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RESEARCH

The Impact of Asset Management and Sustainability on the Economic Depreciation of Real Estate Assets

FULL REPORT

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The Impact of Asset Management and Sustainability on the Economic Depreciation of Real Estate Assets

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Report

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The Impact of Asset Management and Sustainability on the Economic Depreciation of Real Estate Assets

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EXECUTIVE SUMMARY

Depreciation refers to the real estate phenomenon of decaying asset values over time as a consequence of wear and tear, ageing, outdated features, as well as changes in social and economic conditions of the region where they are located (please see the Terminology section for more specific technical definitions).

The Investment Property Forum (IPF) has already commissioned two reports on depreciation of UK real estate assets (ref: IPF05 and IPF11). These were followed by several other studies using different estimation methods in various countries over the past 15 years.

Building on this stream of literature, we combine a series of datasets and models to advance the knowledge on depreciation of real estate assets. Our goal is twofold: we estimate depreciation rates by sector and location extending the set used in previous IPF reports, and we measure the impact of asset management and sustainable asset characteristics on value preservation.

First, we show consistent estimates of depreciation rates for the three main sectors: around 1.3% to 1.5% for industrial properties, 1.2% to 1.9% for shops and 0.1% to 0.7% for offices. Comparing our results with the ones shown in the previous IPF11 report, we report slightly less depreciation for offices and significantly higher for both industrial and shops. Beyond the three main sectors, we also found a higher depreciation for shopping centres (around 0.4 to 0.8%) and negative depreciation for retail warehouses, probably driven by a significant change in retail distribution over the past few years affecting our methodology and estimation, as well as a potential increase in land values due to the potential conversion to a different best use. The Multifamily Build-to-rent sector reports a depreciation in the range of 0.7% to 1.6%.

Second, we find that asset management facilitates value creation and retards depreciation, with capital injections (i.e. capital expenditure (capex)) being positively associated with rental and capital values. Moreover, we importantly show the ability of invested money to moderate the decaying value of real estate assets: increasing capex by one additional percentage point of property value per annum reduces on average the annual depreciation by 0.7-0.9% for offices, 0.3-0.7% for shops and 0.2% for industrial properties. The impact for other sectors could not be measured due to the reduction in sample size when capex was considered.

Third, we report the rather weak evidence of the impact of energy efficiency on the speed of depreciation, with an improvement of the EPC rating by one grade leading to a reduction in depreciation of around 1% to 3%.

Finally, we present insightful results on differences between geographical areas. Depreciation has increased more in the North than in the South over the last 15 years, significantly worsening the depreciation gap that already existed at the beginning of the 2010s. Depreciation rates are also found to depend on the wider socio-economic attractiveness of the area, with more attractive locations (and higher land values) showing lower depreciation rates.

Industry players at different levels of the value chain may take advantage of our findings in a number of areas including investment appraisal, capital budgeting and asset management through the life cycle of a property or portfolio.

EXECUTIVE SUMMARY

Overall, our analysis and report consist of four elements:

1. **Presentation of a scheme of key components of depreciation, through a comprehensive literature review.** This enables the reader to navigate previous findings and, importantly, to better understand the various definitions of depreciation and appreciate differences in approach, computation and outcomes.
2. **Introduction of a newly revised methodology to estimate depreciation rates.** Our newly modified version of the original IPF method uses similar datasets (MSCI and CBRE) but looks at rent review points only. This reduces the impact of agency issues between investors and valuers and produces less sample-dependent results.
3. **Comparison with depreciation rates obtained with regression analysis.** We estimate models using both rents and market values from the same sample, and , and report models estimated in Makovsky and Marcato (2025) using transaction-based data from CoStar. This analysis allows us to show how depreciation rates decrease as the age of a building increases, with the marginal loss in value being higher in the first years of the property lifecycle.
4. **Assessment of the impact of asset management and sustainability features.** We study the effectiveness of asset management and the impact of sustainability features on the decaying shape of real estate values over time.

1. INTRODUCTION

In this first section, we define depreciation, its components, and include a brief summary of recent studies in the field.

1.1 Components and definitions of depreciation

Since the previous two IPF reports on depreciation of real estate assets (IPF05, IPF11), several studies have shed light upon this phenomenon and have estimated depreciation rates in various countries by using different implicit conceptual frameworks and definitions of depreciation. In this section, we intend to contribute to the debate by presenting and categorising these conceptions within a single framework. We believe this attempt helps improve the overall understanding of the different facets associated with the decaying value of real assets.

Depreciation is the process of real estate asset values decaying over time due to several factors (e.g. wear and tear, aging, outdated features, changes in social and economic conditions).

To contrast this natural phenomenon, investors normally intervene through capital expenditures, which are meant to preserve (and in some cases enhance) real estate values. The inclusion or exclusion of such expenses leads us to the first definition of:

- **Net depreciation:** *“is the loss in real value as a function of structure age even after and including capital improvements”* (Bokhari and Geltner, 2019);
- **Gross depreciation:** total capital consumption which *“includes two separable components: capital improvement expenditures (‘capex’) and ‘net depreciation’”* (Bokhari and Geltner, 2019).

The definition used in IPF05 refers to **managed depreciation**, which should be considered equivalent to net depreciation: *“is recorded after the impact of expenditure and management activity”*.

The components of depreciation can relate to a number of factors affecting real estate assets:

- **Physical deterioration:** represents the ‘wear and tear’ of physical real assets and it could be prevented by regular maintenance. It excludes the impact of changing economic/social conditions.
- **Functional (or external) obsolescence:** refers to the mismatch between property design/specification and changing preferences of consumers/society. It can either relate to the property surroundings or to changes in local demand leading to weaker highest and best use of buildings over time (Bokhari and Geltner, 2019). This definition relates to the impact of changing economic/social conditions.
- **Vintage effect:** refers to the characteristics of a property associated with the construction period, not separable from functional obsolescence as they are jointly captured by a cohort effect (Francke and van de Minne, 2017). This factor also relates to the impact of changing economic/social conditions, but the use of specific materials (due to the construction period) may also affect the physical wear and tear. A clear UK example is offered by Reinforced Autoclaved Aerated Concrete (RAAC) used in the building industry between the 1950s and 1990s.

1. INTRODUCTION

Now we come to how we might measure depreciation. This is inevitably through real estate pricing. Considering that the price or value of a building could be obtained by capitalising the rent at the yield (or cap rate), we may alternatively refer to:

- **Rental depreciation:** identifies the decaying rental value of a building (i.e. chargeable rent) due to either physical deterioration or functional obsolescence.
- **Price (or capital) depreciation:** refers to the decaying price (or market value) of a building due to rental reduction and yield increase (called '*cap rate creep*' in Bokhari and Geltner, 2018) exercised by both physical deterioration and functional depreciation.

Clearly, both rental and price depreciation rates can be computed either gross or net of asset management interventions (i.e. capex). For the purpose of this study, we will estimate:

- **Net rental depreciation** that measures the reduction in applicable rent with limited asset management intervention (i.e. excluding capex);
- **Gross rental depreciation** which also includes the average annual capex; and
- **Net price depreciation** reporting a regression model with transaction price, building age and other available data from CoStar.

Figure 1 summarises the aforementioned implicit definitions and components of depreciation. The market value (MV) of a property can be computed as the capitalisation of rental income in perpetuity as follows:

$$MV = \frac{\text{Rental income}}{\text{Cap rate}}$$

The cap rate (or yield) represents the return R investors are willing to obtain, net of rental growth g they expect to achieve:

$$\text{Cap rate} = R - g$$

As buildings depreciate over time, the required return R^* may be higher due to a higher perceived risk for deteriorated properties. Moreover, the observed rental growth g^* is represented by the hypothetical rental growth g achievable without depreciation, reduced by the depreciation rate d (e.g. older or less functional buildings will be expected to have a lower growth):

$$g^* = g - d$$

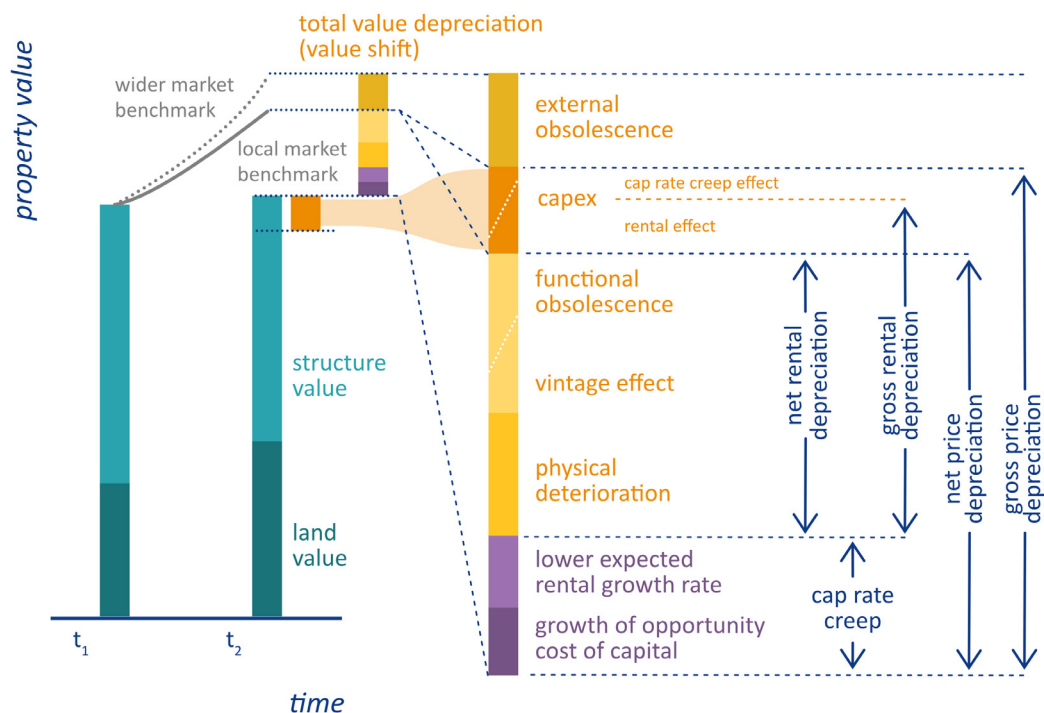
Therefore, we could think of price depreciation as the lower capital growth observed due to the physical or functional deterioration of a property. The first component of price depreciation reflects rental depreciation – in yellow and related to a lower rent due to functional obsolescence, physical wear and tear and vintage. The second component is represented by the cap rate creep, which refers to the higher cap rate associated with properties facing physical and functional deterioration due to a higher risk and associated return R^* , as well as a lower expected future growth g^* – in purple in Figure 1.

1. INTRODUCTION

The impact of capex (if available) can also be split between rental and cap rate creep components because asset management interventions may jointly increase rents and reduce yields (increasing the expected rental growth and reducing the risk and hence required return). Once these components are added, we therefore obtain gross (rental or price) depreciation.

Finally, external obsolescence in Figure 1 refers to the changes in the wider economy that may accelerate or decelerate this process.

Figure 1: Depreciation components



1.2 Brief summary of recent studies and results

Conceptually, separating depreciation into individual components sheds light upon the substantial heterogeneity in depreciation estimates across countries and over time – e.g. notably higher rates in national accounts ('gross price depreciation'), lower estimates in real estate literature based on transaction-based data ('net price depreciation'), and even lower coefficients for 'net rental depreciation' (one of multiple components of 'net price depreciation').

IPF (2005, 2011) adopted a longitudinal method to measure property rental value at the beginning and end of a given period against a market benchmark which captures local prime rents achievable in a newly built property. Divergence from the (constantly new quality) benchmark trend therefore identifies cumulative depreciation over the given period. In particular, IPF05 measures rental depreciation for two periods: 19 years from 1984 to 2003, and 10 years from 1993 to 2003. The estimated annual rental depreciation was respectively 1% and 0.8% for offices, 0.1% and 0.3% for standard shops, and 0.6% and 0.5% for industrial properties. Overall, the estimated property rental depreciation was 1% per annum for the longer period and 0.7% per annum for the shorter one.

1. INTRODUCTION

Furthermore, IPF05 analyses annual capital expenditures excluding complete redevelopments. For the two periods, average annual capital expenditures reached 1% and 0.9% for offices, 0.6% and 0.5% for standard shops, and 0.8% and 0.4% for industrial properties. The pattern of capital expenditures is however quite uneven, with around a third and half of assets experiencing no capital expenditures at all in the longer and shorter period respectively.

IPF11 updates the earlier report with new estimates using the 10-year dataset from IPF05 extended to cover the 16-year period from 1993 to 2009. Results for rental depreciation were found to be almost identical with 0.8% for offices, 0.5% for industrial, and 0.3% for standard retail. Regarding spatial variation in depreciation, higher rates were found outside of London which authors attribute to the relatively high value of the land component in London, which is consistent with other literature reviewed in the next section.

Capital expenditures in IPF11 were found to be relatively small compared to the earlier study, with average annual expenditure as a fraction of property value at 0.6% for offices, 0.3% for industrial and 0.4% for standard shops.

A comprehensive section on the body of literature on depreciation following IPF05 and IPF11 is included in Appendix 2: Research on depreciation since 2011, however a useful summary is shown in Table 1 below. The exercise of comparing and contrasting the numerous studies has highlighted the following implications for the work at hand:

1. As real estate supply in the UK is rather constrained compared to the US and other European countries (Cheshire and Hilber, 2008; housing in Caldera and Johansson, 2013), the fraction of land value on overall property value is expected to be higher, and conversely depreciation relative to total asset value is expected to be lower as the land component does not depreciate (Bokhari and Geltner, 2018).
2. Following the same argument, spatial variation in depreciation is also expected within the UK. Real estate supply is much more constrained in central London (Cheshire and Hilber, 2008), where depreciation is expected to be smaller in magnitude compared to other real estate markets with less constraints on new construction.
3. We may expect an S-shape profile of depreciation, where the marginal rate is high in the early and late stages of the property lifecycle.

1. INTRODUCTION

Table 1: Literature summary

Article	Method	Property Types	Country	Depreciation Type	Baseline Depreciation
IPF (2005)	LGT	Office, Industrial, Retail	UK	rental	0.7%
IPF (2011)	LGT	Office, Industrial, Retail	UK	rental	0.6%
Bokhari and Geltner (2018)	CSR, PDR*	Office, Industrial, Retail, Apartment	US	net	1.5%
Bokhari and Geltner (2019)	CSR	Commercial, Apartment	US	net	1.7% (commercial)
Bokhari and Geltner (2019)	CSR	Commercial, Apartment	US	gross	3.4% (commercial)
Yoshida (2020)	CSR	Commercial	Japan	net	1.6% (outside Tokyo)
Yoshida et al. (2024)	CSR	Office	Japan, Tokyo	rental	0.8% (new leases)
Lopez and Yoshida (2022)	CSR	Single family houses and condominiums	US, Las Vegas	rental	0.9%-1.5% (single-condo)
Francke and van de Minne (2017)	CSR	Family houses	Netherlands	net	0.5%
Wilhelmsson and Roos (2024)	CSR	Single family houses 30+ yrs old	Sweden	net	0.2%

Notes: CSR refers to cross-sectional regression (age as independent variable), PDR to panel data (longitudinal regression (age as independent variable), LGT to longitudinal difference against benchmark following IPF05. Baseline depreciation refers to medium-time horizon if multiple estimates are provided as a robustness check.

2. METHODOLOGY

In this report, we present two main methodological approaches to estimate depreciation rates.¹

1 **Longitudinal Approach.** Two versions are highlighted.

A) The longitudinal approach adopted in earlier IPF reports (IPF05, IPF11) measures the change in rental value (for single assets and portfolios reporting respectively unweighted and weighted averages) over a longer period of time relative to the change in its relative benchmark represented by local prime rental indices of hypothetical newly refurbished buildings.

B) We also propose a modified version of the longitudinal approach, using lease events as points of measurement to compute rental growth rates – see Sections 2.1 and 2.2.

2 **Regression-Based Approach.** This second methodology prevails in more recent studies, where the relationship between value and age is estimated by using a regression-based approach (particularly a cross-sectional hedonic model with age being one of the priced characteristics) – see Section 2.3.

2.1 IPF (2005, 2011) longitudinal approach

Net rental depreciation

The original IPF methodology defines asset-level *net rental depreciation* ($d_{i,t}^a$) as the change in an actual asset (subscript *a*) rental value obtained from MSCI data, relative to the change in *i,t* benchmark (subscript *b*) rental value obtained from the CBRE rental value for that specific asset's submarket.² As the CBRE index measures rents for a hypothetical building which is always new, we expect a lower rental growth for the actual asset which is subject to decaying rental value over time due to depreciation. Considering the number of years (denoted *L* for lag) between the beginning and the end of year period (in our study 2008 and 2023), we can compute the single asset-level annual depreciation as follows:

Equation 1: Asset-level depreciation

$$d_{i,t}^a = 1 - \left(\frac{R_{i,t}^a / R_{i,t-L}^a}{R_{i,t}^b / R_{i,t-L}^b} \right)^{1/L}$$

where the ratio in the brackets is the actual asset rental growth divided by the benchmark rental growth over the entire period (note that this number is normally less than one because hypothetical newly built or refurbished buildings in the CBRE index are expected to show a higher rental growth). Raising to the power of $1/L$ computes the average annual relative rental growth. As an example, if we obtain that the actual asset rental growth is 98% of the benchmark, the average annual asset-level depreciation will be 2% (or in other words 1–98% in the equation). The graphical representation of this computation is reported in Figure 2.

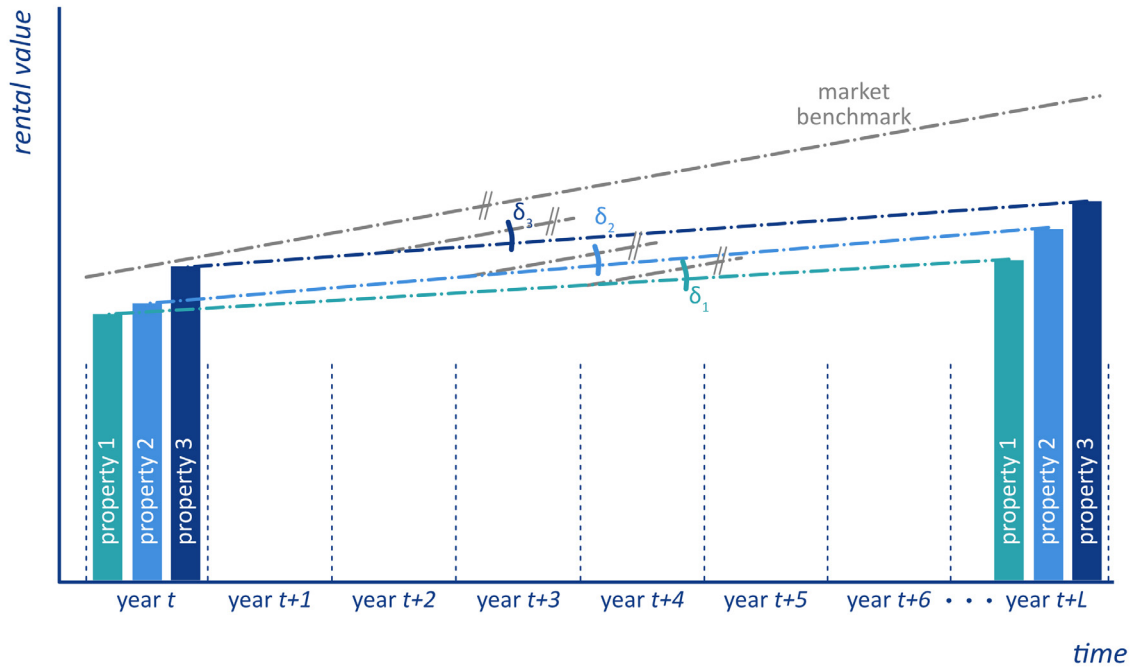
At sector or segment level, the overall depreciation will then be computed as either the simple or weighted (by value) average of the asset-level depreciation rates.

¹ These two main methods are also recognised in the broader depreciation literature, where Yoshida et al. (2024) mention the approach using national accounts and inferring depreciation implicitly from real estate investment flows and changes in stock, and a second one relying on the analysis of the age at which properties are demolished.

² CBRE provided us with proprietary measures of rents for hypothetical buildings by sector and location over the entire sample period. The hypothetical rents are estimated by CBRE leasing professionals at a quarterly frequency. They are headline rent estimates that assume a new letting of the building at each date in question.

2. METHODOLOGY

Figure 2: Previous IPF approach



Capital expenditures and gross rental depreciation

As capex can increase property values and shield from depreciation, the IPF methodology also provides *gross rental depreciation* (subscript *d* added: $d_{i,t}^{ag}$), which includes annual capex as a percentage of the asset price or market value (the ratio of total amount of capex $c_{i,t}$ divided by asset price $P_{i,t}$ is annualised by dividing it by the number of years L as included in the second part of Equation 2).

In other words, continuing the previous example, in the absence of capex, the asset-level net and gross rental depreciation would have been 2%. However, if the asset did record annual capex for 0.5% of the asset value, the estimated net rental depreciation at 2% would therefore refer to an asset effectively depreciating by 2.5% every year (gross depreciation computed as net depreciation 2% + capex 0.5%) but benefiting from capex interventions that shielded part of the depreciation.

At market level and taking the office sector as an example, we notice a consistent amount of capex, which was reported at 1% in the 2005 IPF study (1984-2003 data), 0.5% in the 2011 IPF report (1993-2009) and 1% in this present study (2008-2023).

Equation 2: Asset-level gross rental depreciation

$$d_{i,t}^{ag} = d_{i,t}^a + \frac{1}{L} \sum_{t-L}^{t-1} \frac{c_{i,t}}{P_{i,t}}$$

2. METHODOLOGY

2.2 Modified (MMP) approach based on rent reviews

Applying the IPF methodology to the available dataset is not without difficulties. Notably, earlier reports used asset-level rental value, which is not directly observed in the market, but rather assessed, and therefore could be subject to error. It should be added that the original IPF method covered a period of great moderation up until 2009, which did not include pronounced business cycles (only the first year of the Global Financial Crisis (GFC) period was included in the sample). Data analysed in this report covers the period from 2008 to 2023 which contains the entire aftermath of the GFC, then a gradual decline of retail sector competing with e-commerce, rising demand for logistics to accommodate actual e-commerce, and finally the Covid shock at the end of the study period. All these disruptive events and the associated uncertainty could negatively affect assessed market values of properties, which may then lead to biased estimates of depreciation, especially considering the agency issue between valuers and investors for the actual asset (which is not present in the benchmark series).³

To address these concerns, instead of computing the rental growth of a specific asset relative to its benchmark over the entire sample period, we propose a new methodology (so-called 'modified IPF approach', or *MMP approach* from the authors' names), where the relative rental growth is computed between lease events (i.e. rent reviews).⁴

This new approach should be beneficial because rent reviews are associated with "truer information revelation" than recurring assessments of rental values.⁵

We assume that each asset has a set of rent review years Y^{rr} within the entire sample period. Considering the five-year upward-only rent review structure applied in the UK, within our sample period (2008 to 2023) we should observe at least three rent reviews for each asset. The MMP asset-level depreciation d_i^{arr} (subscript rr for rent reviews) is calculated as a mean of annualised depreciations between all recorded rent review years as follows:

Equation 3: Asset-level rent-review based depreciation

$$d_i^{arr} = \frac{1}{N} \sum_1^N \left[1 - \left(\frac{R_{i,t_n}^a / R_{i,t_{n-1}}^a}{R_{i,t_n}^b / R_{i,t_{n-1}}^b} \right)^{\frac{1}{t_n - t_{n-1}}} \right] \quad \{t_0, t_1, \dots, t_N\} \in Y_i^{rr}$$

Asset-level rent-review *net rental depreciation* is computed similarly to the old IPF method, but multiple depreciation rates are obtained for the same asset comparing the relative rental growth rates between each pair of rent reviews and then averaged out (multiplying by $1/N$). In other words, if there are three rent reviews, we compute the average of two depreciation rates (between rent reviews 1 and 2, and between rent reviews 2 and 3) for that specific asset.

To aggregate at sector or segment level, we still adopt the same procedure, with either simple or weighted (by value) average of the asset-level depreciation rates.

³ Valuers may tend to smooth variations in estimates over time.

⁴ MMP stands for Makovsky, Marcato and Pischedda (2025).

⁵ Problems of upward-only rent reviews and actual method to detect rent review years in the data are discussed later. We also acknowledge that both tenants and landlords recognise the costs involved in changing tenants/landlords (e.g. void periods, fit-out costs etc.). Rent reviews may happen at a discounted value of the market rent (e.g. 90%), and therefore, using rent reviews with the same tenant in situ may slightly overestimate depreciation rates.

2. METHODOLOGY

2.3 Regression-based approach

Regression models currently represent the most common method used to estimate depreciation in the literature and are gaining momentum in more advanced markets, where the presence of research departments informs agents and investors.

In the context of this study, we use regression-based approaches to explicitly link the decaying asset value to the age of the property. These methodologies typically use ordinary least squares (OLS) estimation procedures and, depending upon the actual research design and data used, they can estimate different components of depreciation. Importantly, the modelling in a regression-based approach could be designed to produce estimates equivalent to the longitudinal approach (IPF05, IPF11), but with the advantage of not necessarily needing to use a market benchmark (which is itself subject to biases/errors in its construction and/or matching).

Our estimation model uses the logarithm of capital/rental values (CV_{itm} or RV_{itm}) or sale prices (P_{itm}) as a dependent variable and either age on its own (using MSCI data) or in conjunction with age squared (using CoStar data) to test the concave nature of depreciation along the property lifecycle. Both asset i and market m characteristics are also included as control variables (X_{itm}). A simplified model could be represented as follows:

Equation 4: Regional variation in depreciation

$$\log \begin{pmatrix} CV_{itm} \\ RV_{itm} \\ P_{itm} \end{pmatrix} = \alpha + \delta_1 age_{it} + \delta_2 age_{it}^2 + X_{itm} + \varepsilon_{itm}$$

where δ_1 and δ_2 measure the impact that age (one year increase) has on prices or capital or rental values. The older the building, the lower we expect the price/value to be, with the marginal reduction in price/value (i.e. depreciation rate) being greater for newer building and smaller for older ones.

A note on the use of event study data

In the context of measuring property depreciation, event study data refers to data linked to an event – being either a signed lease agreement or a property transaction. The data contain capital/rental values or sale prices, building age and other (hedonic) characteristics, which are necessary to isolate the impact of age on values (rents or transaction prices). These values are then regressed on property age and a set of other observable property characteristics, including asset quality, amenities and size among others.

To correct for both spatial and temporal heterogeneity, as well as unobserved characteristics, we also introduce location and time-fixed effects (which allow variation across locations and time). Particularly, the role of location fixed effects is used to capture the impact of any local external factors which might positively or negatively affect rental values.

2. METHODOLOGY

If these external effects are correlated with building age, then the estimated depreciation could be biased. An example would be an up-and-coming local area undergoing transformation and seeing substantial new developments. In such a case, if corrections for local factors (i.e. local-fixed effects) are not included, higher rents charged in these locations will be explained by on average lower building age, with the consequence of an overestimated depreciation.

If event study data were collected over a more extended period, long enough that seasonality or changes in rents could have meaningful effects, correction for time varying factors (i.e. time-fixed effects) should be included too to capture the overall change in rents over time.

For further discussion regarding the analytical methods used in the depreciation research in the past decade or so, see Appendix 3: Methodological considerations.

3. DATA DESCRIPTION

In this section, we present the three main datasets of real estate assets and benchmark used for this study.

3.1 MSCI and CBRE benchmark data

To estimate depreciation rates using a longitudinal approach (both original IPF and MMP modified using rent reviews), we obtain the main dataset of real estate asset characteristics and values from MSCI. Furthermore, CBRE provided us with rental indices of hypothetical new or newly refurbished buildings across UK sectors and regions that we use as our benchmark by matching it with MSCI data. We use these two datasets to estimate depreciation rates as the difference between the rental growth of 'permanently new' properties (from the CBRE time series) and the lower rental growth of actual aging buildings (from the MSCI dataset).

MSCI data overview

The main descriptive statistics of the MSCI dataset are reported in Table 2. Firstly, our data sample is three times bigger than the one used in previous IPF studies: 3,531 properties, with more than 47,000 observations considering the 15-year sample period from 2008 to 2023. This coverage is significant and it should lead to more reliable results, especially for sub-samples. While hotels are limited to only 12, all other sectors/segments include over 80 properties. Offices, shops and industrial (the main sectors analysed in the original IPF05 and IPF11 reports) dominate the sample, with 642, 651 and 800 assets respectively. Residential properties (single family and multifamily) and student housing have only recently become mainstream investments among portfolio managers contributing to the MSCI Indices, therefore we can only use a short time series starting from 2017. Importantly, MSCI data are used for both longitudinal and regression methods, while the CBRE data (see below) is only used for the longitudinal approach. The combination of MSCI and CBRE in the longitudinal method leads to data loss. We report the total number of observations used in each estimation at the bottom of each table.

Table 2: MSCI data summary by derived sectors

Sector	Properties	Data Points	Start	End
Hotels	12	181	2008	2023
Industrial	800	11,985	2008	2023
Multifamily	149	1,043	2017	2023
Offices	642	9,577	2008	2023
Shopping Centres	82	1,173	2008	2023
Shops	651	9,268	2008	2023
Single Family	101	707	2017	2023
Student Housing	97	679	2017	2023
Warehouses	390	5,731	2008	2023
Other	607	6924	2008	2023
Total	3,531	47,268		

Notes: Category Other contains Affordable housing (52 prop.), Ground rent (192 prop.), Other specialist types within Residential class (1 prop.), Unclassified residential (28 prop.), and others without more specifications (334 prop.).
Summary by IPD sectors is provided in the Appendix 4.

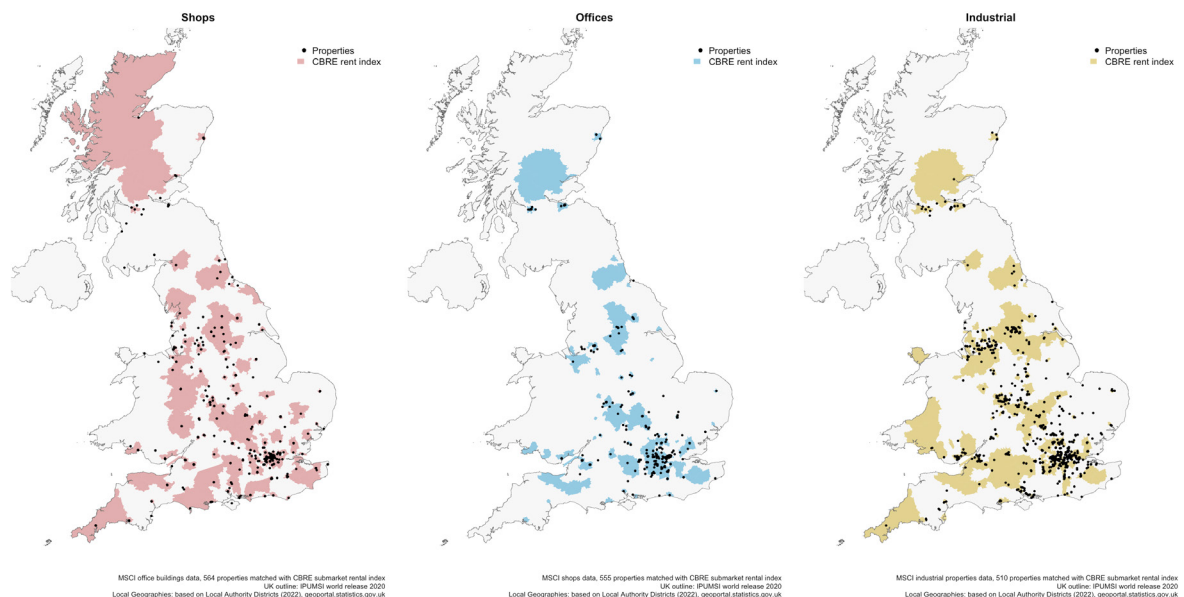
3. DATA DESCRIPTION

Spatial matching with CBRE data

The 3,531 properties provided by MSCI from their UK dataset were chosen to guarantee a regional and sectorial composition similar to the overall index. For some properties (around 14% of the sample), the last two characters of their postcode were missing, so their location was approximated as an average Easting and Northing coordinate from all possible matching postcodes. This approach provides a relatively precise location as each property should be on average located within a mile from the inferred coordinates with a 95% confidence. Overall, 96% of properties from the original sample were geolocated. This information is important to cover the spatial dimension and the presence of external factors affecting the nearby region, as well as to control for unobservable information that may be linked to building age due to market dynamics – see point about the location fixed effect in the methodology, Section 2.3.

As shown in Figure 3, some properties are located in areas not covered by CBRE submarket rental indices. These properties were excluded from the analysis using the original and modified (rent review-based) IPF methodologies. Furthermore, properties with no information about rent, zero reported rent and properties with vacancy rates exceeding 50% were also dropped from the estimation sample. Overall, more than 95% of the original sample was retained to produce the results presented in this report. This provides confidence that the findings are not subject to selection bias.

Figure 3: Spatial distribution of MSCI properties and CBRE submarkets



Note: CBRE data points do not refer to local authorities, but the data points were matched to local authority areas for the purpose of this analysis.

3. DATA DESCRIPTION

3.2 Transaction-based data

In the regression-based approach, we also report some results obtained in an academic paper - Bajaj et al. (2025) - using transaction data from CoStar and estimate a relationship between building age and depreciation rates. Intuitively, we expect real assets to depreciate faster at the beginning of their life and slower as time passes. In other words, the marginal depreciation should decay as building age increases, showing a concave function between the two variables. Alongside the sale price, we use a series of characteristics at building and regional level. The main results are included in a working paper available upon request from the authors, but we hereby report the shape of the concave functions linking building age and depreciation by sector and region. Table 3 presents the main characteristics of the transacted properties from the CoStar sample, drawn from Bajaj et al (2025). The price is in logarithmic form, and the average age is 65 years.

Table 3: Descriptive statistics of the CoStar transaction-based dataset

Variables	Mean	Std. dev.	Min	Max
Price (in log)	13.59	1.73	0.00	21.22
Age	65.40	48.00	6.00	171.00
Square feet	8.84	1.45	6.47	11.51
CBD	0.03	0.18	0.00	1.00
Grade A	0.01	0.09	0.00	1.00
Grade B	0.79	0.40	0.00	1.00
imd_overall	25.48	16.36	0.86	88.77
Nearest motorway dist	8.81	1.22	3.76	13.14
Nearest train st dist	7.04	1.09	1.29	12.57
Population 0-2km	10.31	0.96	6.92	12.22
Population 2-6km	11.71	1.34	6.92	14.06
Population 6-15km	12.98	1.34	6.98	15.26
Population 15-30km	13.95	1.05	8.67	15.63
Star rating (1-5)	2.68	0.60	1.00	5.00
EPC mean rating	4.34	0.41	-0.69	7.18

4. MAIN RESULTS

4.1 IPF longitudinal approach

IPF methodology and sensitivity to the sample period

Table 4 shows depreciation rates obtained with the original IPF longitudinal approach for the overall sample period. Among the three key sectors analysed in previous IPF studies, offices show the lowest depreciation at 0.3% (unweighted), followed by industrial and shopping centres (around 0.5%). The highest depreciation is reported for multifamily (0.9%) and shops (1.5%). Retail warehouse shows a negative depreciation that may be due to a significant change in retail distribution over the past few years. The updating of actual properties measured by MSCI and hypothetical ones used by CBRE may also play a role in this negative outcome for retail warehouse. For example, newly developed properties measured by MSCI may not correspond to 'old properties' still used to compile the CBRE index. As a result, the rental growth from old to new properties in the MSCI database may have been higher than the one reported by the CBRE index (hence negative depreciation). Alongside this data issue, other motives may be behind this result: a potential increase in land value due to the potential conversion to a different use with higher value (e.g. life sciences or industrial); a significant percentage of retail warehouses being represented by supermarkets with index-linked income, which may have reported higher values due to the general decline in bond rates.

The results were highly sensitive to the choice of the sample period as the time window spans from 2008 to 2023 and it includes two exceptional downturns, which significantly affected the real estate market: the aftermath of the GFC at the beginning of the study period, and the Covid pandemic at the end of it. In Appendix 4 Table A2, computed depreciation rates are presented that exclude the GFC for the sample from 2008 to 2019 and exclude Covid for the period from 2013 and 2023.

Furthermore, the whole period saw a relative decline in traditional retail – which has been facing growing competition from e-commerce – and an increasing demand for industrial real estate. All these shocks and changes in trends could partly explain why current results are relatively more volatile compared to those found by earlier IPF reports (2005, 2011).

Table 4: IPF longitudinal approach

Sector	Depreciation		Lower Quartile	Median	Upper Quartile	Sample Size
	Weighted	Unweighted				
Office	0	0.3	-0.8	0.3	1.3	137
Industrial	0.5	0.6	-0.1	0.6	1.4	178
Shops	1.5	0.9	-0.3	0.7	2.9	32
Shopping Centres	0.4	0.8	-0.1	0.5	1.3	15
Retail Warehouse	-1.4	-1.5	-2.3	-1.6	-0.6	127
Multifamily	0.9	1.6	-0.7	1.3	4.9	72

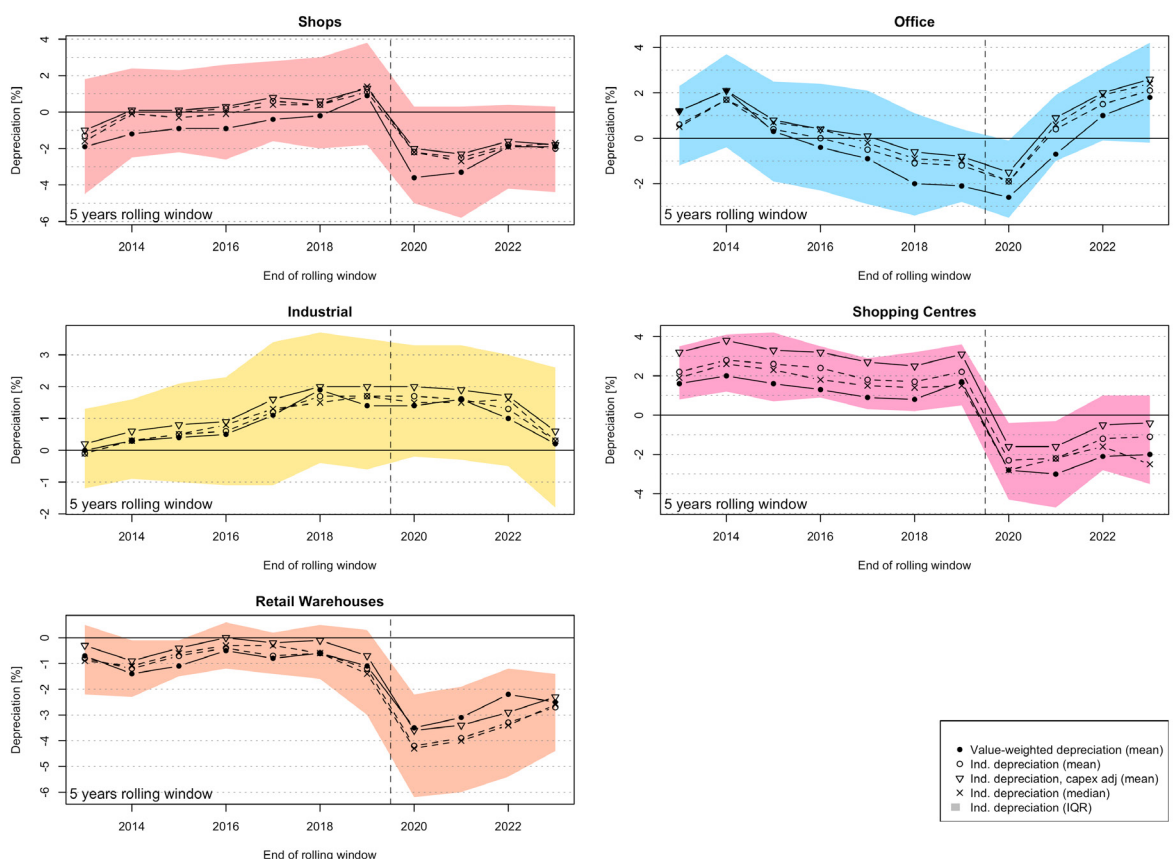
Notes: Shops, Office and Industrial use regional CBRE indexes. Shopping Centres and Retail Warehouses use two CBRE indexes: for London, South East and East, and for the rest of the UK. Multifamily are based only on London observations, with two CBRE indexes: up to Zone 2, and Zone 3 and beyond. Reported results based on sample excluding properties with overly volatile annual cashflows and excluding 5% extreme observations on each side of the distribution (10% winsorization). Shops using only observations from submarkets with growing CBRE rental index. Shops, Office, Industrial, Shopping Centres and Retail Warehouses are based on market rent. Multifamily is based on gross rent.

4. MAIN RESULTS

To illustrate how the choice of specific time window may affect calculated depreciations, Figure 4 shows results for the three main sectors when depreciation is calculated with a five-year rolling window.⁶

Firstly, the volatility of results is not random, and the calculated depreciation shows serial correlation between years. Furthermore, changes in estimated depreciation seem to depend on business cycles and shocks (i.e. the start of the Covid pandemic in 2020 is illustrated by the vertical dashed line). Finally, the impact of business cycles differs by real estate sector, with depreciation for standard retail (shops) slowly rising after the GFC, turning positive in 2019 at the beginning of the Covid period and declining back to below zero for the last years of our sample.⁷ The industrial sector shows a similar pattern, but always remaining positive and lagging the pattern recorded by shops by a few years. In contrast to these two sectors, offices show a positive depreciation in the years following the GFC, before beginning to decline to below zero pre-Covid and returning to positive values over the last two or three years of our sample.

Figure 4: Depreciation with IPF methodology, five-year rolling window



⁶ We also computed depreciation with 10-year rolling windows and results are similar.

⁷ Calculated depreciation for shops is using all observations, unlike results reported in tables where results are based on areas where CBRE index was not declining. This approach, however, cannot be implemented for rolling windows as for some years number of observations in non-declining markets is too small.

4. MAIN RESULTS

To compare these results from the most recent sample with earlier works (IPF11), a comparable time window 2010-2019 was selected, where there is a relatively long period without major crises and rather smooth growth (similar to the case of the ‘great moderation’ in 1990s and 2000s). Table 5 reports the main findings with a replication of the original IPF methodology. Depreciation increased for shops and industrial properties and declined for the office sector.

Table 5: IPF methodology, based on market rent, time window from 2010 to 2019

Sector	Depreciation		Lower Quartile	Median	Upper Quartile	IPF 2011 Depreciation	
	Weighted	Unweighted				Weighted	Unweighted
Office	-0.6	-0.2	-1.8	-0.2	1.3	0.8	1.0
Industrial	1.0	1.3	-0.1	1.3	2.6	0.5	0.4
Shops	0.7	1.7	-0.4	1.5	3.5	0.3	0.4
Shopping Centres	1.6	2.2	0.6	2.2	3.6	0.1	-0.2
Retail Warehouse	-1.2	-1.1	-2.2	-1.2	0.0	0.9	1.6

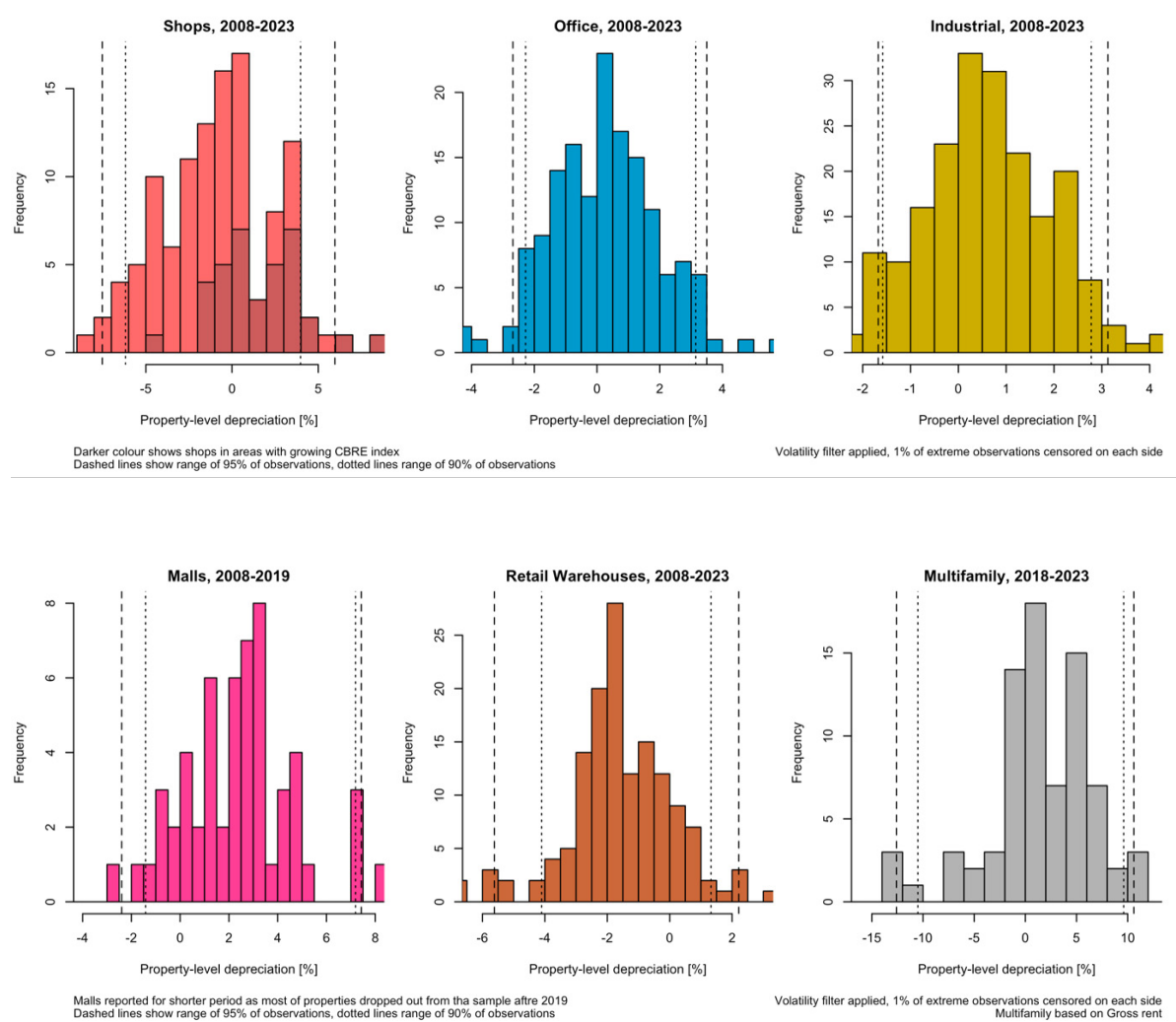
Notes: Reported results are based on a sample using volatility filter and excluding 5% extreme observations on each side of the distribution. Shops using only observations from submarkets with growing CBRE rental index.

While economic depreciation is affected by market cycle, as shown by Crosby et al. (2011), Crosby et al. (2016) found evidence of depreciation being higher in strong markets compared to weak markets as lower depreciation is induced by a lack of competition from new construction. However, differences may also be caused by the methodology because estimated rental values do not necessarily reflect changes in actual market rents due to the variation in the definition of hypothetical newly refurbished buildings underlying the CBRE index, and/or estimated rental values in the MSCI data not fully reflecting market conditions in the event of a rotation between headline and effective rents, depending upon the following upcoming lease event. Moreover, there might be a systematic bias in the case of declining markets when assessors do not reflect the true decline in rental values that will lead to properties apparently appreciating when compared to the market benchmark.

Figure 5 shows the distribution of asset-level depreciation for the different sectors over the entire sample period. For retail warehouses, the reported depreciation is always negative, but at the same time a negative index growth rate is always reported for both regionally defined submarkets and for all studied time periods. A similar but less extreme picture is found for shops, with a high proportion of negative figures. Other sectors predominantly show positive depreciation rates.

4. MAIN RESULTS

Figure 5: Distribution of asset-level depreciation



Local growth effect on depreciation

In this section, we more formally analyse the impact that local growth exercises on depreciation. This aspect is important as it sheds light upon local socio-economic changes and their impact on depreciation rates. As already presented, results using the previous IPF methodology are highly dependent on the adopted sample period. Therefore, we may be in the presence of time-dependent agency and reporting issues for both market rents and the CBRE synthetic rental index. If this bias is true, it is expected that locations with more or less growth may be affected differently because the gap between actual and synthetic rental changes may be different in rising and falling markets. To test this intuition, a simple model was constructed where local growth is regressed against depreciation at the individual property level as follows:

Equation 5: Impact of rental growth on depreciation

$$d_i^a = \alpha + \beta \text{ growth}_i + \varepsilon_i$$

4. MAIN RESULTS

Table 6: Depreciation and local growth

Dependent Variable: Depreciation	Shops		Office		Industrial	
	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
(Intercept)	-0.123	-0.291	-0.416	-1.915*	-0.938***	-1.171***
	(0.283)	(0.337)	(0.993)	(0.785)	(0.253)	(0.322)
Local Benchmark Growth	0.483***	0.426***	0.360	0.987**	0.390***	0.446***
	(0.071)	(0.083)	(0.353)	(0.306)	(0.061)	(0.085)
Number of observations	115	115	153	153	198	198
R ² (full model)	0.307	0.254	0.005	0.085	0.164	0.158
Adj. R ² (full model)	0.301	0.247	-0.001	0.079	0.160	0.154

Notes: Dependent variable is property-level depreciations calculated with the IPF method. 'W' stands for regression weighted by floor area. Heteroskedasticity-robust standard errors in parentheses.

Table 6 suggests enough evidence to support this argument, and further testing was undertaken to ascertain if this issue is particularly present in falling markets. By regressing separately positive and negative growth, it is shown that depreciation tends to be more pronounced in areas with higher rental contraction (i.e. negative benchmark growth). This evidence is also supported by the final analysis of the regional variation of depreciation rates over time. The model specification is represented by the following:

Equation 6: Impact of positive vs. negative rental growth on depreciation

$$d_i^a = \alpha + \beta_1 \text{growth}_i[\text{growth}_i > 0] + \beta_2 \text{growth}_i[\text{growth}_i \leq 0] + \varepsilon_i$$

As shops are the only sector with enough negative rental growth observations, Table 7 reports the main results of our estimation on this sub-sample.

Table 7: Depreciation and local growth

Dependent Variable: Depreciation	Shops	
	Unweighted	Weighted
(Intercept)	0.506	0.014
	(0.669)	(0.899)
Local Benchmark Expansion	0.032	-0.021
	(0.215)	(0.337)
Local Benchmark Contraction	0.558***	0.444*
	(0.159)	(0.203)
Number of observations	147	147
R ² (full model)	0.163	0.09
Adj. R ² (full model)	0.151	0.077

Notes: Dependent variable are property-level depreciations calculated with the IPF method. 'W' stands for regression weighted by floor area. Heteroskedasticity-robust standard errors in parentheses.

4. MAIN RESULTS

4.2 MMP Modified approach based on rent reviews

As evidenced in the previous section, especially during unstable periods, the original IPF methodology tends to be inadequate. Using the modified MMP approach and rental growth rates computed at the point of lease events (i.e. rent reviews), we find much more consistent depreciation rates – see Table 8. Excluding retail warehouses (that suffer from the aforementioned issue of overall negative rental growth during the sample period), shops show the highest depreciation at 1.5%-1.9%, followed by industrial at 1.3%-1.4% and offices at 0.1%-0.7%.

Table 8: Modified longitudinal approach using rent reviews

Sector	Depreciation		Lower Quartile	Median	Upper Quartile	Sample Size
	Weighted	Unweighted				
Office	0.1	0.7	-0.7	0.5	2.4	32
Industrial	1.4	1.3	0.1	1.3	2.7	48
Shops	1.9	1.5	-0.7	0.3	4.1	29
Retail Warehouse	-2.5	-2.3	-2.9	-1.7	-1.2	36

Notes: Reported results based on excluding 5% extreme observations on each side of the distribution. Shops using only observations from submarkets with growing CBRE rental index. Results based on less frequent rent reviews.

4.3 Regression-based methodology

The final part of our report presents the main results obtained through the estimation of regression models. This methodology is prevalent in recent literature, and we suggest its use as it estimates depreciation rates explicitly corrected for several asset and market characteristics.

This methodology is also useful for valuers, and asset and portfolio managers to estimate more precisely the depreciation rate of a specific building. As depreciation is part of the assumptions used in a discounted cashflow model, for example, the outcome of this third methodology allows to price each characteristic of the building to be priced, and an asset-specific depreciation rate can be used rather than relying on an average depreciation rate by sector and region.

Regression-based using MSCI capital and rental values data

Firstly, we present results obtained using MSCI data. Table 9 reports depreciation rates (coefficients for building age) for each sector using either rent passing or estimated market rent (with or without floorspace control). We find the highest depreciation for student housing (1.5%-2.0%) and hotels (1.0%-1.5%), with other sectors showing a lower estimate of around 0.2%-0.4%. Slightly higher depreciation rates are found for offices and multifamily and lower for student housing when market rents are used. Importantly, this model uses annual observations for the overall sample, and it is therefore subject to smoothing due to capital and rental values not necessarily reflecting the full extent of market movement.

4. MAIN RESULTS

Table 9: Rental values and building age (MSCI data)

Dependent Variable	Rent Passing		Market Rent		"Market Rent (floorspace control)"	
	Weighted	Unweighted	Weighted	Unweighted	Weighted	Unweighted
Age Hotels	0.010**	0.013***				
	(0.004)	(0.003)				
Age Industrial	0.000	-0.006***	0.000	-0.007***	-0.002***	-0.005***
	(0.001)	(0.001)	0.000	0.000	0.000	0.000
Age Multi Family	0.000	0.002**	0.005***	0.004***	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Age Office	-0.004***	-0.002***	-0.006***	-0.009***	-0.006***	-0.008***
	(0.001)	(0.001)	0.000	0.000	0.000	0.000
Age Shopping Centre	-0.004*	-0.004***	0.001	-0.002	-0.002	-0.001
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Age Shops	0.001	-0.001	0.001***	0.000	0.002**	0.000
	0.000	(0.001)	0.000	0.000	(0.001)	0.000
Age Single Family	0.003***	0.004***	-0.003***	-0.002***	0.000	-0.001*
	(0.001)	0.000	(0.001)	0.000	(0.001)	0.000
Age Student Housing	-0.020***	-0.015***	-0.012***	-0.010***	-0.008**	-0.009***
	(0.004)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)
Age Retail Warehouse	-0.002	-0.015***	-0.001	-0.010***	-0.003***	-0.012***
	(0.001)	(0.002)	0.000	(0.001)	(0.001)	(0.001)
Vacancy Rate (floorspace)			-0.254***	-0.028	-0.189***	-0.055
			(0.045)	(0.033)	(0.031)	(0.029)
Number of observations	15244	15244	26471	26471	26471	26471
Num. groups: year_sector_FE	104	104	101	101	101	101
Num. groups: pc2_FE	157	157	157	157		
Num. groups: pc3_FE					522	522
R² (full model)	0.836	0.787	0.875	0.791	0.911	0.823
Adj. R² (full model)	0.833	0.783	0.874	0.788	0.908	0.818

Notes: Convention for reporting results is different for regression analysis results: Depreciation here is reported as negative number, because increasing age negatively affects rental value. Columns 1 and 2 use 'gross rent passing', including only observations for which rent passing differs from previous year. Columns 3 and 4 use 'market rental value'. Columns 2 and 4 (W) weight observations by floorspace. All specifications include log (Floorspace) interacted with sector. Standard errors clustered at year-sector level are reported in parentheses.

4. MAIN RESULTS

Table 10 produces the same analysis but just utilising the rent review sample. As rent passing and market rent are equal at the point of rent review, we only report one estimation. Consistent results are still found for this estimation, with low depreciation for shops (0.2% - 0.5%) and slightly higher for both offices (1.7%-1.9%) and industrial (1.2%). Retail warehouses show a plausible depreciation rate of between 0.4% and 0.8%, confirming the need to use methodologies different from the previous IPF longitudinal approach.

Table 10: Baseline regression results, MSCI data, rents at rent review

Dependent variable	Rent Passing	
	Weighted	Unweighted
Age Industrial	-0.012***	-0.012***
	(0.003)	(0.002)
Age Office	-0.017*	-0.019***
	(0.007)	(0.003)
Age Shops	-0.005**	0.002**
	(0.002)	(0.001)
Age Retail Warehouse	-0.008*	-0.004*
	(0.003)	(0.002)
Number of observations	826	826
Num. groups: year_sector_FE	63	63
Num. groups: Region	15	15
R ² (full model)	0.762	0.786
Adj. R ² (full model)	0.736	0.763

Notes: Convention for reporting results is different for regression analysis results: Depreciation here is reported as negative number, because increasing age negatively affects rental value. Rent passing is equal to market rent in the sample at rent reviews. All specifications include log (Floorspace) control. Standard errors clustered at year-sector level are reported in parentheses. Column 1 (W) weights observations by floorspace. The second column is not weighted (NW).

Regression-based results using CoStar transaction prices data (from Bajaj et al, 2025)

Following our theoretical framework, 'net depreciation' based on asset transaction prices should be larger than 'net rental depreciation', which does not consider the impact of depreciation on property yields (i.e. cap rate creep). However, differences between the two should be marginal.

The model uses the logarithm of sale price as the dependent variable and both age and age squared as key regressors to test the concave nature of depreciation along the property lifecycle. Both asset i and market m characteristics are included as control variables (X_{itm}).

Equation 7: Regional variation in depreciation

$$\log(P_{itm}) = \alpha + \delta_1 \text{age}_{it} + \delta_2 \text{age}_{it}^2 + X_{itm} + \varepsilon_{itm}$$

4. MAIN RESULTS

Figure 6 represents the reconstructed shapes of depreciation rates by building age for the different sectors (Panel A) and regions (Panel B). We show the decaying nature of the marginal depreciation, which is higher for younger buildings and lower for older assets.

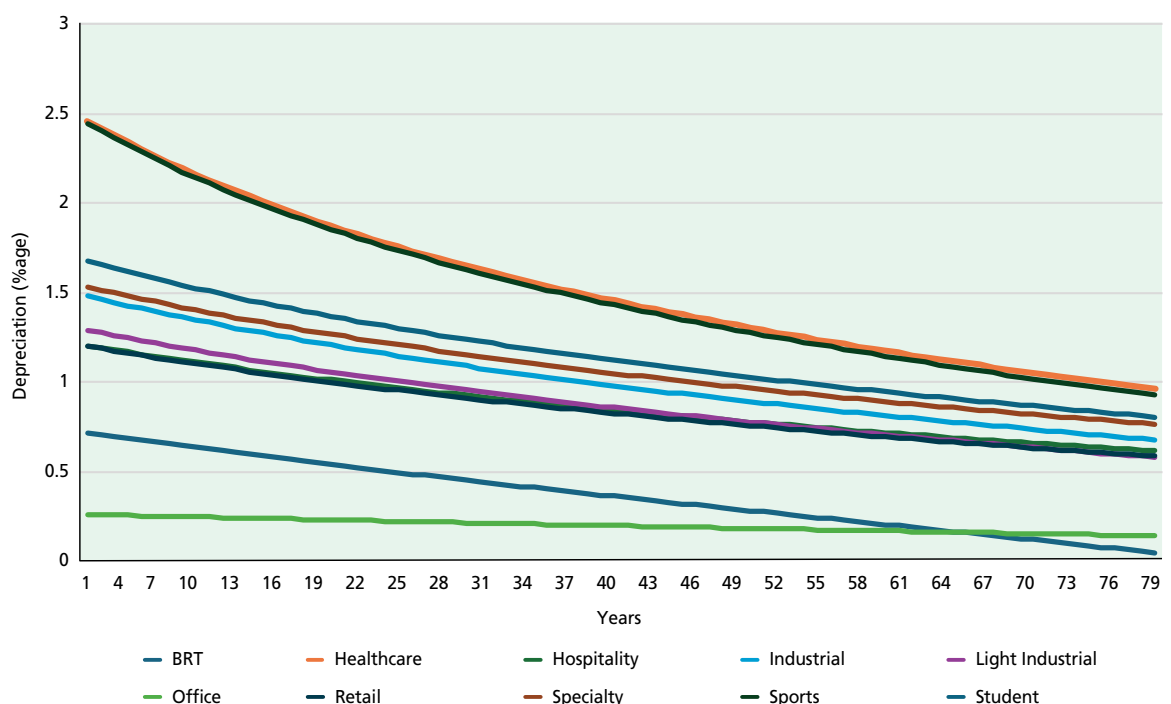
Sports and healthcare have both the highest and steepest depreciation, with a rate of almost 2.5% for newly built assets and falls below 1.0% for assets that are 70+ years old. Student accommodation and industrial follow, while the build-to-rent (BtR) sector ranges from 0.7% for newer to 0.1% for older buildings. Offices are confirmed to show the lowest depreciation at 0.3%.

As far as regions are concerned, we find that the North tends to show higher depreciation rates (North East being the top) and London, with more thriving economic activities effectively showing a depreciation close to zero. The South East holds the second lowest depreciation at 0.2% to 0.5% depending upon building age, while the West of the country (both South and North) is only second to the North East in this ranking.

Importantly, this report does not include the full analysis that can be found in Makovsky and Marcato (2025). As aforementioned, this methodology is preferred as the regression-based approach allows for the estimation of an asset-specific depreciation rate by pricing all different building and market characteristics. Such a feature would not be possible using the original and modified longitudinal approach that would only allow the estimation of average depreciation rates by sectors and regions. This can be demonstrated taking the example of a 30-year old 10-storey office building located one mile away from the city centre in Leeds (building A), and a 15-year old 20-storey office building located three miles away from the city centre in Sheffield (building B). As each characteristic or location has an impact on the depreciation rate, this methodology allows us to obtain a precise measure of the impact of each factor to obtain a tailored depreciation rate for each building. Therefore, a potentially different depreciation rate for buildings A and B can be identified that can be more appropriately used to take investment and asset management decisions on each property.

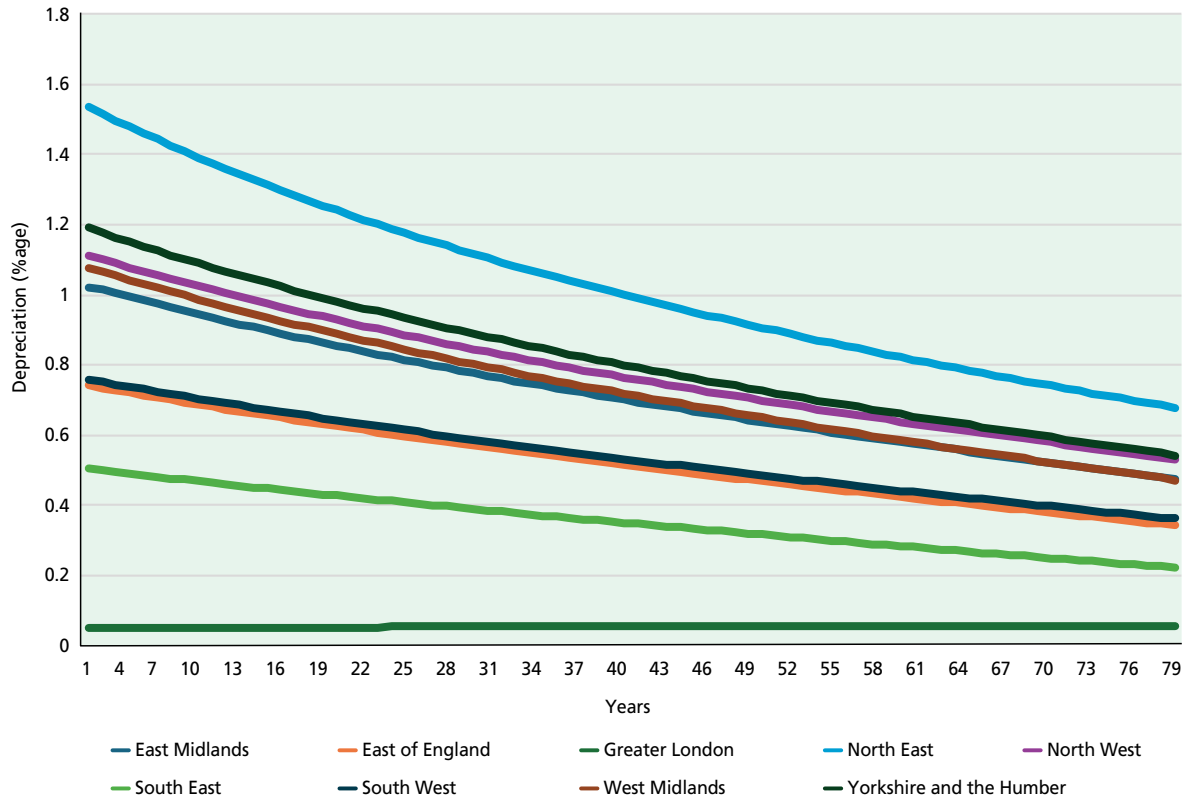
Figure 6: Relationship between depreciation rates and building age (from Bajaj et al, 2025)

Panel A: Marginal depreciation rates by sector



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Panel B: Marginal depreciation rates by region



Further analysis on regional variation

As a final step for our regression-based approach, we assess regional variation in depreciation at county level estimating the following model:

Equation 8: Regional variation in depreciation

$$\log(P_{islct}) = \delta_c \text{age}_{it} * c_i + \delta_s \text{age}_{it} * s_{it} + \mathbf{x}'_{it} \boldsymbol{\beta} + \mathbf{z}'_i \boldsymbol{\theta} + \lambda_l + \tau_t + \varepsilon_{islct}$$

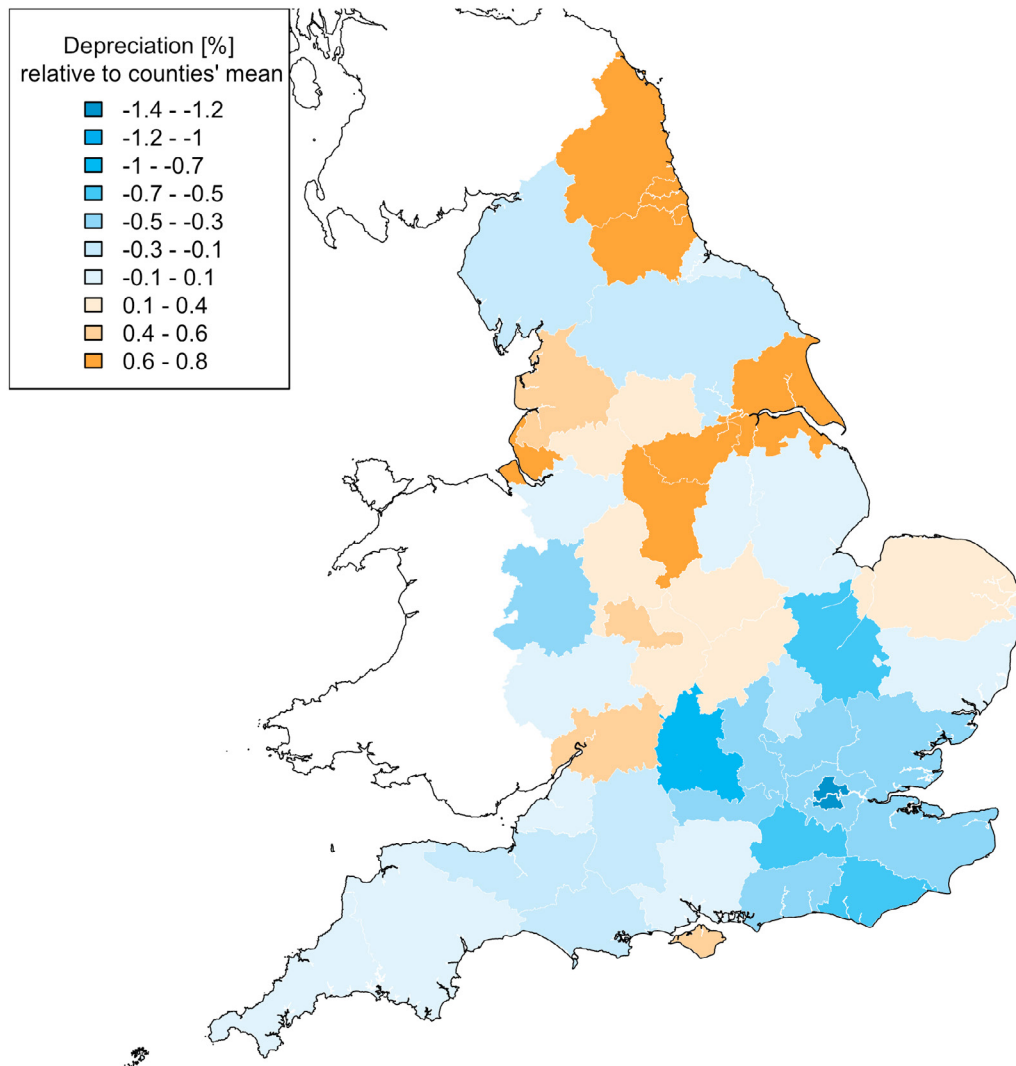
The logarithm of the sale price P of property i in real estate sectors s located in a post area l and county c and sold in year t is regressed on interaction of property age and property location county c , and on interaction of property age and property sector s . Industrial is excluded from the set of sector dummies to avoid multicollinearity, so estimates δ_c for individual counties could be interpreted as depreciation rates for industrial properties. Estimates δ_s then show how depreciation for other sectors differ relative to industrial. Further regressors include property-level characteristics $\mathbf{x}$, and location characteristics $\mathbf{z}$. λ_l is a post area (usually first two letters of the postcode) fixed effect and τ_t is a year-sector fixed effect.

By assumption, differences in depreciation between sectors are held constant for all counties, because there might not be enough observations to estimate sector-county specific depreciation for all sectors and counties.

Deviation of county-specific depreciation from the cross-county mean depreciation is shown in Figure 7. Lower depreciation is found in general in the South East, and notably in central London. Results in the Midlands and North of England show greater variation in depreciation levels.

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Figure 7: Relative differences in depreciation across counties (from Makovsky and Marcato, 2025)



Based on CoStar data
Geometry: Counties (1981) Boundaries EW, geoportal.statistics.gov.uk

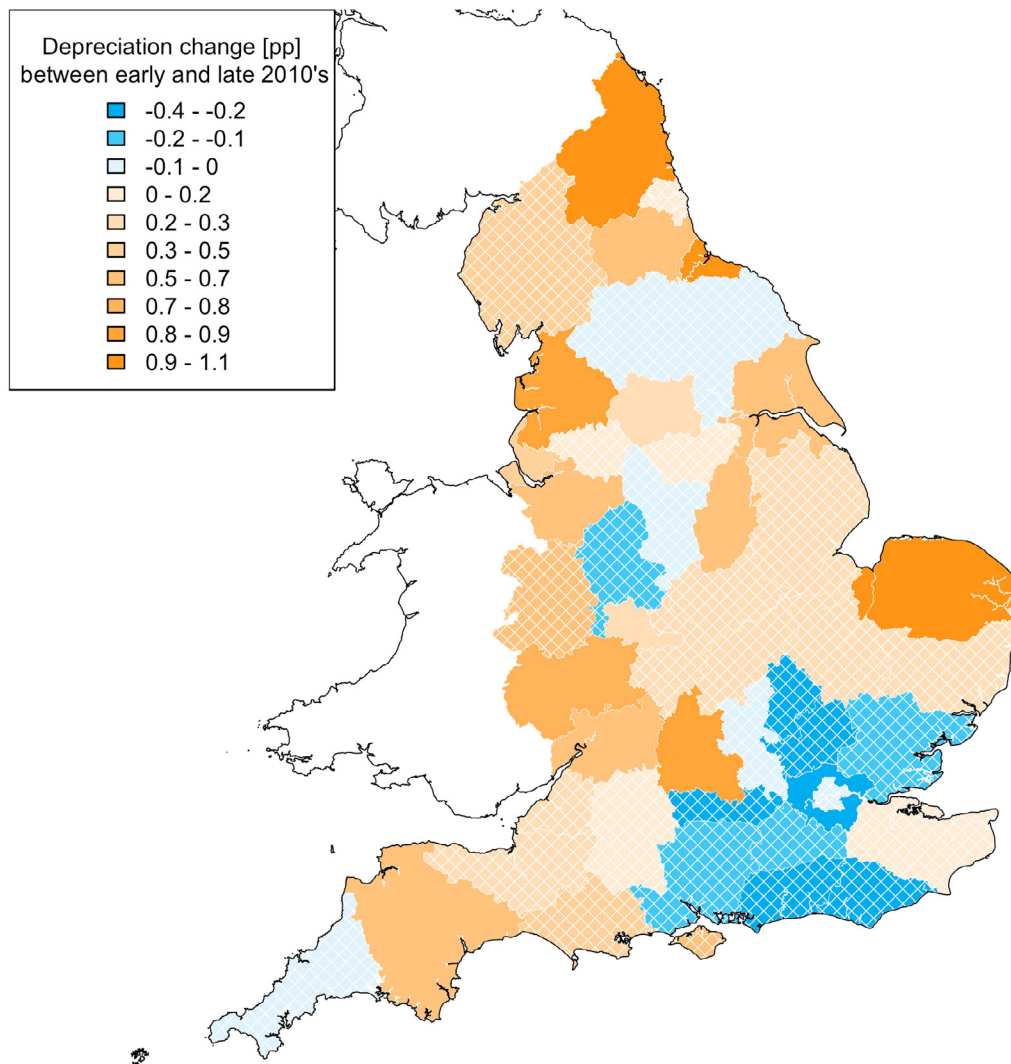
Finally, a modified version of Equation 8 was used to estimate the change in depreciation between the 2010-14 and 2015-19 periods. These two periods were chosen to exclude immediate effects of the GFC in 2008 and 2009, and Covid from 2020 onwards.

Figure 8 shows the main results, with areas where depreciation increased in orange and areas where depreciation decreased in blue. Counties where differences are not significantly distinctive from one another (at 90% confidence level) are left white.

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While depreciation decreased in the South East (blue areas), the remaining parts of England reported depreciation rates not changing or increasing from the first to the second half of the 2010s. Given the relatively lower depreciation in the South East compared to the North of England at the beginning of our sample period, we therefore find evidence of a higher and increasing depreciation (and depreciation gap) between the North and the South, which is explained by the relative development of economic activities in these regions. Levelling up targets and reduction of economic inequalities should reduce this gap, lowering depreciation in less thriving regions and slightly accelerating it in other parts of the country.

Figure 8: Change in depreciation between first and second half of 2010s (from Makovsky and Marcato, 2025)



Based on CoStar data
Geometry: Counties (1981) Boundaries EW, geoportal.statistics.gov.uk
Hatched counties show no statistically significant change (t value below 1.65)

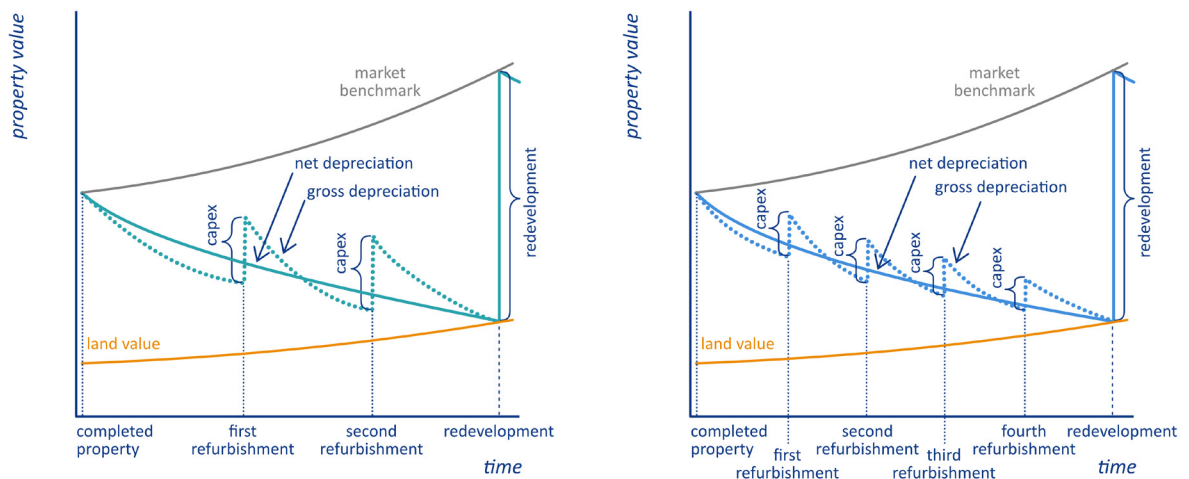
5. IMPACT OF ASSET MANAGEMENT AND SUSTAINABILITY ON DEPRECIATION

In this section of the report, we assess the impact of asset management interventions and sustainability features of real estate assets on the process and speed of capital and rental values decaying over time.

5.1 Optimality of asset management strategies

Depreciation depends on asset management strategies that may affect the decaying value of real estate assets. A higher amount and frequency of capex may lead to a greater real estate/rental value retention. Figure 9 shows two different types of asset management strategies, where the asset manager may decide to intervene with larger capex amounts less frequently (left graph), or with smaller amounts but more frequently (right graph).

Figure 9: Market benchmark, capital investment and depreciation by asset management approach

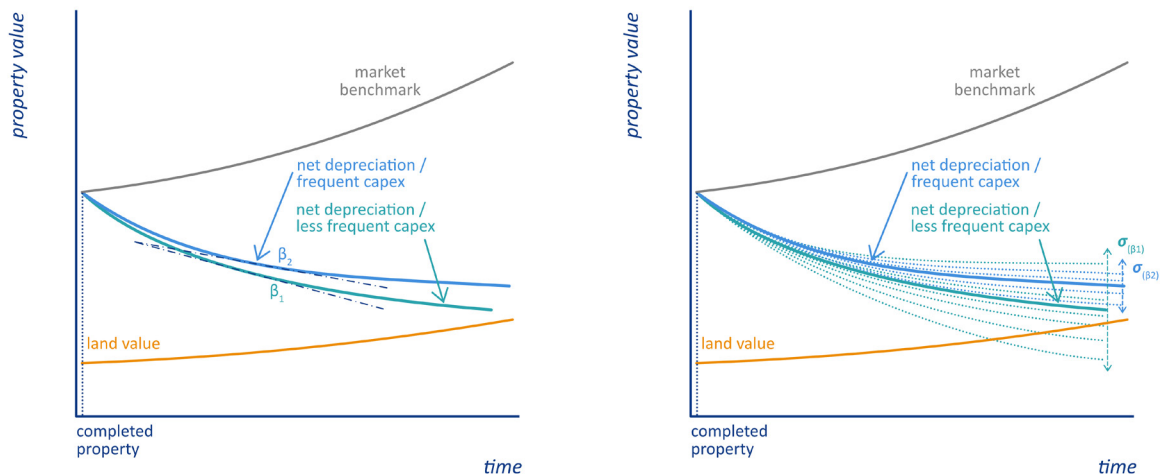


While the two asset management strategies may appear to produce similar decaying values of real estate assets (the green and blue lines), they could also lead to a different depreciation pattern. In Figure 10, the graph on the left shows a slower depreciation for the blue line and a faster one for the green line. Furthermore, the different asset management strategies and building characteristics will determine a range of depreciation rates (denoted as standard deviation σ) within groups of properties, highlighting the importance of controlling for key factors affecting the decaying process of real estate asset values. The graph on the right shows two different possible ranges of outcomes, wider for the green line and narrower for the blue one.⁸

⁸ These graphical examples are only illustrative: small and frequent capex (green line) are not necessarily linked to a lower average depreciation and a smaller range of rates than large and infrequent capex (blue). Our empirical analysis will test these relationships.

5. IMPACT OF ASSET MANAGEMENT AND SUSTAINABILITY ON DEPRECIATION

Figure 10: Mean depreciation and its variance



Depreciation and capital expenditure

Table 11 presents an analysis of gross (capex-adjusted) depreciation by adding the average annual capex amount (in percentage of the asset market value) to net depreciation. We find that on average shopping centres show the most active asset management, with 100% of properties recording some capex intervention (on average 0.9% of the capital value) over the sample period 2008-23. Offices, retail warehouses and industrial properties follow with an annual capex of around 0.4%-0.5% and interventions made on 63%-83% of properties. Shops and multifamily tend to lag behind, showing on average the lowest annual capex (0.1-0.2%) and percentage of properties with investment during the sample period (59% and 29% respectively).⁹

The gross (capex-adjusted) depreciation is obtained by summing the unweighted depreciation with the average annual capex and is reported in the last but one column in Table 11. We also report the depreciation of the sample of properties where no capex interventions were made during the overall sample period. Shopping centres and multifamily show the highest gross depreciation at 1.7%, followed by shops, industrial and offices (respectively 1.1%, 1.0% and 0.8%). Finally, notwithstanding the impact of 0.5% of capital expenditures, retail warehouses still 'suffer' a negative gross depreciation (-1.0%).

⁹ Multifamily refers only to the available sample 2018-23.

5. IMPACT OF ASSET MANAGEMENT AND SUSTAINABILITY ON DEPRECIATION

Table 11: Net and gross (capex-adjusted) depreciation rates using the IPF longitudinal methodology by sector

Sector	Sample Size	% Sample With Capex	Net Depreciation Unweighted	Mean Capex	Gross Depreciation Capex-Adjusted	Depreciation Sample With No Capex
Office	137	62.8%	0.3	0.5	0.8	0.4
Industrial	178	73.6%	0.6	0.4	1.0	0.8
Shops	32	59.4%	0.9	0.2	1.1	0.8
Shopping Centres	15	100.0%	0.8	0.9	1.7	
Retail Warehouse	127	83.5%	-1.5	0.5	-1.0	-1.5
Multifamily	72	29.2%	1.6	0.1	1.7	2.3

Notes: Reported results are based on a sample using volatility filter and excluding 5% extreme observations on each side of the distribution. Shops using only observations from submarkets with growing CBRE rental index. Depreciation adjusted for capex is a sum of property-level depreciation and average annual capex. All reported depreciations and mean capex are unweighted unless stated otherwise.

Table 12 reports the same analysis for market segments as defined by MSCI. Clear differences are shown, especially in the office market where the low depreciation in the City and West End appears evident and drags the overall depreciation of the office sector down. For industrial properties, there is little difference between the South East and the rest of the country and for standard retail we report a slightly higher net and gross depreciation in the South East.

5. IMPACT OF ASSET MANAGEMENT AND SUSTAINABILITY ON DEPRECIATION

Table 12: Net and gross (capex-adjusted) depreciation rates using the IPF longitudinal methodology by market segment

Segment	Sample Size	% Sample With Capex	Net Depreciation Weighted	Unweighted	Mean Capex	Gross Depreciation Capex- Adjusted
PAS Industrial - Rest of UK	84	70.2%	0.5	0.6	0.5	1.1
PAS Industrial - South East	93	75.3%	0.6	0.6	0.3	1.0
PAS Office - City	16	93.8%	-1.0	-1.0	1.0	0.0
PAS Office - Rest of South East	18	83.3%	0.5	0.8	0.9	1.7
PAS Office - Rest of UK	17	94.1%	1.7	1.5	1.3	2.8
PAS Office - West End & Mid Town	86	46.5%	-0.1	0.1	0.3	0.4
PAS Standard Retail - Rest of UK	25	64.0%	0.5	0.7	0.1	0.9
PAS Standard Retail - South East	33	57.6%	1.5	1.0	0.2	1.2

Notes: Reported results are based on a sample using volatility filter and excluding 5% extreme observations on each side of the distribution. Shops using only observations from submarkets with growing CBRE rental index. Depreciation adjusted for capex is a sum of property-level depreciation and average annual capex. All reported depreciations and mean capex are unweighted unless stated otherwise. PAS Segment is a MSCI data classification.

Capex effect on market rental value and capital value

In this section, we determine the effectiveness of asset management in value creation. We determine the relationship between capex and capital values by estimating the following model, where capital or rental values (V_{ist}) are regressed against capex (sum spent during the overall sample period), building age and a series of other control variables, i.e. asset (Y s) and market (Pr) characteristics:

Equation 9: Estimation of depreciation using capital or rental values

$$\log r_{it} - \log r_{jt} = \alpha + \beta \text{ year}_t + \varepsilon_{ijt}$$

We find evidence of capex significantly affecting both capital and rental values, with shopping centres being the sector most able to capitalise on investment – see Table 13. Properties that received no capex investment during the sample period are on average less valuable and report a lower rental value, which is likely due to their lower quality from wear and tear.

5. IMPACT OF ASSET MANAGEMENT AND SUSTAINABILITY ON DEPRECIATION

Table 13: Capex effect on market rental value and capital value

Dependent Variable: log(rental value), log(capital value)	Rental Value		Capital Value	
	All Property	Sector	All Property	Sector
Sample With No Capex	-0.530*		-0.688*	
	(0.131)		(0.162)	
Sum Of Capex Over Period	0.072*		0.089*	
	(0.019)		(0.020)	
Capex Industrial		0.040***		0.053***
		(0.003)		(0.003)
Capex Office		0.077***		0.095***
		(0.005)		(0.002)
Capex Shopping Centre		0.207***		0.248***
		(0.007)		(0.008)
Capex Shops		0.066***		0.082***
		(0.001)		(0.003)
Capex Retail Warehouse		0.056***		0.085***
		(0.002)		(0.003)
Age Industrial	-0.007***	-0.007***	-0.011***	-0.010***
	0.000	0.000	0.000	0.000
Age Office	-0.009***	-0.009***	-0.011***	-0.011***
	(0.001)	(0.001)	0.000	0.000
Age Shopping.Centre	0.001	0.003*	-0.005**	-0.003*
	(0.001)	(0.001)	(0.001)	(0.001)
Age Shops	0.000	0.000	-0.002***	-0.002***
	0.000	0.000	0.000	0.000
Age Retail Warehouse	-0.006***	-0.006***	-0.006***	-0.006***
	0.000	0.000	(0.001)	0.000
Number of observations	1529	1529	1532	1532
Num. groups: year_ sector_FE	5	5	5	5
Num. groups: Region	16	16	16	16
R ² (full model)	0.747	0.759	0.719	0.728
Adj. R ² (full model)	0.742	0.752	0.713	0.721

Notes: Standard errors clustered at sector level

5. IMPACT OF ASSET MANAGEMENT AND SUSTAINABILITY ON DEPRECIATION

Capex effect on depreciation

Finally, we test the ability of capex to recover asset value (and therefore reduce the rate for depreciation) by regressing capital expenditure (and other characteristics) on the previously computed depreciation rate for each property. Table 14 shows the ability of invested money to recover 70-90% of the value for offices and less so for other sectors. In other words, increasing capex by one additional percentage point of property value per annum reduces on average the annual depreciation by 0.7-0.9% for offices, 0.3-0.7% for shops and 0.2% for industrial properties.¹⁰

Table 14: Depreciation and capex

Dependent Variable: Depreciation	Shops		Office		Industrial	
	Weighted	Unweighted	Weighted	Unweighted	Weighted	Unweighted
Capex	-0.683**	-0.290	-0.702*	-0.906**	-0.163*	-0.194*
	(0.255)	(0.320)	(0.305)	(0.274)	(0.081)	(0.088)
Other control variables	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	147	147	245	245	245	245
Num. groups: Region	11	11	12	12	11	11
R ² (full model)	0.278	0.284	0.097	0.189	0.288	0.286
Adj. R ² (full model)	0.213	0.220	0.046	0.143	0.252	0.249

Notes: Dependent variable are property-level depreciations calculated with the IPF method. 'W' stands for regression weighted by floor area. Heteroskedasticity-robust standard errors in parentheses.

5.2 Sustainability and depreciation

Table 15 presents the impact of the EPC rating on depreciation after correcting for several factors including the benchmark rental growth for the sector in the region where the asset is located. Overall, we find some weak evidence of the influence exercised by energy efficiency on the speed of depreciation. In particular, improving the EPC rating by one grade is associated with a reduction in depreciation of around 1% to 3%. Importantly, we note the significant reduction of sample size when we tried to match the EPC rating and the actual building. The availability of data only allows us to cover a sub-sample of the overall properties we measure in the main analysis.

¹⁰ Ranges are due to the difference between weighted and unweighted depreciation used as dependent variable in the model estimation.

5. IMPACT OF ASSET MANAGEMENT AND SUSTAINABILITY ON DEPRECIATION

Table 15: Depreciation and EPC rating

Dependent Variable: Depreciation	Shops		Office		Industrial	
	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Log (Mean EPC Rating)	-0.001	0.022*	0.009*	0.011	0.027*	0.008**
	(0.013)	(0.011)	(0.004)	(0.013)	(0.011)	(0.003)
Other control variables	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	47	89	74	47	89	74
Num. groups: Region	9	11	9	9	11	9
R² (full model)	0.407	0.227	0.522	0.56	0.369	0.615
Adj. R² (full model)	0.243	0.105	0.446	0.438	0.27	0.554

Notes: Dependent variable are property-level depreciations calculated with the IPF method. 'W' stands for regression weighted by floor area. Heteroskedasticity-robust standard errors in parentheses.

6. RESULTS SUMMARY AND CONCLUSION

In this concluding section, we present an overview and summary of the results obtained with the longitudinal (original and modified) method, as well as with a regression-based approach using CoStar data (Makovsky and Marcato, 2025) and allowing for a concave age-price relationship (i.e. age squared included). Table 16 presents weighted and unweighted depreciations, alongside the main results of the previous IPF11 study (reported in the last two columns). If we mainly focus on our preferred methodologies (MMP modified longitudinal approach using rent reviews and regression-based models using transaction prices and including both age and age squared), we find consistent estimates of depreciation rates for the three main sectors: around 1.2% to 1.9% for shops, 1.3% to 1.5% for industrial properties and 0.1% to 0.7% for offices. Comparing our results to the ones shown in the 2011 IPF report, we show slightly less depreciation for offices and significantly higher for both industrial and shops.¹¹

As far as offices are concerned, we believe that several factors could have led to lower depreciation estimates. Firstly, valuations may not reflect the reality of clearing prices. Over our sample period, there were two major events (GFC and Covid) that reduced market liquidity and comparable evidence for valuers, and they determined a higher proportion of low (and negative) rental and value growth over the measurement period. A lack of information may have determined a conservative approach, leading to reported growth rate estimates (source: MSCI) being lower than hypothetical ones (source: CBRE) used for our benchmark (always newly refurbished buildings). A lower-than-expected decay in values (i.e. lower depreciation) could therefore be the outcome of such particular time period. Secondly, the office sample reports a much higher proportion of buildings located in London than other sectors. Therefore, rising land values in London (more pronounced than in other locations), may have led to a higher increase in market values than we would have recorded using the value of the physical building component sitting on the land. The result is a lower estimate of depreciation as the recorded market or rental value increase is higher mainly due to the land value component. Thirdly, a building may also show a value being held higher (with depreciation then being lower) by a potential change of use. A clear example of this possible effect is represented by Covid and the impact of working from home on the spatial distribution of real estate use within urban areas.

If we extend the analysis beyond the three main sectors, we also find shopping centres with a depreciation of 0.4% to 0.8% using a longitudinal approach (results with a MMP Modified and regression-based approach are not reported because the sample is not big enough). The depreciation is evidently in line with other sector estimates and we obtained a slightly higher depreciation than the one shown in the previous IPF11 report.

Furthermore, a significant change in retail distribution over the past few years and the updating of actual properties measured by MSCI and CBRE may have led to retail warehouse showing a negative depreciation. For example, newly developed properties measured by MSCI may not correspond to 'old' properties still used to compile the CBRE index. As a result, the rental growth from old to new properties in the MSCI database may have been higher than the one reported by the CBRE index (hence negative depreciation). Alongside this data issue, other motives may be behind this result: a potential increase in land value due to the potential conversion to a different use with higher value (e.g. life sciences or industrial); a significant percentage of retail warehouses being represented by supermarkets with index-linked income, which may have reported higher values due to the general decline in bond rates.

¹¹ The replication of the IPF longitudinal approach to our new data are hereby reported in the first two columns and show results slightly different from our preferred approaches as they may be affected more by the two major events of GFC and Covid.

6. RESULTS SUMMARY AND CONCLUSION

Finally, residential (multifamily and BtR) properties recorded a depreciation between 0.7% and 1.6%. As the MMP Modified approach (to be preferred to the IPF Longitudinal approach) could not be applied because of the reduction in sample size required for the application of this method, we tend to rely on the lowest value of the range which was obtained using a regression-based approach with transaction-price data. This result places the depreciation of residential properties between offices (lowest) and shop and industrial (highest).

Table 16: Results comparison on overall market level

Sector	IPF Longitudinal		"MMP Modified (RR sample)"		Regression (transaction-price)	IPF11	
	Weighted	Unweighted	Weighted	Unweighted	Unweighted	Weighted	Unweighted
Office	0.0	0.3	0.1	0.7	0.3	0.8	1.0
Industrial	0.5	0.6	1.4	1.3	1.5	0.5	0.4
Shops	1.5	0.9	1.9	1.5	1.2	0.3	0.4
Shopping Centres	0.4	0.8				0.1	-0.2
Retail Warehouse	-1.4	-1.5	-2.5	-2.3		0.9	1.6
Residential	0.9	1.6			0.7		

Notes: Dependent variable are property-level depreciations calculated with the IPF method. 'W' stands for regression weighted by floor area. Heteroskedasticity-robust standard errors in parentheses.

Furthermore, we find that capital injections during the property lifecycle are positively associated with rental and capital values and they slow the process of decaying values, allowing rental and capital value recapture. In fact, increasing capital expenditures by one additional percentage point of property value per annum reduces annual depreciation by 0.7-0.9% for offices, 0.3-0.7% for shops and 0.2% for industrial properties.

As far as sustainability features are concerned, we find weak evidence of the impact of energy efficiency on the level of depreciation. In particular, improving EPC ratings by one additional grade leads to a reduction in depreciation of around 1% to 3%.

Finally, our analysis for different locations highlights that depreciation rates significantly depend on the wider socio-economic attractiveness of different locations. The more attractive geographical areas are normally associated to a higher component of land values on the overall real estate asset value and therefore they exhibit lower depreciation rates. We show that depreciation has increased more in the North of England than in the South East over the last fifteen years, and this trend has significantly worsened the depreciation gap that already existed at the beginning of the 2010s.

APPENDIX 1: TERMINOLOGY

A large share of research literature comes from the US context, where the terminology differs to some extent to the one adopted in the UK. However, more importantly, different streams of literature, often relying on different types of data, use the term 'depreciation' for different components/facets of overall depreciation. Our objective is therefore to review the use of language and provide a unifying conceptual framework.

Net and gross depreciation

Following Bokhari and Geltner (2019), 'net depreciation' *"is the loss in real value as a function of structure age even after and including capital improvements"* (p. 562) and 'gross depreciation' is total capital consumption which *"includes two separable components: capital improvement expenditures ('capex') and 'net depreciation'"* (p. 563). 'Gross depreciation' therefore captures the decline in property value if there is no asset management intervention, such as refurbishment or upgrades beyond necessary repairs (or maintenance). Furthermore, the real estate and investment literature usually refers to the concept of 'net depreciation' while the national accounts literature discusses 'gross depreciation'.

Equivalent to 'net depreciation', we find previous IPF reports and terminology referring to 'managed depreciation' as the *"depreciation recorded after the impact of expenditure and management activity"* (IPF, 2005, p. 65). In this report, we use the terms 'net' and 'gross' depreciation, instead of 'managed depreciation' used by earlier IPF studies so to align with the overall worldwide literature and offer a contribution more easily adopted globally.

Depreciation components

'Physical deterioration' represents the 'wear and tear' of real assets, and it could be prevented by regular maintenance, while 'functional (or external) obsolescence' refers to the mismatch between property design and the changing preferences of consumers.

Furthermore, 'external obsolescence' can be either related to the property surroundings (e.g. decrease in local amenity values) or to changes in local demand leading to buildings not showing their highest and best use over time. In particular, the discussion of external obsolescence related to the changes in local demand in Bokhari and Geltner (2019) is structure-related and not affecting land values, while the external obsolescence related to property surroundings affects the current structure, its use and land values.

An additional related feature is the vintage effect, which refers to the characteristics of a property associated with the construction period (Francke and van de Minne, 2017). Importantly, the vintage effect is not separable from functional obsolescence as they are jointly captured by a cohort effect.

Rental value and capital depreciation

IPF05 primarily focuses on 'rental depreciation', and partly on 'capital shift', which refers to the change in overall property market value throughout time. This is distinguished from 'capital depreciation' (elsewhere called 'cap rate creep' – Bokhari and Geltner, 2018) because 'capital shift' is partly determined by the change in rental value (alongside yield movements).

We introduce the new term 'gross rental depreciation' to describe rental depreciation occurring without any asset management interventions (i.e. capex). This contrasts with '(net) rental depreciation' which denotes depreciation after active asset management interventions.

APPENDIX 1: TERMINOLOGY

External obsolescence

Separating 'external obsolescence' from the remaining components of net depreciation might be practically difficult as it would rely on the methodology and the spatial reach of underlying amenities, such as retail for offices or entertainment for multifamily. For instance, when the previous IPF methodology (IPF05, IPF11) with local prime rent benchmarks is adopted, changes in 'local amenities value' may already be captured by the benchmark (i.e. therefore external obsolescence is not included) if amenities enter in the spatial dimension of the benchmark area (i.e. if all properties included in the benchmark are equally affected by the change in amenities, e.g. accessibility to a new transport hub). However, if the spatial reach of the amenity is much smaller than the area covered by the benchmark (e.g. decline in shopping attractiveness of a single street), then the relative depreciation would be captured by comparing the value to a benchmark which remains unaffected (or mildly affected) on average. At the same time, if a large enough number of observations is available, the isolation of external obsolescence could be possible using more sophisticated regression-based methodologies (or micro-level benchmark sampling). For example, the coefficient of decaying value by building age identified using transaction-based data refers to 'rental depreciation' (rental data) or 'net depreciation' without external obsolescence, could be modelled using location- and time-related variables (e.g. so-called fixed effects) to control for differences between locations (and/or against city-wide price trend) over time.

Structural and total value depreciation

Bokhari and Geltner (2018) carefully distinguish between estimates of structure depreciation, of higher research interest in the US due to its tax policy relevance, and total value depreciation (i.e. the combined value of structure and land), of more importance from a before-tax investment perspective. In this report, the term 'depreciation' refers to total value depreciation, and we explicitly mention 'structural depreciation' otherwise.

Land value is commonly assumed not to depreciate, with the exception of 'external obsolescence', which is unrelated to the structure. All depreciation components are instead related to the structure. If we omit the role of 'external obsolescence', then structural and total value depreciation differ only in the size of the denominator. As structure value is lower than total property value, structure-related depreciation will be higher in percentage terms. Finally, as the share of structural value generally declines with time, the structure-related depreciation might seem to increase over time relative to the total value-related depreciation.

APPENDIX 2: RESEARCH ON DEPRECIATION SINCE 2011

As earlier IPF reports present a useful review of the literature up to 2011, we briefly mention some older papers for broader context but mainly focus on more recent contributions from 2012 onwards.

Commercial properties

Bokhari and Geltner (2018) study depreciation of office, industrial, retail and apartment properties using transaction-based data with more than 100,000 properties sold in the US between 2001 and 2014. Their baseline method is a cross-sectional regression, although they also perform longitudinal regression for a subsample of repeatedly sold properties. Their mean estimate of depreciation is 1.5% a year, which rises to 1.8% for newly built properties, and declines to 1.1% for properties of 50 years of age and above. By property type, apartments seem to depreciate more and industrial less relative to offices and retail. Additionally, Bokhari and Geltner (2018) found that around 90% of depreciation is driven by a decline in rental value, while only 10% could be explained by yield changes.

However, driving factors of depreciation include local market and innovation in the construction sector as reported by Yoshida et al. (2024), where depreciation in rental value is only 50% of the overall value of rental depreciation for Tokyo office buildings. They hold information about new rents for around 6,100 buildings (with monthly frequency), and more detailed cash flow information for almost 300 buildings over 10 years (time period 2007-16). The main rental depreciation estimates are 0.8% for new leases and 0.6% for all leases. It is argued that the estimated rental depreciation being lower than total value depreciation (1.1% in Tokyo reported in Yoshida, 2020) is due to a “cap rate creep”. Furthermore, mean capital expenditure in the data is approximately 9% of net operating income (NOI) and they estimate capital expenditure to increase by 2.4% annually on average, although with significant noise. In an alternative model, they find capital expenditures increasing until a building age of 16 to 20 years, before stabilisation. Annual capital expenditure as a fraction of market value, rather than NOI, for a sample of US properties is on average 1.6% for commercial and 1.3% for apartment buildings (Bokhari and Geltner, 2019). In comparison, capital expenditure for commercial properties in the UK is found to be 0.8% of the capital value (IPF, 2005).

As far as the individual mechanisms leading to rental depreciation, Yoshida et al. (2024) study the Tokyo market and find half of the rental depreciation to be caused by functional obsolescence while the remaining half is due to physical deterioration. They list changing preferences of tenants and ceiling heights to accommodate high-speed network infrastructure as examples of functional obsolescence. For residential properties, Lopez and Yoshida (2022) find similar physical deterioration for single family houses and condominiums, while functional obsolescence is much higher for condominiums. They speculate this might be the cause of an easier upgrading of single-family houses.

As buildings age and the preferences of tenants change, the whole age cohorts lose value relative to most recent cohorts of properties. Therefore, functional depreciation may be proxied by differences in value between buildings' age cohorts. Physical deterioration is instead given by age difference and respective value difference within an age cohort.

APPENDIX 2: RESEARCH ON DEPRECIATION SINCE 2011

Bokhari and Geltner (2019) supplement estimates of ‘net depreciation’ obtained with the same dataset in an earlier paper – Bokhari and Geltner (2018) – and infer ‘gross depreciation’ by examining the impact of capital expenditure using more than 17,000 property-level records of capital improvements in US real estate assets. For a 25-year old commercial property, they estimate annual ‘net depreciation’ at 1.63%, capex at 1.75%, and a combined ‘gross depreciation’ at 3.39%. Similar numbers for residential properties are 2.38%, 1.96% and 4.34% respectively. All figures are reported as ‘total value depreciation’, although the authors also report estimates related to the structure value separately.

Heterogeneity in depreciation

Similarly to Bokhari and Geltner (2018), Lopez and Yoshida (2022) find decline in depreciation as properties age, and they conclude that not considering this time-varying feature of depreciation in real estate appraisals would lead to overvaluation of newly built properties and undervaluation of older ones. In case of single-family houses, they estimate new single-family houses to depreciate by 0.9% annually, with the figure decreasing to 0.5% when property reaches 50 years of age.

Using the same US dataset as in Bokhari and Geltner (2018), Bokhari and Geltner (2019) focus on stages of depreciation as building ages. They define a building as ‘Youth’ if they are up to 30 years of age, ‘Middle Age’ until the age of 65 years, and ‘Old Age’ until 100 years (the assumed maximum life expectancy of a building). During Youth, the value of a building decreases sharply and it moves from a new-build ‘A class’ to ‘B class’, with expected changes in type of tenants and achievable rents. When a building reaches its Middle Age, the effect of age on value drops, and then increases again when it enters the Old Age and moves to ‘C class’.

Bokhari and Geltner (2019) show support for the decaying nature of depreciation by age (based on non-parametric estimation). There is however sparser evidence supporting other depreciation patterns as well, for instance the Barras and Clark (1996) study of 150 London city offices demonstrate an ‘S-shape’ depreciation where buildings keep (rental) value initially, then the value drops before it stabilises again.

Yoshida (2020) refer to urban economic theory when proposing five characteristics which affect depreciation rates within a city: (i) building age, (ii) city size, (iii) unit commuting cost in a city, (iv) distance to the CBD, and (v) physical density of a property.

Bokhari and Geltner (2018) find substantial variation in depreciation across cities ranging from 0.42% in Los Angeles to 2.95% in Dallas. Estimates are strongly positively associated with housing supply elasticity due to different shares of land values on overall property values (including both land and building). Land itself does not depreciate and in unconstrained cities with rather inexpensive land, like Dallas, its share on overall value is lower so higher total value depreciation could be explained by higher share of depreciating structure. Lower depreciation measured in more land-constrained cities could be also due to the bias caused by not including option value of redevelopment, which attenuates estimated depreciation towards zero (Clapp, 2012). In land-constrained places, the option value could play a more important role compared to land-abundant places and so depreciation might be biased downwards. However, from a theoretical perspective, implications of construction constraints on option value are ambiguous, because the aforementioned channel could be (more than) offset by the opposite effect of land-constrained places also regulating developable densities. If current structures are developed at limits, then option value of redevelopment is rather low as no more space could be added.

APPENDIX 2: RESEARCH ON DEPRECIATION SINCE 2011

While Bokhari and Geltner (2018) study differences in depreciation between cities, Yoshida (2020) investigates its heterogeneity within cities. He finds that depreciation tends to increase with distance from the city centre, which is consistent with standard models predicting land values to decrease with distance. All else equal, for two similar buildings located on equally-sized plots of land only differing in proximity to the city centre, the share of land on overall property value will be higher for the more centrally located building, and therefore its depreciation will be lower as the land component does not depreciate. However, the effect is more apparent for residential than for commercial properties.

Depreciation in Japan is found to be relatively large. Beyond reasons such as development of earthquake-resistant structures and frequent changes to building code, Yoshida (2020) also notes that due to the specific institutional context for non-mandatory building inspections, adverse selection and moral hazard lead to low maintenance expenditures and fast depreciation. Yoshida (2020) further studies effects of structural density on depreciation and finds, all else being equal, denser structures to depreciate faster.

Another dimension of depreciation heterogeneity concerns lease structures. Yoshida et al. (2024) study rental depreciation of new and existing leases and find new leases depreciate by 0.23 percentage points. They argue that this evidence could be caused by lock-in effects as relocation is costly for tenants.

Besides mean depreciation, Crosby, Devaney and Law (2012) studied heterogeneity in rental depreciation measured between 1993 and 2009 for building age cohorts. Whereas they find almost no differences for office buildings, they find a large difference for industrial properties. The cohort built between 1989 and 1993 depreciated by almost 1% annually, while buildings built before 1983 depreciated at approximately one third of that rate.

Depreciation could also depend on local real estate market performance. Crosby, Devaney and Law (2011) analyse several European cities, and their findings suggest depreciation to be higher in strong markets where existing properties have to compete with new construction, than in weak markets with a lack of competition from new construction. This result is confirmed for properties across the UK in Crosby, Devaney and Nanda (2016).

Residential properties

Francke and van de Minne (2017) disentangle the share of structure and land in property total value and estimate effects of functional and external obsolescence, vintage and time on property value. They analyse almost 10,000 transactions of houses in the Netherlands between 2000 and 2012 using cross-sectional non-linear regression to separate combined functional obsolescence and vintage effects from physical depreciation and year effect of sale. Their main results for physical obsolescence are 0.66% annually for barely or not maintained structures, and 0.45% for well-maintained structures, both averaged over 50 years. Very well-maintained homes do not physically depreciate over time. They also estimate relatively large effects for some vintages, 22% positive effects for architecturally valuable houses from 1931 to 1944, and negative 16% effects for houses built in the 1960s. Wilhelmsson and Roos (2024) also study effects of maintenance and reinvestment on depreciation of owner-occupied single-family houses in Sweden older than 30 years. Their sample includes almost 10,000 properties transacted between 2021 and 2022 and they adopt cross-sectional regression design. Their baseline depreciation estimate is quite low at 0.2% annually, likely partly driven by estimating the effect only for relatively old properties. While focusing on residential properties, they also argue reinvestment shields against depreciation.

Lopez and Yoshida (2022) find heterogeneity in depreciation based on size of living area. In the case of single-family houses, increasing living area by one standard deviation is associated with 0.13 percentage point higher depreciation and the estimate is three times as high as 0.43 percentage point for condominiums.

APPENDIX 3: METHODOLOGICAL CONSIDERATIONS

Regarding analytical methods used in the depreciation research in the past decade or so, the most common methodology by far is some form of cross-sectional regression where a relationship between the natural logarithm of property or rental value and age is established after excluding the impact of other factors (i.e. value is regressed against age and control variables). This baseline specification implicitly assumes geometric depreciation (because of the logarithm scale of value). Some papers depart from this baseline model and further allow non-parametric (i.e. without assuming any specific probability distribution) age-related depreciation, but in most cases geometric depreciation seems to represent a reasonably good approximation (e.g. Bokhari and Geltner, 2019).

From a methodological perspective, Bokhari and Geltner (2018), who primarily study cross-sectional variation in the data, adjust observed property prices to tackle survivorship bias when only successful and valuable properties remain operational while less valuable assets are torn down and replaced. For that reason, they adopt a method by Hulten and Wyckoff (1981) and multiply actual property prices by their probability of surviving operationally up until their age. This approach seems appropriate to estimate structural depreciation as structure value likely approaches zero at the time of demolition.¹² However, when estimating the total (including land) value depreciation, the value is unlikely to approach zero even at the time when the structure needs to be torn down. Nevertheless, estimates with and without proposed bias correction are not significantly different, especially during the first 50 years of a property's lifespan when the survivor probability is high – Bokhari and Geltner (2019).

Crosby, Devaney and Nanda (2016) admit that capex could be an endogenous response to previous performance, but they claim that they do not find such a relationship in their data. Nevertheless, the issue of size and timing of capex does not seem to be further addressed in the existing literature.

IPF05 / IPF11 approach

We firstly present the original IPF (2005, 2011) methodology with minor adjustments in notation, explicitly distinguishing between asset-level depreciation d^a and sub-market-level depreciation d^m . We also add a time subscript to formally take into account that depreciation could differ by time period t . While notation is not an issue for understanding the original methodology, more explicit notation should ease understanding of the newly introduced methodology using regression analysis.

Equation A1: Asset-level rental values

$$R_{i,t}^a = r_{i,t}^a S_i, \quad R_{i,t}^b = r_{m,t}^b S_i, \quad i \in m$$

where $R_{i,t}^a$ is rental value of an asset i in time t , which is a product of an asset mean rent $r_{i,t}^a$ and an asset rentable area S_i . $R_{i,t}^b$ is benchmark rental value for an asset i in time t , which is a product of submarket m benchmark rent $r_{m,t}^b$ and an asset i rentable area S_i . In other words, it is an asset i rental value had the asset charged submarket benchmark rent. Each property i belongs to some submarket m for which benchmark rent is available.

Asset-level depreciation is then defined as change in asset (actual) rental value relative to change in asset benchmark rental value.

¹² Hulten and Wyckoff (1981) indeed study structural depreciation, not total value depreciation and Yoshida et al. (2018) studying rental value depreciation do not apply any adjustment and admit the Hulten-Wyckoff method is designed for property value depreciation.

APPENDIX 3: METHODOLOGICAL CONSIDERATIONS

Equation A2: Asset-level depreciation

$$d_{i,t}^a = 1 - \left(\frac{R_{i,t}^a / R_{i,t-L}^a}{R_{i,t}^b / R_{i,t-L}^b} \right)^{1/L}$$

Depreciation of an asset a in time t

Equation A3: Sub-market-level depreciation

$$d_t^m = 1 - \left(\frac{\sum_{i=1}^I R_t^a / \sum_{i=1}^I R_{t-L}^a}{\sum_{i=1}^I R_t^b / \sum_{i=1}^I R_{t-L}^b} \right)^{1/L}$$

Gross rental depreciation

The IPF methodology provides net rental depreciation, a measure not considering capital expenditures (capex) that can increase property values and shield from depreciation. At the same time, asset management strategies and the amount of capex invested seem to have changed over time. For example, between 1993 and 2009 the average capex in office sector was 0.5% p.a. (IPF11, table 3.2). This estimate however doubled to 1% p.a. from 2008 to 2019.¹³ At the same time, 62% of office buildings in the sample received some capital expenditures over that period of time. Increased capital expenditure likely translates into lower depreciation and figures based on a sample of properties where some receive investment and others do not show the full extent of depreciation. For that reason, we also construct gross rental depreciation on asset level g^{ag} as the sum of net rental depreciation and the average annual capex c in year t expressed as a share of property value P in a given year t . The number of included years is equal to the time lag L , so the last year included is $t-L$:

Equation A4: Asset-level gross rental depreciation

$$d_{i,t}^{ag} = d_{i,t}^a + \frac{1}{L} \sum_{t-L}^{t-1} \frac{c_{i,t}}{P_{i,t}}$$

Modified IPF approach based on rent review events

The following is the formal construction of our modified IPF depreciation measure at asset level d^{arr} , which could be aggregated to sub-market depreciation d^{mrr} . Instead of comparing rental growth rates within a property relative to a relevant sub-market benchmark rental growth rate over a fixed period of time, the modified IPF depreciation measure identifies depreciation for the time period between two rent reviews, as we argue that the actual rental market value is always revealed at the time of rent review.¹⁴

We assume there is a set of rent review years Y^{rr} which differs for each asset i , with the overall number of rent reviews N in the set differing for each property as well. This set contains individual years t_0, t_1 up to t_N when rent is adjusted to the actual rental market value. For each property, the depreciation d^{arr} is calculated as a mean of annualised depreciations between all recorded rent review years following Equation A5:

Equation A5: Asset-level rent-review based depreciation

$$d_i^{arr} = \frac{1}{N} \sum_{n=1}^N \left[1 - \left(\frac{R_{i,t_n}^a / R_{i,t_{n-1}}^a}{R_{i,t_n}^b / R_{i,t_{n-1}}^b} \right)^{\frac{1}{t_n - t_{n-1}}} \right] \quad \{t_0, t_1, \dots, t_N\} \in Y_i^{rr}$$

¹³ Capital expenditures around 1% p.a. were reported earlier by IPF05 for period between 1984 and 2003.

¹⁴ Problems of upward-only rent reviews and actual method to detect rent review years in the data is discussed later.

APPENDIX 3: METHODOLOGICAL CONSIDERATIONS

Asset-level rent-review depreciation in Equation A5 is very similar to the IPF method shown in Equation A2, with the only difference being that it takes into account varying time windows over which depreciation is measured for individual properties, and measuring depreciation multiple times in a single property if more than two rent review years are recorded in the data.

This approach however cannot be scaled up for the whole submarket as in the IPF method in Equation A3, because of the assumption on the same time window over which depreciation is measured for all properties.

Instead, we calculate sub-market (value-weighted) rent-review based depreciation as a weighted average of individual asset-level rent-review based depreciations, following Equation A6. Property weights w_i are defined as mean gross rental revenues recorded at the end of each period as newly achieved rent passing:

Equation A6: Sub-market rental-review based depreciation

$$d_t^{mrr} = \frac{\sum_1^I (d_i^{arr} w_i)}{\sum_1^I (w_i)} \quad w_i = \frac{1}{N} \sum_1^N (R_{i,t_n}^a)$$

Identification of lease events (i.e. rent reviews)

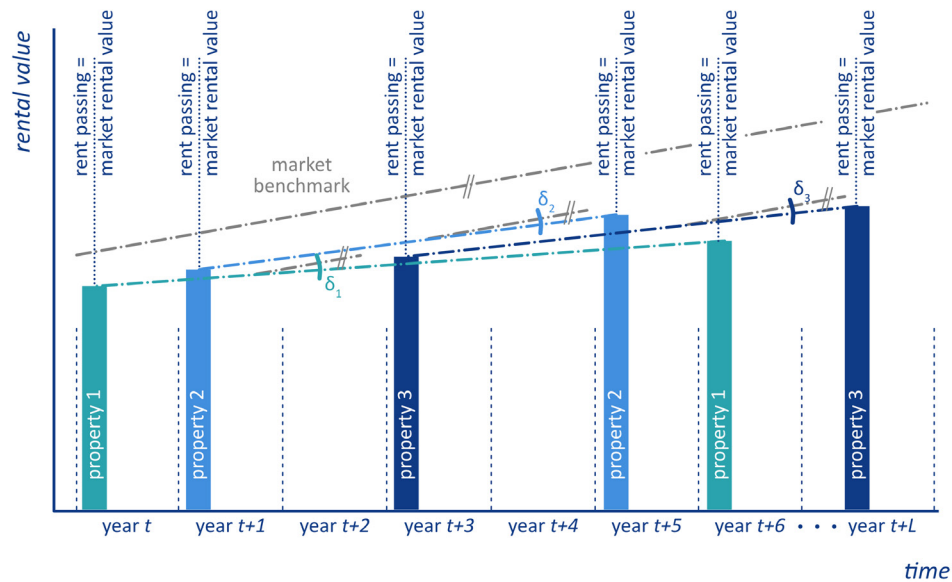
Rent review events are not directly observable in the data and for that reason we take two alternative approaches to infer them.¹⁵ Firstly, they are inferred from the available MSCI data by comparing gross rent passing and assessed market value in each year. As rent passing reverts to the market rent at the time of rent review, whenever these two are equal, we treat that given year as a potential rent review year. Moreover, this procedure also considers and adjusts for upward-only and indexed rent reviews, which might not revert to true market value. In fact, even if the new rent passing does not equal the estimated rental value (ERV), we still identify a period being a review year if the five-year rental growth rate is above a certain threshold. Figure A1 illustrates the rental growth computed between rent reviews for three different properties. For each property, the depreciation rate will be computed as the asset rental growth relative to the benchmark over the same period (between rent reviews).

Furthermore, our dataset contains instances of gross rent passing being constant and equal to the ERV. To address this issue, we adopted two alternative approaches. First, we selected only properties with a maximum of five potential rent review years over the study period (i.e. rent reviews less frequent than once every three years on average). Second, we also excluded rent reviews if they occur in a subsequent year. This procedure however led to a relatively small subsample, notably with low representation of office buildings as this method selects mostly single-tenant properties for which cash flows are stable and change at the time of a rent review, making rent review years easier to detect.

¹⁵ We also tested an alternative approach based only on major changes in gross rents passing. This approach did not seem to be as successful as the other two methods described in this section. Although this alternative method was not adopted, its description in more detail is provided in Appendix.

APPENDIX 3: METHODOLOGICAL CONSIDERATIONS

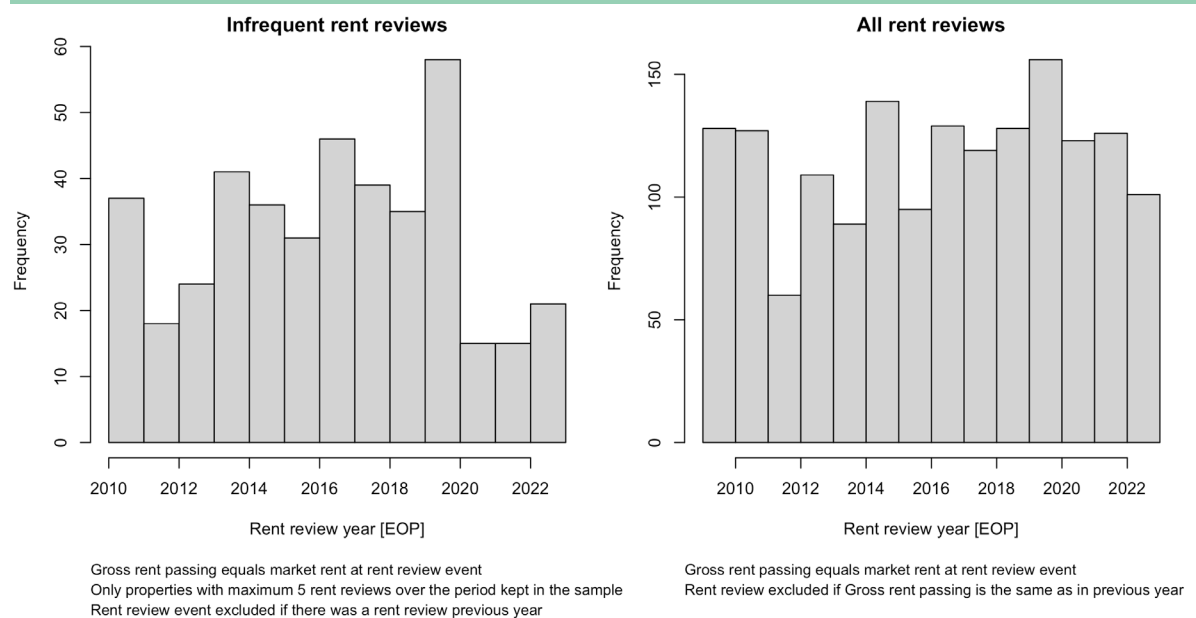
Figure A1: IPF modified methodology



The second approach for the identification of rent reviews does not limit the overall number of potential rent review years. Instead, it excludes all potential rent review years for which the gross rent passing is equal to the previous year. This approach increases the sample size by not excluding multi-tenant properties for which the rent passing adjusts more smoothly. The shortcoming of this second approach is linked to the possible inclusion of observations not reflecting true market rental value (i.e. if the rent passing follows some pre-agreed indexation and the same value is entered in the database as ERV).

Figure A2 reports a histogram chart showing the number of properties with rent review events for every year of our sample using the two methodologies.

Figure A2: Histogram of rent review years



APPENDIX 3: METHODOLOGICAL CONSIDERATIONS

Regression-based approaches and “event study” data

In the context of measuring property depreciation, “event study” data refer to events such as agreed leases and transactions, and data containing property rents or sale prices and age of properties i located in location l , collected in a relatively short period of time, which could be subdivided into shorter periods t . The depreciation rate of property segment m denoted by δ^m is estimated using Equation A7.. Rents (property value) in property i located in location l and recorded at time period t are regressed on property age and a set of other observed property characteristics x_{ilt} , which could for instance include property quality, amenities and size. Property *age* should be given in years so that estimated depreciation will be annual.¹⁶ Term ε_{ilt} is random error which captures unobserved reasons why rents in properties are higher or lower than mean prediction given by the model. These unobserved reasons should be however uncorrelated with *age*, because otherwise estimated depreciation would be biased.

Equation A7: Cross-sectional estimation equation

$$\log(r_{ilt}) = \delta^m age_{ilt} + x'_{ilt}\beta + \lambda_l + \tau_t + \varepsilon_{ilt}$$

If the data sample size is large enough, location fixed effects λ_l are included. Local-fixed effects essentially include ‘local baseline rental value’ and all other coefficients are estimated only from variation in data coming only from within of a local area. The role of location fixed effects is to capture the effects of local external factors which might positively or negatively affect rental values. If these external effects were correlated with building age, then estimated depreciation could be biased. As an example, we could think about an up-and-coming local area undergoing transformation and seeing substantial new development. In such a case, if local fixed effects are not included, higher rents charged in the up-and-coming location will be explained by the average lower age of buildings there which will overestimate depreciation. Instead, some share of relatively higher rents should be explained by local-specific desirable characteristics. As new buildings are usually built in desirable locations not including location fixed effects might lead to upward bias in estimation.

If event study data were collected over a longer period of time, long enough that seasonality or change in rents could have meaningful effects, time fixed effects τ_t should be included too as they capture the overall change in rents over time. In other words, they effectively represent an average rental index for the overall period and the area where observations come from (if interacted with location fixed effects).

Within the usual range of estimated depreciation up to several percent annually, the estimated δ^m is a very close approximation of the exact depreciation d^m .¹⁷ However, to obtain the exact value of depreciation, one might use Equation A8:

Equation A8: Depreciation exact value

$$d^m = 100 * (1 - e^{\delta^m})[\%]$$

¹⁶ Using year of construction instead will yield the same estimated coefficient, but with opposite sign.

¹⁷ The exact difference between d^m and δ^m when evaluated for depreciation of 1.5% is around 0.01 percentage point, or 0.75%. Approximation is however getting less precise when δ^m is larger.

APPENDIX 4: MSCI DATA, RENT REVIEWS AND NEIGHBOURING SUBMARKETS

MSCI data classification

Table A1: MSCI data summary by sectors and market segments

Sectors	UK - PAS Segments	No. Of Properties	Observations
Industrial	PAS Industrial - Rest of UK	360	5327
Industrial	PAS Industrial - South East	440	6658
Office	PAS Office - City	68	1022
Office	PAS Office - Rest of South East	163	2366
Office	PAS Office - Rest of UK	111	1596
Office	PAS Office - West End & Mid Town	300	4593
Retail	PAS Retail Warehouse	390	5731
Retail	PAS Shopping Centre	82	1173
Retail	PAS Standard Retail - Rest of UK	328	4593
Retail	PAS Standard Retail - South East	323	4675
Hotel	PAS Other	12	181
Residential	PAS Other	620	4340
Other	PAS Other	334	5013
Total		3,531	47,268

Alternative approach to define rent review events

This approach aims at selecting mostly single-tenant properties for which rent reviews create a discrete 'jump' in gross rents passing. As we want to identify standard rent reviews, instead of annual changes possibly due to indexation, we consider candidate rent review events as those that occur in years when gross rent passing changes by more than 10%. To further restrict the sample to standard rent reviews, we keep only records of properties for which there were no more than three candidate rent review events recorded over the 15 years study period, so we assume rent reviews to be less frequent than once in five years. As it was mentioned above, this approach likely identifies single tenant properties for which a rent review disruptively changes the rental revenue on the whole property. However, this method would likely fail in case of multi-let properties where rent reviews happen in different years and property-level rental revenue thus adjusts smoothly from year to year.

Neighbouring submarkets

CBRE rental and yield trends data are provided for individual submarkets, but with the exception of the office sector in central London they do not refer to exact geographical areas. However, a matching key between submarkets and local authority areas was provided, although some local authorities contain multiple submarkets which required further adjustments of local authority boundaries to create a spatial definition for submarkets.

APPENDIX 4: MSCI DATA, RENT REVIEWS AND NEIGHBOURING SUBMARKETS

Uncertainty regarding spatial definition of individual submarkets might introduce error if some properties are incorrectly assigned to a submarket different from the one they belong to. This could bias the results if there is a systematic pattern in this error. Figure A3 shows estimated differences in rental (linear) trends between neighbouring submarkets for the three main sectors estimated according to Equation A9:

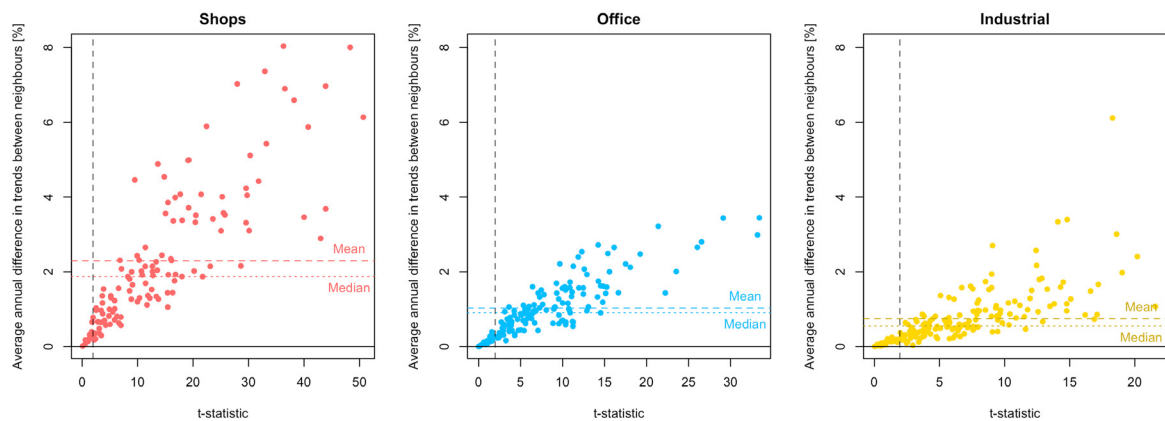
Equation A9: Difference in linear trends

$$\log r_{it} - \log r_{jt} = \alpha + \beta \text{ year}_t + \varepsilon_{ijt}$$

where the dependent variable is the difference in natural logarithm of rents between neighbouring submarkets i and j in a year t . The dependent variable is year t . The model is estimated separately for each i - j pair.

The estimated coefficient is plotted on the vertical axis, while t-statistics based on heteroscedasticity-robust standard errors showing the precision of the estimate is plotted on the horizontal axis. The figure shows that annual differences are mostly economically meaningful and statistically significantly different from zero (threshold t-statistics of 1.96 is shown as a vertical dashed line). On average, the largest differences in trends are in the standard retail sector (shops) at around 2% annually. Differences are lower for offices and industrial, with around 1% and below 1% respectively. However, given the magnitudes of annual depreciation, these differences in rental trends could have meaningful impacts on depreciation estimation if properties are allocated to incorrect spatial submarkets.

Figure A3: Differences in trends between neighbouring submarkets



To test whether results are not affected by systematic error in assigning properties into spatial submarkets, key specifications were recalculated using smaller subsample with properties which are located relatively more centrally within their respective submarkets.

More specifically, we measured the relative distance of each property from its submarket boundary. In the next step, one half of observations which are further away from their submarket boundaries were used for recalculation of value-weighted and unweighted depreciations, which are reported in Table A2. The table shows that baseline value-weighted depreciations differ only marginally between the whole sample and the subsample consisting of the properties further away from submarket boundaries.

APPENDIX 4: MSCI DATA, RENT REVIEWS AND NEIGHBOURING SUBMARKETS

Table A2: Comparison of full sample and subsample far from boundaries (market rent)

Sector	Start	End	Whole sample		Far From Boundaries	
			Depreciation	Mean	Depreciation	Mean
Industrial	2008	2023	0.5	0.6	0.5	0.5
	2008	2019	0.9	0.9	1.1	0.9
	2013	2023	1.0	1.0	0.8	0.9
Office	2008	2023	0.0	0.3	-0.3	-0.1
	2008	2019	-0.3	-0.2	-0.4	-0.4
	2013	2023	0.1	0.4	0.0	0.1
Shops	2008	2023	-1.6	-0.9	-1.4	-0.3
	2008	2019	-0.7	0.0	-0.8	0.6
	2013	2023	-1.4	-0.9	-1.6	-0.6

Notes: 'Depreciation' refers to value-weighted submarket-level depreciation (Equation A3), while 'Dep. ind. mean' is a mean of individual asset depreciations (according to (Equation A2)).

APPENDIX 5: REGRESSION MODEL WITH TRANSACTION PRICES (FROM BAJAJ ET AL, 2025)

Table A3: Depreciation and building age (CoStar): baseline results and multi versus single tenant.

VARIABLES	Baseline results					Multi	Single
	M1	M2	M3	M4	M5		
Age	-0.007***	-0.008***	-0.009***	-0.007***	-0.007***	-0.002***	-0.011***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Agesq	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Square feet	0.787***	0.883***	0.851***	0.779***	0.775***	0.803***	0.762***
	-0.003	-0.003	-0.003	-0.002	-0.002	-0.005	-0.003
CBD	0.117***	0.070***	0.054***	0.310***	0.212***	0.106***	0.194***
	-0.020	-0.021	-0.020	-0.021	-0.023	-0.036	-0.037
A	1.224***	0.938***	0.963***	1.139***	1.038***	1.234***	0.915***
	-0.035	-0.035	-0.033	-0.033	-0.033	-0.050	-0.053
B	0.240***	0.068***	0.129***	0.212***	0.189***	0.266***	0.161***
	-0.008	-0.008	-0.008	-0.008	-0.008	-0.016	-0.010
Constant	6.211***	6.195***	6.041***	6.802***	7.099***	6.385***	7.803***
	-0.039	-0.079	-0.080	-0.066	-0.095	-0.160	-0.132
Other spatial controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects:							
Industry	NO	YES	YES	NO	NO	NO	NO
Post Code 2	NO	NO	NO	YES	NO	NO	NO
Post Code 3	NO	NO	NO	NO	YES	YES	YES
Time	YES	NO	YES	YES	YES	YES	YES
Number of observations	82,968	82,968	82,968	82,958	82,958	31,003	39,013
Adjusted R-squared	0.718	0.718	0.741	0.742	0.753	0.736	0.764

REFERENCES

Makovsky, L., & Marcato, G. (2025). The Impact of Sustainability and Asset Management on Economic Depreciation of Real Assets. *Working Paper*.

Barras, R., & Clark, P. (1996). Obsolescence and performance in the Central London office market. *Journal of property valuation and investment*, 14(4), 63-78.

Bokhari, S., & Geltner, D. (2018). Characteristics of depreciation in commercial and multifamily property: An investment perspective. *Real Estate Economics*, 46(4), 745-782.

Bokhari, S., & Geltner, D. (2019). Commercial buildings capital consumption and the United States national accounts. *Review of Income and Wealth*, 65(3), 561-591.

Caldera, A., & Johansson, Å. (2013). The price responsiveness of housing supply in OECD countries. *Journal of Housing Economics*, 22(3), 231-249.

Cheshire, P. C., & Hilber, C. A. (2008). Office space supply restrictions in Britain: the political economy of market revenge. *The Economic Journal*, 118(529), F185-F221.

Clapp, J. M., Jou, J. B., & Lee, T. (2012). Hedonic models with redevelopment options under uncertainty. *Real Estate Economics*, 40(2), 197-216.

Crosby, N., Devaney, S., & Law, V. (2011). Benchmarking and valuation issues in measuring depreciation for European office markets. *Journal of European Real Estate Research*, 4(1), 7-28.

Crosby, N., Devaney, S., & Law, V. (2012). Rental depreciation and capital expenditure in the UK commercial real estate market, 1993–2009. *Journal of Property Research*, 29(3), 227-246.

Crosby, N., Devaney, S., & Nanda, A. (2016). Which factors drive rental depreciation rates for office and industrial properties?. *Journal of Real Estate Research*, 38(3), 359-392.

Francke, M. K., & van de Minne, A. M. (2017). Land, structure and depreciation. *Real Estate Economics*, 45(2), 415-451.

Hulten, C. R., & Wykoff, F. C. (1981). The estimation of economic depreciation using vintage asset prices: An application of the Box-Cox power transformation. *Journal of Econometrics*, 15(3), 367-396.

IPF05 - IPF (2005), Depreciation in Commercial Property Markets. *Investment Property Forum*.

IPF11 - IPF (2011). Depreciation of commercial investment property in the UK. *Investment Property Forum*.

Lopez, L. A., & Yoshida, J. (2022). Estimating housing rent depreciation for inflation adjustments. *Regional Science and Urban Economics*, 95, 103733.

Wilhelmsson, M., & Roos, H. (2024). Age-related depreciation of older properties. *Journal of Property Research*, 41(1), 44-70.

Yoshida, J. (2020). The economic depreciation of real estate: Cross-sectional variations and their return implications. *Pacific-Basin Finance Journal*, 61, 101290.

Yoshida, J., Kawai, K., Geltner, D., & Shimizu, C. (2024). How property rents and expenses depreciate: A case of Tokyo Office Properties. *Journal of Real Estate Research*, 46(3), 272-307.

GLOSSARY OF TERMS

Asset Management: The strategic management of real estate assets through maintenance, refurbishment, and capital expenditure to preserve or enhance value.

Benchmark Rental Index: A market reference index representing rents for hypothetical newly built or refurbished properties in a given submarket.

Cap Rate (or Yield): The ratio of a property's income to its market value, representing the expected return on investment.

Cap Rate Creep: The increase in yields associated with older or deteriorating properties due to increased perceived risk and lower expected growth.

Capital Depreciation: The decline in a property's capital value over time due to depreciation effects.

Capital Expenditure (Capex): Money spent on improving, upgrading, or maintaining a property beyond routine repairs.

Capital Value: The market value of a property asset.

Concave Depreciation Function: A depreciation pattern where assets depreciate faster when new and more slowly as they age.

CoStar Data: A transaction-based real estate dataset used to estimate regression-based depreciation models.

Depreciation: The decline in real estate asset value over time due to physical deterioration, obsolescence, ageing, and changing market conditions.

Economic Depreciation: The reduction in value of a property caused by economic, social, or market-related factors.

Energy Performance Certificate (EPC): A rating system measuring the energy efficiency of a building.

Event Study Data: Data linked to specific market events such as lease agreements or property transactions.

External Obsolescence: Loss in property value caused by changes in surrounding economic, environmental, or social conditions.

Fixed Effects: Regression controls used to account for location- or time-specific influences on property values.

Functional Obsolescence: A decline in value caused by outdated design, layout, or property specifications relative to market preferences.

Gross Depreciation: The total decline in property value before accounting for asset management interventions or capital improvements.

Gross Rental Depreciation: Rental depreciation measured before accounting for capital expenditure interventions.

GLOSSARY OF TERMS

Hedonic Regression: A statistical method estimating the contribution of property characteristics to value or rent.

IPF Longitudinal Approach: The original methodology used in previous IPF reports comparing asset rental growth with benchmark rental growth.

Lease Event: A rent review, lease renewal, or lease-related transaction used as an information point in depreciation analysis.

Location Fixed Effect: A regression control accounting for differences between geographic areas.

Managed Depreciation: Depreciation measured after the impact of expenditure and management activity; equivalent to net depreciation.

Marginal Depreciation: The additional reduction in property value associated with one more year of age.

Market Rent: The estimated rental income achievable under current market conditions.

Market Value: The estimated price at which a property would transact in the market.

MMP Approach: A modified longitudinal depreciation methodology based on rent review events rather than continuous valuation estimates.

Net Depreciation: The loss in real estate value over time after accounting for capital improvements and asset management activity.

Physical Deterioration: Wear and tear affecting the physical condition of a property.

Price Depreciation: The decline in property price or market value caused by lower rents and/or higher yields.

Regression-Based Approach: A methodology estimating depreciation using statistical models linking property value to age and other characteristics.

Rent Passing: The actual rent currently paid under an existing lease agreement.

Rent Review: A contractual reassessment of rent during the term of a lease.

Rental Depreciation: The decline in rental value over time due to deterioration or obsolescence.

Sustainability Features: Building characteristics related to environmental performance, efficiency, or ESG standards.

Total Value Depreciation: Depreciation measured against the combined value of land and structure.

Vintage Effect: The influence of a property's construction era and associated design or material characteristics on value.



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