rushmoor, Wokingham, Bolsover, and South Derbyshire. Each case study area had experienced above-average housing growth and above-average productivity growth in the period from 2012-2022. Case studies were developed further through the analysis of secondary data, a review of relevant grey literature and policy documents from each area, and interviews with local experts and representatives. Mixed methods analysis revealed local factors driving housing growth and productivity growth, and uncovered patterns and trends across areas. Key themes from the case studies are presented in detail below.

Productivity growth is being driven by the expansion of highly productive sectors

106. Data analysed on productivity, as measured by average output per hour worked, confirmed that all areas experienced an above-average increase in productivity.

107. Across all five case study areas considered in the research, productivity growth of the local area is explained by the growth of highly productive sectors, relative to those that are less productive. The sectors that experienced the fastest expansion in output (GVA), were also those with above-average starting productivity, therefore leading to overall greater productivity of the local area. These findings support the hypotheses provided in Section 8, on the role of industry specialisation and agglomeration. More detail is provided on each case study area below. Relevant sectors were identified through the desk-based review and engagement with key local stakeholders.

- In Cambridge, the professional, scientific, and technical activities sector grew in terms of GVA from 2011-2022. While productivity per hour worked of the sector (£41) is only slightly higher than the average output per hour of the local economy as a whole (£40), it consists of several sub-sectors with substantially higher productivity and may have experienced significant expansion in its size, to ultimately drive overall industrial productivity in the area. For example, the subsector scientific research and development has a higher output per hour worked (£81) and had experienced rapid growth in the area.
- Wokingham experienced significant GVA growth in the Information and Communication sector from 2011-2022, which has an average output per hour worked of £72, much greater than the UK average. This is in line with the growth of the high-tech and IT cluster in the M4 Corridor.
- Rushmoor experienced significant GVA growth in the Rental and Leasing activities sector. This is likely based on the expansion of the airline leasing sector in the area, supported by the expansion of Farnborough Airport and the Farnborough Aerospace Centre. The Rental and Leasing sector has an output per hour of £72, which is much higher than the UK average, and is therefore responsible for some of the productivity growth of the local area as a whole.
- Bolsover experienced an increase in GVA in the transportation and storage sector. This was confirmed by the importance of warehousing and logistics businesses to the area, along the M1 in particular. The transportation and storage sector has an output of £71 per hour, greater than the UK average.
- South Derbyshire experienced a large increase in GVA of the manufacturing sector. While the productivity of the manufacturing sector is in line with that of the average for the whole economy (£39), this is not true for all manufacturing sub-sectors. The UK-wide output per hour for the “manufacturing of machinery and equipment” was £64 per worker, greater than the UK average. The growth of these sub-sectors with above-average productivity would drive overall productivity growth of the local area.

108. Findings from the interviews and review of local policy documents and literature confirmed the importance of these industries to the local economy, with some areas specifically prioritising the growth of these sectors

through grants and loans to relevant businesses and favouring key sectors in planning applications and development.

Agglomeration

109. In some areas, growth of higher productivity sectors was associated with agglomeration or clustering effects, where several related businesses benefit from being geographically closer to one another, such as by taking advantage of information and technology spillovers, sharing resources and a pool of skilled workers, and having lower transportation and infrastructure costs between businesses in the supply chain.
110. The presence of clusters as a facilitator to productivity growth supports the hypotheses set out in Section 8 on the role of agglomeration, highlighting the importance of industry specialisation and concentration. Examples of key clusters uncovered through the case studies are provided below.
111. In Cambridge, key industries included life science, biotechnology, and research and development, which have been developed over time based on proximity to Cambridge University and a high concentration of life sciences businesses and research centres. Cambridge City Council specifically supports the development of these clusters through “selective management of the economy”, in which planning permissions favour businesses supporting the sector cluster and have a proven need to be close to the university (Cambridge Local Plan, 2006). Stakeholders in Cambridge highlighted the importance of agglomeration effects in drawing businesses to the area, citing key “pull factors” to Cambridge as being its pool of skilled workers, the potency of the Cambridge brand, information spillovers, and the existence of spontaneous collaborations that can occur amongst the business and research ecosystem in Cambridge.
112. Stakeholders were mixed on the extent to which the growth of the cluster has contributed to inequality in the area. One stakeholder added that there is the perception that Cambridge is becoming a two-speed city, with many locals feeling like they “aren’t a part of things”. The Local Plan also cautions against over-prioritisation of industries within the cluster, due to potential inequality implications. However, other stakeholders discussed that growth of the innovative economy has also led to growth in the “foundational” or “supportive” economy, in sectors such as service, healthcare, and childcare, creating jobs and opportunities for people not directly employed within sectors within the cluster. However, another stakeholder added that the cost of living in Cambridge has created issues recruiting within the functional economy.
113. In Wokingham, a third of GVA is driven by activity in the IT and communications sector. The IT cluster in Wokingham, as well as that along the wider M4 corridor, has drawn in several large multinational businesses including Johnson and Johnson, the National Grid, Bayer, and PepsiCo. The presence of these large organisations in Wokingham is likely to have contributed to productivity growth and furthered agglomeration and industry specialisation in the area. Stakeholders also cited the importance of Wokingham’s good connections to London, Heathrow, and Reading as additional pull factors for businesses.
114. In Rushmoor, a significant aviation and leasing cluster has developed around Farnborough Airport. Following a transition from Ministry of Defence (MoD) management to private ownership in 2007, annual flights increased from 28,000 to 50,000 (Rushmoor Borough Council). This expansion of the airport was cited by stakeholders as being a key driver of the expansion of rental-related activities, such as the booking of private jets, helicopters, limousines, hangar space rentals, and associated insurance services.
115. The aerospace cluster is also served by Farnborough Aerospace Centre, home to several large multinational businesses within the cluster including Airbus, BAE Systems, Lockheed Martin, and Sodexo. One stakeholder also noted that the growth of the finance and insurance sector (which also has a high average output per hour), can partially be explained by demand from these large multinationals. This indicates that similar to patterns identified in Cambridge, growth in one specialised sector can result in spillovers to the wider local economy.
116. There is evidence from South Derbyshire of similar agglomeration effects. The area benefits from the presence of a large Toyota plant in the locality, as well as a Rolls Royce plant in a neighbouring district, contributing to an automotive manufacturing cluster. Around these two larger businesses, over 250 smaller manufacturing

businesses have emerged (South Derbyshire District Council, 2016). These businesses can draw on workers with specialist and relevant skills and generate business by serving specific parts of the supply chain, creating opportunities for a large pool of workers.

Transport is important for growth

117. In areas where clusters and agglomeration were less central to productivity growth, connectivity to surrounding areas and large economic centres were key drivers of productivity. In Rushmoor, South Derbyshire, Bolsover, and Wokingham; stakeholders specifically noted that proximity to other large urban centres contributed to population and productivity growth and influenced the growth of key sectors.
118. While in Bolsover there was less evidence of a distinct sectoral cluster, or agglomeration effects, the transportation and logistics sector has played a large role in the local economy and expanded in recent years. This industry is served by warehouses in the district being easily connected to London, ports in the South East, and other logistics hubs in the Midlands, highlighting the importance of connectivity to the growth of the area. Further, Bolsover's connection to other local areas and larger employment centres has contributed to the growth of the area, based on workers living in the district and commuting elsewhere for work. Similarly in South Derbyshire, inward migration has been driven by good connectivity to urban centres such as Derby, Birmingham, Leicester, and Nottingham.
119. In contrast, a lack of transport infrastructure was noted by stakeholders as a barrier to further growth in Rushmoor. However, key infrastructure investments in this area included (i) upgrades to the M3 motorway, including smart motorway technology, (ii) the construction of dedicated bus and taxi lanes at Farnborough station, and (iii) improvements to local roads to improve connectivity and further economic growth.
120. In Wokingham, interviewees believed that significant investment in transportation infrastructure is likely to have contributed to the observed productivity growth. These improvements have enhanced Wokingham's transport connectivity, making commuting to and from the area easier. These upgrades are particularly relevant for Wokingham given that, according to the 2021 Census, 35.5% of residents travel more than 10 km to work, indicating a high level of commuting to nearby employment hubs like Reading or London. In turn, these improvements may facilitate more workers commuting into Wokingham and make it a more attractive location for businesses.
121. In summary, transport infrastructure and connectivity can spur growth by (i) facilitating the movement and commuting activity of workers, and (ii) generating additional opportunities for local businesses.

Housing supports the expansion of productive sectors

Meeting housing demand

122. All areas have experienced positive inward migration and population growth, broadly corresponding to the growth of key sectors which indicates an increase in the local workforce. As a result, all areas experienced an increase in housing demand.
123. There were similarities across case study areas in terms of how housing demand was met. Increased land availability facilitated housing growth in all case study areas, with all areas having newly acquired brownfield sites or releases of land from green belts. In some cases, those interviewed reported that land availability was a key constraint to further industrial growth, by affecting the amount of space for business activities and housebuilding to ensure an adequate supply of local workers.
124. Where brownfield or green belt land was not available, regeneration of areas with poor quality housing stock was used to increase housing supply. In two case studies (Bolsover and South Derbyshire), housing growth was focused on development or regeneration of previously deprived towns within the locality. This served a dual purpose of providing additional housing close to employment centres to meet demand, while also redeveloping

a struggling or previously less-desirable area. These areas may also provide more affordable housing stock. Specific examples of regeneration or the use of newly available land from the case studies are provided below.

125. In Wokingham, housing growth was planned around specific strategic development locations (SDL), chosen based on their proximity to existing amenities, while still acting as distinct communities in their own right. One such strategic location was the Arborfield Garrison, previously owned by the Ministry of Defence. The site was planned to provide up to 3,500 new homes as well as local amenities and green spaces. The other SDLs in Wokingham are also large sites, allowing for the planned development of 1,500-2,500 homes at each of the three additional sites, which has only been achieved due to land availability.
126. The strategy for housing growth in Cambridge was also predicated on new land becoming available. The Local Plan (2006) outlined that the release of 5-6 sites from the Green Belt around Cambridge would allow for the development of 6,000 additional homes between 1999-2016. In reality, Cambridge did see significant housing growth and the development of urban extensions throughout the study period. Similar to Wokingham, other development sites in Cambridge were planned in response to different local needs, including regenerating areas of poor-quality housing, or urban extensions accommodating population growth and increased housing demand.
127. Part of the plan for housing growth in Rushmoor included the development of an urban extension to the town of Aldershot, consisting of 4,250 new homes by 2027. Aldershot was identified by the council as a “step-up town”, in contrast with Farnborough which was designated a “growth town”. A step-up town was a designation added to towns and villages in the Hampshire region by the LEP, indicating that while they had potential for future growth, their current economic performance was below the regional average (Enterprise M3, 2014).
128. Growth towns like Farnborough were expected to deliver one-third of the jobs and GVA in the Enterprise M3 region, (a group of 30+ local enterprise partnerships centred around the M3 Motorway) with potential for growth above the UK average. Step-Up towns, like Aldershot, were identified as areas with latent economic potential, hindered by barriers to growth. Investment in housing in Aldershot was coupled with investment in transport and infrastructure to link housing in the town with more prosperous areas and more employment opportunities, including Farnborough. Housing in Aldershot was also relatively more affordable, as compared to other areas.
129. The housing strategy in Bolsover consisted of both regeneration of deprived areas and repurposing of land previously used for the mining industry. Bolsover has undergone significant regeneration since the decline of the coal mining industry in the 20th century. According to the Northeast Derbyshire and Bassetlaw House Market Area: Local Investment Plan Draft 2011-2014 (governing the start of the study period) over £38.5 million has been spent on reclaiming 115 hectares of brownfield land for residential and employment use in Shirebrook South. Further, over £88 million has been invested into regenerating the Markham Colliery site located near the town of Bolsover. The aim of this investment was to transform the district and contribute to the environment and the quality of the area. Interviewees purported that these regeneration activities contributed to increased housing demand, by attracting new residents to the district. The District Council’s Housing Strategy Action Plan for 2021-2024 highlights that the regeneration of Brownfield sites and new development within towns remains a key priority to enable growth, and ensure the district remains attractive.

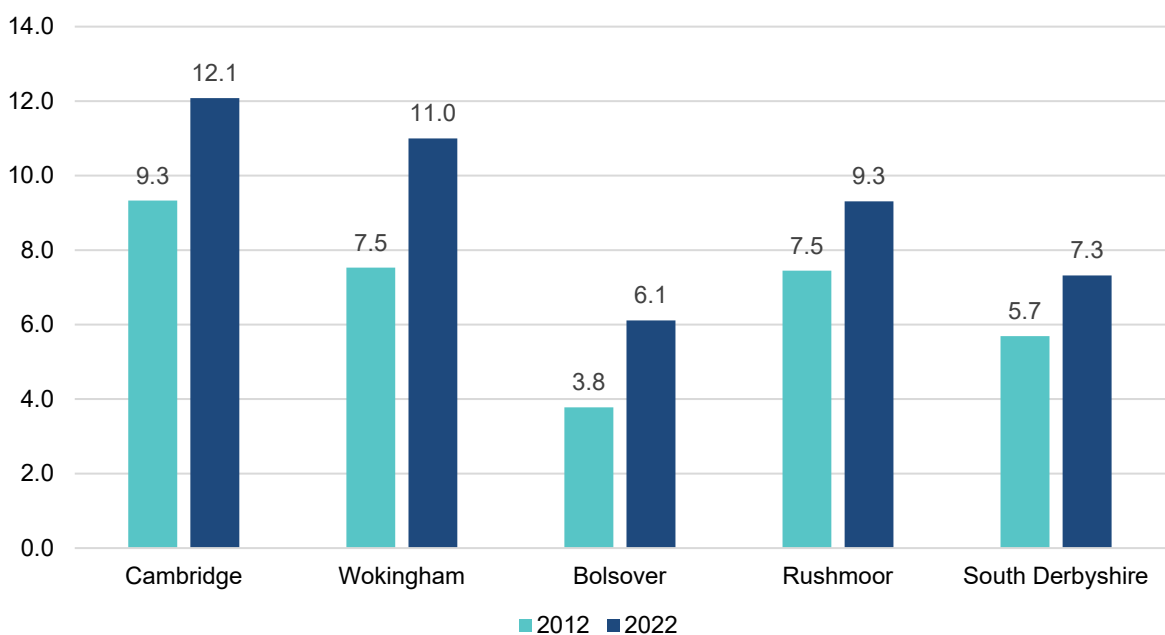
Joined up working and collaboration with developers

130. A key theme mentioned by stakeholders was the importance of joined up working and collaboration with developers to increase housing supply. Several local authority representatives noted the importance of maintaining positive relationships with developers to attract new development into their area. The importance of capacity within the local authority was also noted as a key factor in facilitating housing growth. For example, it was mentioned that when local authorities were able to dedicate more resources and officers to planning, this facilitated faster turnaround of planning applications and allowed for better collaboration with developers. Stakeholders added that collaboration with neighbouring local authorities and planning departments can contribute to sustainable housing development and allow for more housing demand to be met by spreading growth across a wider area.

Housing stock growth must be accompanied by other policies to address key issues

131. All areas which experienced high productivity growth also experienced a reduction in the affordability of housing, driven by greater demand for housing from workers moving into the area. Some case study areas remained relatively more affordable than neighbouring districts, driving inward migration. However, the resulting demand for housing also led to an acceleration of house prices, therefore placing pressure on affordability. The following figure shows the house price to earnings ratio, in each case study area in 2012 compared to 2022. In all areas, the ratio has increased, indicating all areas became less affordable. In England, the average house price to earnings ratio has increased from 6.8 in 2011 to 8.3 in 2022.
132. Across the case studies, the reducing affordability of housing was cited as a key challenge for maintaining an adequate supply of local workers. This would suggest that a lack of affordable housing may constrain the expansion of highly productive sectors and therefore economic growth.

Figure 5: House price to earnings ratio, 2012 versus 2022



Affordability of housing

133. Case study areas took different approaches to the provision of affordable housing, with stakeholders across all areas highlighting affordability as a key challenge, both in terms of maintaining a stock of below market rate social housing, as well as providing housing that is reasonably affordable for someone on an average salary for the area.
134. Cambridge has the highest house prices to earnings ratio of all case study areas, with one stakeholder noting that while high earners are moving into Cambridge, workers such as lab technicians, nurses, and other non-managerial roles are forced to move into the fringes or out of the area altogether, hampering recruitment in key sectors. To alleviate these issues, stakeholders mentioned developments and proposals for targeting the provision of affordable housing to specific workers deemed as key to local businesses and clusters. These included Eddington, which provides below market rate flats for university workers, and the Wellcome Trust, which one stakeholder noted would provide thousands of units of housing for their workers once completed. There were also proposals put forward to build a similar development, serving healthcare workers at Addenbrooke’s Hospital.
135. The development of these types of affordable housing products allows Cambridge to continue to grow key clusters, by targeting housing offers to key workers who may not otherwise qualify for affordable housing but may struggle with the cost of living in Cambridge. However, stakeholders also noted several challenges and

limitations of these types of solutions, with a few stakeholders concerned with the inequality implications of prioritisation of these types of schemes. For example, key worker housing needs to be balanced with more general options, as the most vulnerable, or those at risk of homelessness are likely unable to qualify for specialist schemes. One stakeholder mentioned that this strategy could be done in a “less specific” way, giving the example of new housing developments in the North East of Cambridge, which serve workers in the science parks, without being owned by the parks themselves.

136. Similar to Cambridge, increasing unaffordability and unavailability of housing in Wokingham have led to recruitment issues in some key industries. Further, demand for council-owned properties is high, with, according to the Wokingham Housing Strategy (2010), seven applicants on average to each available socially rented property, indicating that affordability and availability of social housing was challenging even at the start of the study period. However, unlike Cambridge, Wokingham has not committed to strategies targeting specific industries, instead using a more general strategy for the provision of affordable housing.
137. In contrast, Rushmoor's relative affordability compared to London has played a significant role in attracting new residents. Based on ONS private rental market statistics, in 2022, the median house price in Rushmoor was £412,000 lower than in London, and the monthly rent for a one-bedroom apartment was £475 less. These cost differences, coupled with the convenient 50-minute train journey to London, make Rushmoor an attractive option for those looking to reduce living expenses while remaining close to major urban centres. The 2016 Aldershot town prospectus²⁸ identified Rushmoor as having a relatively young population and strong demand from young professionals looking to move to the area. Interviews supported these findings, with respondents describing Rushmoor as “the most affordable part of Hampshire” for those wanting proximity to London without the high housing costs.
138. While South Derbyshire benefits from having more affordable housing than the national average, house prices within the district are greater than those in other districts in the Derby Housing Market Area²⁹. The median house price in South Derbyshire in 2022 was £230,000 compared to £188,000 in Derby, and £195,000 in the Amber Valley.
139. Bolsover is the most affordable area, relative to other case studies in consideration. However, the district has experienced a reduction in its stock of council housing over time. Socially rented housing occupies the second largest share in housing within Bolsover (18%), behind privately owned homes (67%). The private rental market itself plays a small role and is often of poor quality, as revealed by a stock condition survey conducted in 2014. Apart from the increased demand for housing, this creates an additional need to increase the number of dwellings within the district. Accordingly, the Bolsover District Council has undertaken several steps to provide affordable housing within the district. As per the Bolsover Local Plan Strategy 2013, allocations would be made to ensure sufficient land for the proposed delivery of more than 5,000 homes between 2011 and 2031.

Transport links and connectivity

140. Transport infrastructure may come under greater pressure if there is a significant expansion in housing stock. Increased road congestion was seen as a key challenge in several areas, including Cambridge, particularly where housing stock was delivered through increasing “densification” of urban areas. Reduced housing affordability was associated with increased numbers of workers commuting in from more affordable surrounding areas, further contributing to congestion issues. In addition, stakeholders noted that planning should ensure that new housing developments, particularly those that are distinct from existing urban centres, are well connected and have good transport connections.
141. While transport and congestion remain a barrier to housing growth, investment in key transport options both within Cambridge city and the wider area, allowed for further growth. Key investments include the opening of

²⁸ 2016 falls within the study period of 2012-2022.

²⁹ Housing Market Areas are groups of local authorities that have functional relationships with one another with regards to commuting, transport, and housing. The HMA allows them to take a more joined up approach to planning. The Derby HMA includes the Amber Valley, Derby, South Derbyshire and Derbyshire County Council.

Cambridge North train station, which will serve both residential areas and business parks making up a key part of the cluster, the guided busway and new city centre bus routes, connecting Cambridge to housing in Huntingdon and Trumpington, and significant investment in new and existing greenways and cycle infrastructure. One stakeholder noted that once these elements are introduced, travelling to and from work and home will be significantly easier. Another stakeholder added that the result of previous investment in transport infrastructure can already be seen in new developments like Northstowe, which are served by a number of options including divided cycle and busways, and have seen a reduction in congestion in recent years.

142. While transport and connectivity to large urban centres was a contributor to growth in some areas, rapid population growth and housing expansion generated congestion problems within areas. For example, within South Derbyshire, the Swarkestone Bridge and Causeway is one of the only roadways that crosses the River Trent in the North of the district. The bridge currently lacks the capacity to support current traffic volumes, leading to congestion. Interviews with stakeholders from Derbyshire suggested that this barrier restricts the extent to which South Derbyshire can grow further, and further benefit from proximity to Derby.

Deprivation and inequality

143. Greater unaffordability of housing has implications for inequality. In order to examine inequality in high housing growth and high productivity areas, spatial analysis of LSOA level data on deprivation and population density was undertaken. In the maps below, areas shaded more darkly are areas experiencing greater levels of deprivation, based on the 2010 and 2019 indices of multiple deprivation. Dots on the map show the most densely populated LSOAs, representing major towns or population centres.

Figure 6: Deprivation decile and population density in Wokingham, 2010 vs 2019

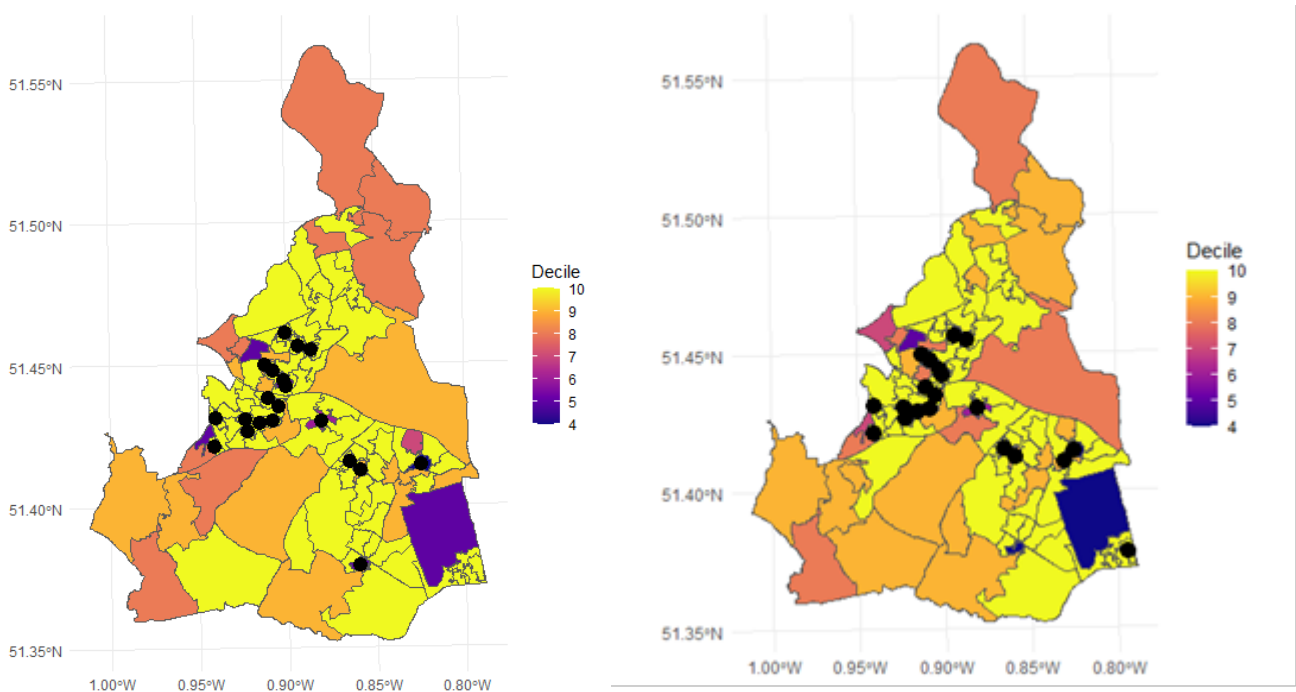


Figure 7: Deprivation decile and population in Cambridge, 2010 vs 2019

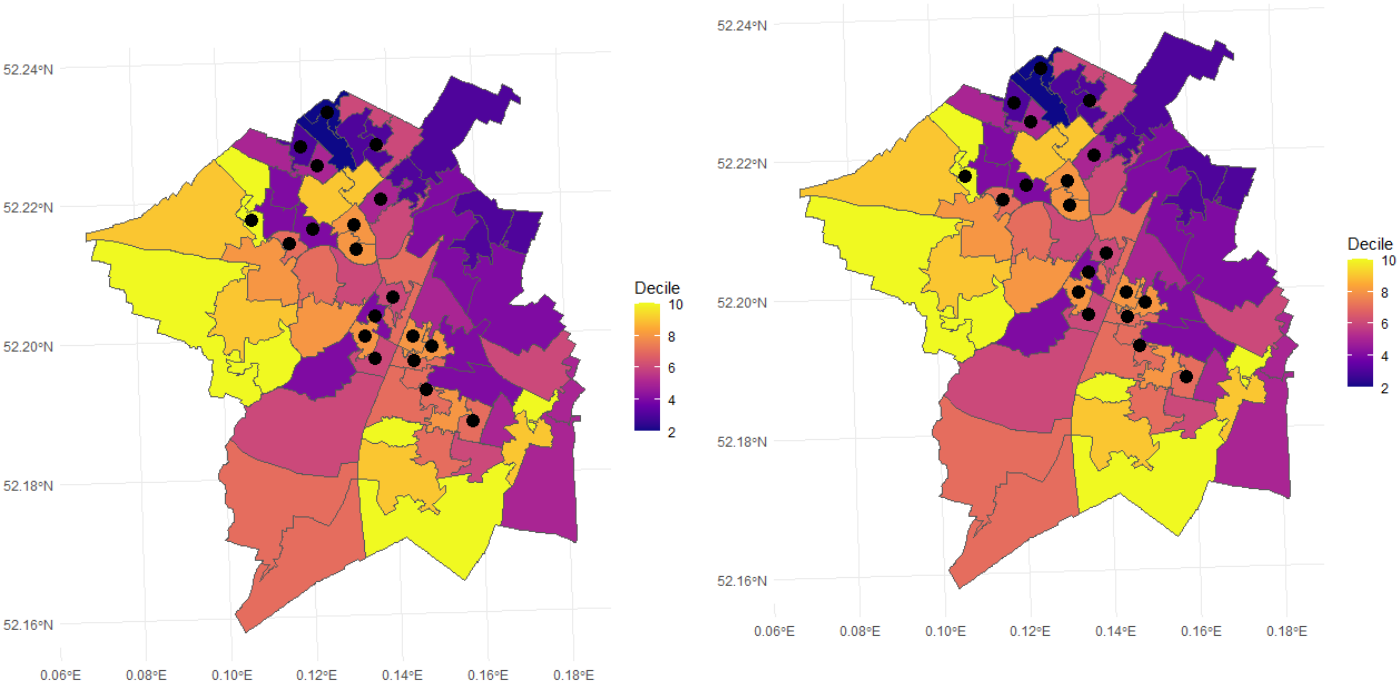


Figure 8: Deprivation decile and population density in South Derbyshire, 2010 vs 2019

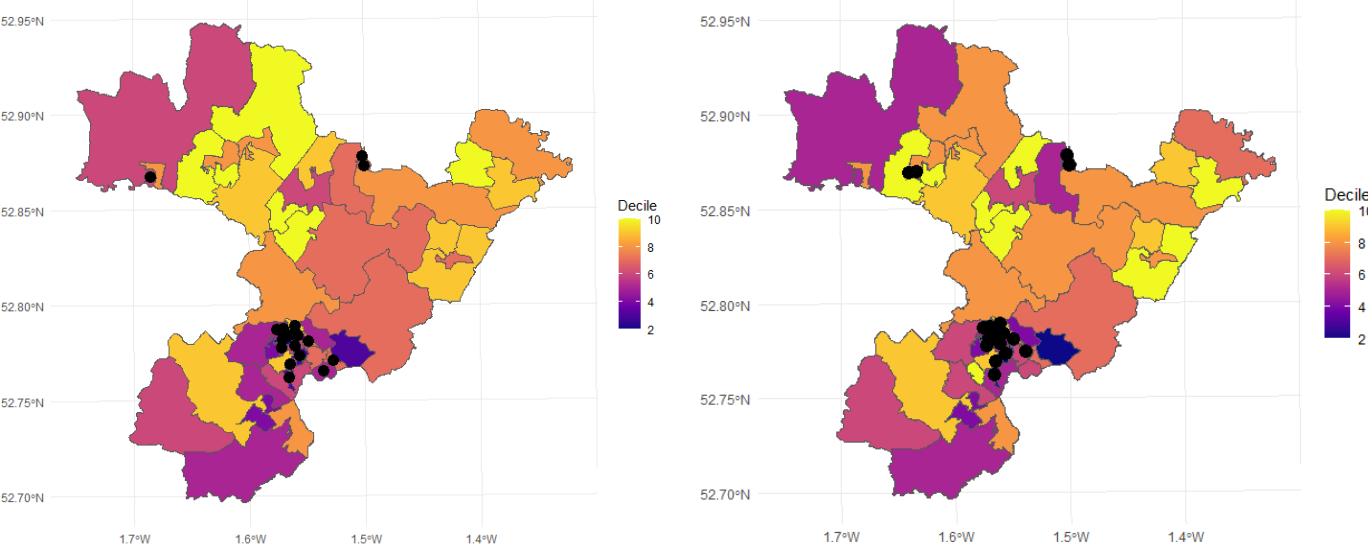


Figure 9: Deprivation decile and population density in Bolsover, 2010 vs 2019

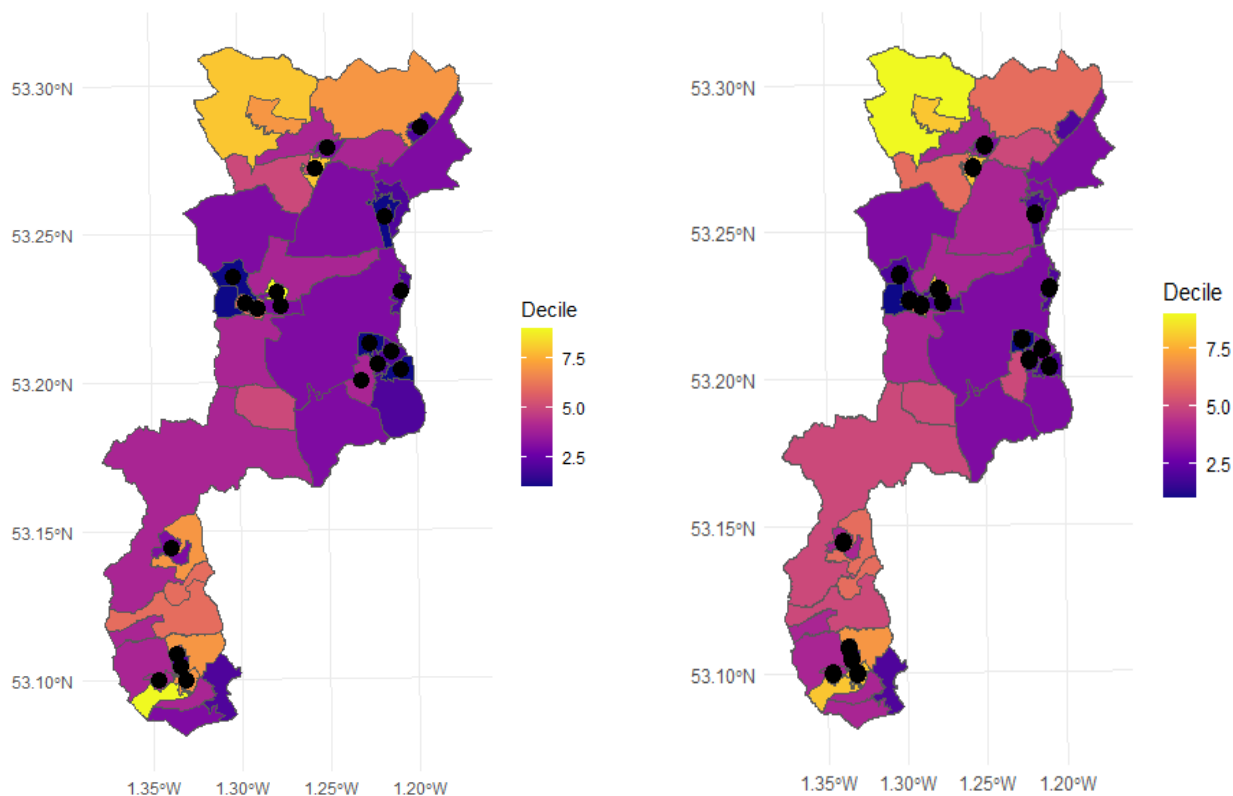
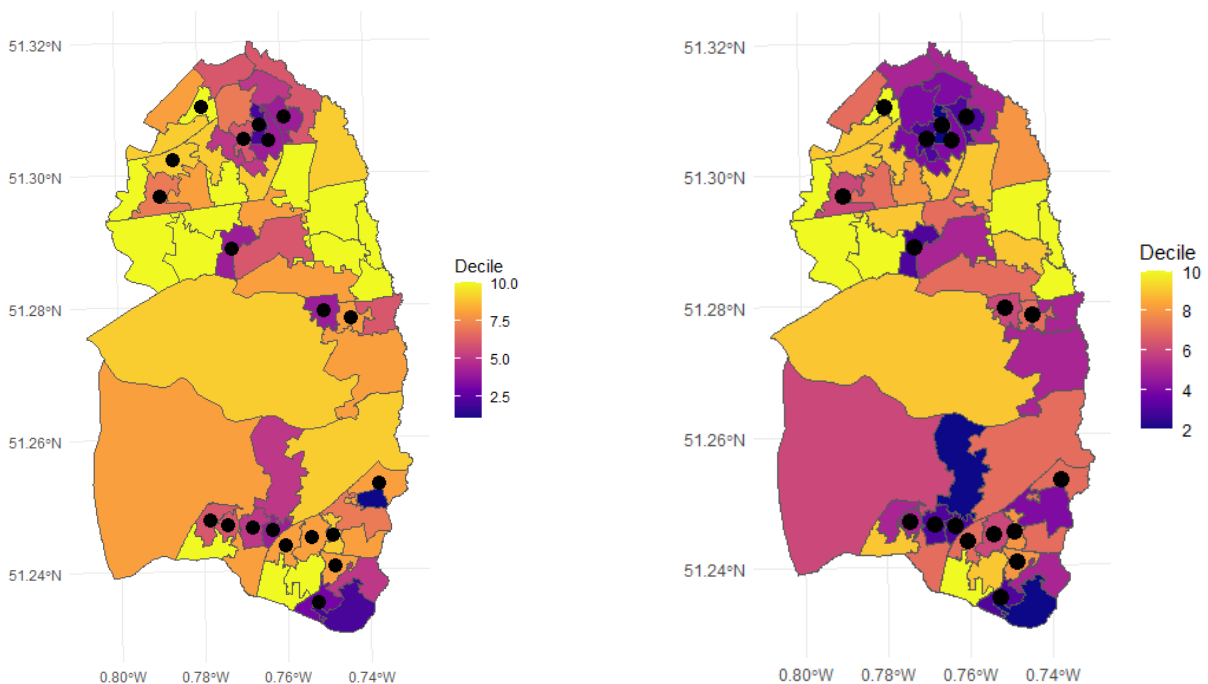


Figure 10: Deprivation decile and population density in Rushmoor, 2010 vs 2019



144. There are not many notable changes in deprivation across case study areas over the period of interest. This is likely based on deprivation being a slow-moving impact, meaning it may take longer than 10 years for there to be visible changes. Based on this data, productivity growth and housing becoming increasingly unaffordable does not seem to have impacted deprivation at a local level. However, it is recognised that such impacts may occur over a much longer time horizon and may not yet be observable.
145. In four out of five case study areas, notably Rushmoor and Bolsover, areas of dense population are also the most deprived areas. This may suggest that a high number of residents are being priced out of low-deprivation areas based on increased unaffordability, however, this cannot be assumed from data on deprivation alone. The only area where this trend does not hold is Wokingham. Wokingham is an outlier with regards to deprivation based on having less variation amongst LSOAs and being less deprived overall.

10. Conclusion from case study analysis

146. The QCA found that local authorities that had above-average starting levels of: skills, housing stock, productivity, and industry concentration, were associated with a higher probability of subsequently experiencing higher housing growth and high productivity growth, as compared to local authorities who had below average levels of those factors. Additionally, local authorities with a combination of above-average starting levels of deprivation and above-average starting levels of productivity were also associated with high growth in productivity and housing.
147. **Housing can support productivity growth in areas experiencing growth of productive sectors with agglomeration effects.** As shown through the case studies, productivity growth is associated with increasing inward migration, leading to greater housing demand. Housebuilding allows growing sectors to access local labour supply by providing housing near to jobs and other amenities. While all case study areas experienced growth in housing broadly in line with growth in productivity, a causal link between the two factors could not be confirmed due to the mixed methods nature of the research activity and lack of data at a granular level.
148. For housebuilding to support productivity growth, it should be targeted in areas with promising industrial clusters that are expected to grow in future, to ensure there are enough workers to fuel this growth. Across case study areas, such as Wokingham and Cambridge, stakeholders highlighted that unavailability of housing was a key push factor for some businesses deciding whether or not to locate or stay in the area. Business representatives noted that when housing was scarce, it was difficult to recruit skilled workers which potentially may constrain future growth. It should also be noted that this applies both to housing within the immediate area, as well as surrounding areas for workers that would commute in for work. It is, therefore, important that housing policy is considered alongside industrial growth. The findings of the QCA indicate that this targeting of house building might already be happening, as it identified that above-average levels of industry concentration and productivity levels were associated with higher future housing growth and high productivity growth.
149. Housing affordability becomes a key challenge in areas experiencing productivity growth, indicating a role for affordable housing. Increasing unaffordability was a key theme across all case study areas, which experienced rising house prices as a result of increased housing demand. This also affects recruitment in foundational sectors and public services such as childcare and healthcare which may be priced out of the housing market. A lack of affordability is likely to result in more workers living in surrounding “cheaper” areas and commute in for work. However, this is unlikely to be a sustainable solution given these surrounding areas will subsequently experience a decline in affordability over time. While increasing the general supply of housing may help, it is important that there is a supply of housing that is affordable for local residents in order to mitigate inequality impacts on those with lower incomes.
150. **It is important to consider both housing that is affordable, as well as affordable housing programmes.** The case studies demonstrated ways in which local authorities can expand the supply of affordable housing, with some examples of programmes which target workers in key industries. While there is a role for affordable housing programmes to protect those on the lowest incomes, there is also a role for housing that is affordable for workers who may not be eligible for housing programmes but still may find nearby housing too expensive.
151. **Transport infrastructure investment is critical for maximising the benefits of industrial growth and growth in housing supply.** Transport connectivity was seen as another critical factor enabling productivity growth, particularly in case study areas like Wokingham and Bolsover, where good links to other large economic areas supported worker commuting patterns and business logistics. Yet, rapid expansion in population and housing presented challenges in some areas, including congestion in South Derbyshire and Cambridge. New developments, especially those in new communities or urban extensions, should be accompanied by investment not only in transport but also other “soft” infrastructure such as schools, GPs, and shops to attract residents to the area.
152. Housebuilding can be facilitated by improving relationships with developers, and the availability of land should also be considered. All case study areas had newly acquired brownfield sites or releases of land from green

belts, allowing for large new developments. Residential and commercial land availability was also cited as a key constraint to further growth in some areas, which had limited space available especially for specific businesses or functions. Several stakeholders discussed the importance of working collaboratively with developers and neighbouring local authorities and planning services to increase housing supply and remain flexible to increasing demand.

153. Industrial growth is also associated with increased housing unaffordability, which may exacerbate inequality.

Analysis of the relationship between deprivation and population density at the end of the period shows variation in the level of deprivation in the most populous areas. This indicates that a large number of residents are not benefitting from GVA growth in the area, suggesting that additional measures are required to translate productivity growth into wider economic and social benefits.

154. Labour mobility is crucial for ensuring that growing sectors are able to access an adequate supply of workers.

The case studies demonstrated how areas experiencing productivity growth are also associated with inward migration. Given at a national level the supply of workers is relatively fixed, the research highlights the role of labour mobility in allocating this scarce resource across regions. To facilitate this mobility, both the availability of housing that is affordable and transport connectivity are important factors. While availability of high-paying jobs plays a role in a worker's decision to move to an area, housing costs and availability will factor into any financial and practical considerations.

Recommendations for future research

155. Based on the findings, the following section presents avenues for future research into the relationship between housing growth and productivity growth.

156. This analysis sought to investigate the relationship between housing supply and productivity at a local level. This analysis concludes that housing can facilitate local productivity growth, namely by providing an adequate supply of local workers to fuel growth in above-average sectors, however, it is likely to be one of several factors in this role.

157. Further research could be undertaken to examine the role of transport infrastructure in supporting large increases in local housing stock. While transport was a key factor mentioned by stakeholders in the research, a detailed analysis of transport and commuting patterns was out of the scope of the current research. Research could include analysis of (i) the extent to which new housing developments create additional strain on existing transport systems and how much additional capacity is needed to meet demand, (ii) surveys of residents of new developments to uncover preferences and transport use patterns, and (iii) analysis of ONS data on travel to work method and commuting patterns to understand how wider patterns may influence local transport use and housing demand. Ultimately, this research could add to the evidence base around where housing growth should be focused, and what additional infrastructure is needed to promote further growth.

158. Understanding the role of housing affordability could also be further explored, given that the case studies highlight how housing affordability affects commuting patterns and the availability of local labour supply, which in turn may impact growth of key sectors.

159. Other further research could include identifying best practice of how local authorities can work together with developers effectively, as well as how they can work with neighbouring areas to meet demand. Several local authority stakeholders and academics discussed the importance of working collaboratively with developers, and speedy processing of planning applications to facilitate housebuilding in the area. However, Alma were unable to reach developers or housing associations through the research to confirm the extent to which these factors influenced developers in their decisions. Additional qualitative research includes (i) interviews with developers, planning heads, and trade associations, and (ii) in-depth analysis of planning applications and permissions to gain insight into best practice in different local authorities' approach to planning and collaboration with developers and other stakeholders.

160. Key worker-targeted affordable housing, as exists in Cambridge, provided a potential solution to meeting the increased housing demand driven by growth in key clusters. However, stakeholders were mixed with regard to the efficacy of these products and had concerns about potential equality implications and the possibility of specialised housing crowding out more general offers. A **process, impact, and economic evaluation of a key worker housing scheme, such as Eddington or the Wellcome Trust**, could shed additional light on the impact of such programmes, and provide additional insight into the benefits and disbenefits to the wider area.

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12. Annex: Econometric Analysis

Methodology

161. The following equation describes the static version of the baseline model estimated by panel-fixed effects. The dynamic versions include lag values of the affordability variable.

$$\ln(\text{Productivity}_{i,t}) = \alpha + \beta \ln(\text{Affordability}_{j,t}) + \theta_i + \theta_t + e_{i,t}$$

162. where $\ln(\text{Productivity}_{i,t})$ is the natural logarithm of productivity in local authority, i , in year, t , $\ln(\text{Affordability}_{j,t})$ is the natural logarithm of housing affordability in area j , which are aggregated within distance bands (0, 10, 20, 30km) around the centroid of local authority i in year t , θ_i is the local authority fixed effect, θ_t is a year fixed effect, and $e_{i,t}$ is the error term. The two variables are calculated as follows.

$$\text{Productivity}_{i,t} = \frac{\text{Real Gross Value Added}_{i,t}}{\text{Number of jobs}_{i,t}}; \text{Affordability}_{i,t} = \frac{\text{House prices}_{j,t}}{\text{Earnings}_{j,t}}$$

Data

Table 6: Variable definitions and data sources

Variable	Description	Additional information	Source
Productivity	Gross Value Added (GVA) per job filled	This is the dependent variable in the model expressed in real terms, accounting for price inflation—real GVA per job filled. The total number of jobs is a workplace-based measure and includes employee jobs, self-employed individuals, government-supported trainees, and HM Forces. A workplace-based measure is used rather than a resident-based measure to assess productivity at the workplace. A workplace-based measure is more appropriate for assessing productivity, as it aligns output (GVA) in an LA with the number of jobs in the same LA.	ONS
Affordability	House prices-earnings ratio	House prices are the median price paid for residential property across all residential property types. The earnings data provide an estimate of the median gross annual earnings for full-time employees whose pay was not affected by absence. The data does not cover the self-employed. The data is based on a 1% sample of employee jobs taken from HM Revenue and Customs PAYE records. Similar to the productivity measure, a workplace-based measure is used for earnings. The rationale is that the analysis aims to calculate how many annual salaries of individuals working in an LA are needed to purchase a home within the same LA.	House prices: ONS based on data collected from the Land Registry Earnings: Annual Survey of Hours and Earnings (ASHE) obtained from the ONS
Green Belt	Proportion of a local authority that represents Green Belt	Instrumental variable: Green belt share times a time trend was used as instrument.	Ministry of Housing, Communities & Local Government

Planning application refusal rate	Total planning applications refused divided by total planning decisions	Instrumental variable	Ministry of Housing, Communities & Local Government
Share of planning applications decided on time	Total planning applications decided on time divided by total planning decisions	Instrumental variable	Ministry of Housing, Communities & Local Government

Industry composition

Table 7: Industry composition by English regions (2023)

	North East	North West	Yorkshire and The Humber	East Midlands	West Midlands	East	London	South East	South West
Manufacturing	15%	14%	15%	17%	14%	11%	2%	8%	11%
Construction	6%	6%	6%	7%	6%	9%	4%	7%	7%
Wholesale and retail trade; repair of motor vehicles	9%	12%	11%	12%	12%	12%	7%	11%	10%
Information and communication	6%	5%	5%	4%	5%	5%	13%	10%	5%
Financial and insurance activities	4%	6%	6%	3%	5%	5%	18%	5%	6%
Real estate activities	13%	12%	12%	12%	12%	14%	14%	15%	15%
Professional, scientific and technical activities	5%	8%	6%	6%	6%	7%	13%	9%	7%
Administrative and support service activities	4%	5%	5%	5%	5%	6%	5%	5%	5%
Public administration and defence	6%	5%	5%	4%	5%	4%	4%	4%	6%
Education	7%	6%	7%	7%	7%	6%	4%	6%	6%
Human health and social work activities	11%	9%	9%	8%	9%	7%	5%	7%	9%

Source: ONS; Alma Economics calculations

Sensitivity checks

Table 8: North – Sensitivity checks

Model	1	2	3	4	5	6	6
Sensitivity check	Baseline	Exclude contemporaneous effect	Linear trend	No buffer	10km buffer	30km buffer	Exclude 2020-2022 data
Affordability (t)	0.014						
	[0.114]						
Affordability (t-4)	0.012	0.016	-0.013	0.021	0.036	0.126	-0.003
	[0.089]	[0.102]	[0.023]	[0.054]	[0.068]	[0.117]	[0.100]
N	1064	1064	1064	1064	1064	1064	896

Table 9: Midlands – Sensitivity checks

Model	1	2	3	4	5	6	6
Sensitivity check	Baseline	Exclude contemporaneous effect	Linear trend	No buffer	10km buffer	30km buffer	Exclude 2020-2022 data
Affordability (t)	0.035						
	[0.082]						
Affordability (t-4)	-0.177**	-0.172**	-0.057***	-0.042	-0.059	-0.166	-0.148*
	[0.082]	[0.084]	[0.019]	[0.047]	[0.053]	[0.100]	[0.086]
N	1197	1197	1197	1197	1197	1197	1008

Table 10: North & Midlands

Model	1	2	3	4	5	6	6
Sensitivity check	Baseline	Exclude contemporaneous effect	Linear trend	No buffer	10km buffer	30km buffer	Exclude 2020-2022 data
Affordability (t)	0.02						
	[0.077]						
Affordability (t-4)	-0.085	-0.083	-0.030**	-0.024	-0.026	-0.057	-0.075
	[0.054]	[0.055]	[0.015]	[0.033]	[0.037]	[0.061]	[0.057]
N	2261	2261	2261	2261	2261	2261	1904

Table 11: Midlands and South West – Sensitivity checks

Model	1	2	3	4	5	6	6
Sensitivity check	Baseline	Exclude contemporaneous effect	Linear trend	No buffer	10km buffer	30km buffer	Exclude 2020-2022 data
Affordability (t)	0.107						
	[0.073]						
Affordability (t-4)	-0.110*	-0.091	-0.042***	-0.024	-0.033	-0.111	-0.092
	[0.063]	[0.067]	[0.016]	[0.043]	[0.047]	[0.077]	[0.066]
N	1615	1615	1615	1615	1615	1615	1360

Instrumental variable estimates

163. This section presents the results of the IV estimation alongside those of the conventional panel-fixed effects model. The NERA instrument based on the share of green belt is used; however, two additional instruments based on planning applications, which vary both across LAs and over time, are also considered. Instrument relevance and exogeneity tests are also presented, as well as the Wu-Hausman test for exogenous regressors.

164. The results do not favour the use of IV. First, although the instruments are relevant, they might not be exogenous, at least based on the J-statistic. Second, in the IV approach, the negative and significant estimates from the panel-fixed effects become statistically insignificant. This could be due to several factors. There is little variation in predicted affordability from the first stage regression—i.e., after instrumenting the affordability variable, minimal variation remains, which inflates standard errors and/or makes it challenging to estimate the effect of affordability. Additionally, it may reflect multicollinearity between the time-fixed effects and the predicted affordability. Finally, if affordability is actually exogenous, as suggested by the Wu-Hausman tests, the IV approach may discard useful information, biasing the estimates towards zero. These findings reflect the difficulty of finding good instruments, while a lack of suitable instruments could make the IV approach counterproductive.

165. Most importantly, if affordability is endogenous, and the analysis has failed to account for it, then the true impact of the affordability on productivity would be greater (in absolute terms) than the baseline estimate of -0.31.

Table 12: Instrumental Variable estimates

Model Estimator	1 Fixed Effects	2 IV Fixed Effects	3 Fixed Effects	4 IV Fixed Effects	5 IV Fixed Effects	6 IV Fixed Effects
Instrument(s)	-	(Green belt share)x(time trend)	-	(Green belt share)x(time trend)	(Green belt share)x(time trend)	(Green belt share)x(time trend); Planning refusal rate; Planning applications decided on time
Affordability (t)	-0.218*** [0.064]	-0.001 [0.372]	-0.088* [0.052]	0.12 [0.325]	0.959 [1.465]	-0.077 [0.282]
Affordability (t-4)			-0.223*** [0.054]	-0.315** [0.143]	-0.113 [0.154]	-0.230* [0.121]
Affordability (t-1)					-0.986 [1.345]	
Lewis-Mertens statistic		23.3		42.50	41.50	19.8
Critical value (Imhof)		23.1		23.1	23.1	13.2
Critical value (Simplified)		23.1		23.1	23.1	14.1
Hansen J statistic p-value		-		-	-	0.0095
Wu-Hausman exogeneity test (p-value)		0.54		0.51	0.50	0.97
N	3174	3128	2622	2584	2584	2579

Notes: The dependent variable is productivity; Both productivity and affordability are in natural logs; Affordability is measured using the "20km buffer" approach; The Greater South East includes London, the East, and the South East; N represents the sample size; Cluster standard errors are shown in brackets; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; The Lewis-Mertens statistic is a test for instrument relevance; The test rejects the null hypothesis when the test statistic exceeds a critical value—it extends Stock and Yogo's (2005) test, which is based on the first-stage regression F-statistic, by allowing for heteroskedasticity and autocorrelation; The Hansen J statistic tests the null hypothesis that the instruments are exogenous; The Wu-Hausman test's null hypothesis is that affordability is exogenous; Source: Alma Economics analysis.

Unit root tests

166. Unit roots in the dependent variable (productivity) and the independent variable (affordability) are tested for using panel unit root tests. If productivity and affordability have a unit root, an alternative approach—potentially more suitable—would involve testing for cointegration and estimating cointegrating relationships.

167. The Harris-Tzavalis and Im-Pesaran-Shin unit root tests have been used due to the size of the panel, that is large N and Fixed T. However several other panel unit root tests were also checked. All these tests rejected the null hypothesis of unit roots. A sample of unit root tests is provided below.

Table 13: Harris-Tzavalis panel unit roots tests
All English LAs

	rho statistic	z	p-value
Productivity	0.73	-18.86	0.000
Affordability	0.76	-14.95	0.000
Affordability (20km buffer)	0.87	-1.24	0.108

Greater South East LAs

	rho statistic	z	p-value
Productivity	0.79	-7.50	0.000
Affordability	0.71	-14.53	0.000
Affordability (20km buffer)	0.85	-2.55	0.005

H0: Panels contain unit roots; Ha: Panels are stationary; Number of periods = 23; AR parameter: Common; Panel means: Included; Time trend: Not included

Table 14: Im-Pesaran-Smith panel unit roots tests
All English LAs

	W-t-bar	p-value
Productivity	-10.24	0.000
Affordability	-9.79	0.000
Affordability (20km buffer)	-5.96	0.000

Greater South East LAs

	W-t-bar	p-value
Productivity	-4.91	0.000
Affordability	-8.38	0.000
Affordability (20km buffer)	-5.72	0.000

H0: All panels contain unit roots; Ha: Some panels are stationary; AR parameter: Panel-specific; Panel means: Included; Time trend: Not included; ADF regressions: Lags chosen by AIC.