Modelling sustainable rents for estimation of long-term or fundamental values of commercial real estate

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Modelling sustainable rents for estimation of long-term or fundamental values of commercial real estate

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ABSTRACT

Commercial real estate occupier markets are analysed in the context of the debate over the role of real estate lending in financial stability and the search for long-term valuation methods to complement market value estimations. Models of sustainable rent, including a long-term trend model and an econometric equilibrium rent model, are tested to examine whether they provide early warning of upcoming corrections in real rental values. Models were estimated using rental value data for the UK and predictions of corrections from the mid-1980s through to 2018/9 and were then compared against actual real rental growth. The models were successful in identifying the occupier market crash of the 1990s and the more muted downturn of the early 2000s, but were less successful at predicting the falls in real rental value that followed the GFC in 2008/9. There is a late reaction to this downturn in estimates from the econometric model, while other approaches struggled to identify it at all. Econometric modelling of sustainable rental values is the recommended approach and could be used in conjunction with a model of sustainable cap rates to develop long-term valuations. This would aid lending decisions and provide evidence for regulators of cyclical movements in CRE markets. For the UK, there are data issues related to this recommendation, especially concerning stock data.

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Sustainable rents; long-term value; financial stability; equilibrium models; commercial real estate

Introduction

The failure of financial markets to withstand significant real estate market downturns has been cited as a major cause of the 2007/8 Global Financial Crisis (GFC) (see, for example, ICB, 2011, in the UK; Duca et al., 2011, in the US). Researchers in finance have become more aware of the key linkage between lending, liquidity and asset price cycles in generating risk and instability (Brunnermeier & Pedersen, 2009). In contrast to the US, attention in the UK has focused on commercial real estate (CRE) lending and asset values as a key source of instability rather than on residential real estate.[1] This paper concentrates on the private CRE market in the UK in contrast to the more widely analysed REIT and residential sectors. The UK has a combination of relatively good long-term data on CRE covering multiple cycles that enables models to be developed and tested. Effective

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mechanisms to identify the risk of real estate market downturns are important to bank regulators, lenders and policy makers and this research feeds into that debate.

Valuations[2] are used to underpin loan origination decisions for CRE. The basis used is predominantly an assessment of Market Value (MV).[3] In 2014, a group of UK CRE market stakeholders identified long-term value and valuation (LTV) as one of seven initiatives to protect the financial system from a repeat of the GFC in the event of another CRE market downturn (REFG, 2014). This precipitated further research examining the LTV questions raised in the 2014 report (Cardozo et al., 2017) which identified three approaches that could form an alternative basis to Market Value for assessing CRE loan security.[4] Two of the three alternatives were already defined in valuation standards or statute; Investment Value (IV) and Mortgage Lending Value (MLV). The third was a historical linear trend model termed Adjusted Market Value (AMV). However, a key weakness in the testing of these approaches was that the measure of rent employed did not reflect economic fundamentals. It is this weakness that has motivated this research and which this study seeks to address.

Cardozo et al. (2017) examined the UK CRE market over a period that included two major downturns, in 1990 and 2007. They compared deviations between Market Value and each of these three approaches to see which, if any, produced early warning signals of impending falls in UK real estate values. Had such signals been available, then remedial action might have been taken by regulators and lenders in time to prevent excessive lending in the run-up to the downturn and reduce the subsequent losses (Clarke, 2018). They found that the earlier 1990 downturn was driven by occupier market conditions (a major downturn in market rental values), whereas 2007 was driven by falling capitalisation rates followed by a sharp upward correction in those rates. Cardozo et al. also found that the IV and MLV models as applied in Crosby and Hughes (2011) did not signal the 1990 downturn. There were two reasons. First, these models used the market rental value as a proxy for a long-term equilibrium or sustainable rent, without any adjustments for occupier market conditions. Second, they used industry forecasts of rental growth which, in the late 1980s, failed to indicate the subsequent downturn in rents. As a result, their assessments of a sustainable capital value unhelpfully mirrored reported Market Values quite closely.

This practice-based research sits within a wider literature that has modelled and compared levels of fundamental value to current pricing in real estate markets (see Fabozzi et al., 2020; Hendershott et al., 2003). This literature builds from work in financial markets, but it has often used current market rent as the income component in models, sometimes in reflection of data availability and adequacy. Another body of literature highlights how rents in occupier markets can deviate significantly from their equilibrium levels driven by factors such as lease structures and lengthy development processes that generate slow responses in both demand and supply to changing market conditions. Econometric modelling of equilibrium rent has been developed by Hendershott and others, defined as the market clearing rent at any particular time given demand and supply conditions.[5] Such modelling can estimate the effects of deviations from the equilibrium rent on short-term market movements as well as the adjustment process back to a long-term relationship. So, there is mismatch in regard to the treatment of rents between the literature on modelling long-term values and the literature on modelling real estate occupier markets.

This indicates that further work on the concept and measurement of sustainable rent is required. This study tests different models of sustainable rent, examining the ability of each model to signal forthcoming downturns in market rental values based on data for the UK CRE market. The timing of this research is important. At the time of writing, the European Commission is consulting on new definitions of sustainable long–term value or prudent value contained in the Basel III Accord, while central banks and related organisations such as the Bank of England and the International Monetary Fund are assessing CRE markets and including CRE modelling within their financial stability reports (BOE, 2019: 17–19; IMF, 2019a: 8–10, 2019b: 39–41). Therefore, it is important to examine the appropriate inputs for the rent component of such models. This paper makes recommendations as to which approach gives the best results and it provides evidence of the timescale of any warning. Notably, it highlights that the use of a sustainable market rental value based on fundamentals is an improvement on other methods.

The next section sets out the different approaches that have been used to approximate a sustainable or equilibrium level of rent for use in market analysis. It also reviews briefly the literature on accuracy of rental forecasts. Existing studies of commercial real estate have focused on accuracy of forecasts over short (typically 1-3 year) horizons. This study examines the ability of different models to signal medium-term movements in real market rental values predicated on reversion to a sustainable level of rent. The third section outlines data used in this study and the fourth section shows the results of measuring sustainable rental value for indexes of UK CRE rental value growth. The fifth section applies formal tests of forecasting accuracy to the results while a final section concludes.

Concept and measures of sustainable rent

We define a sustainable rent as the typical (real) market-based rent that a building (or buildings) can command through time rather than at any given point. This recognises that market rents fluctuate in response to market conditions and that the rent negotiated at any one time might not be a good signal of the long–term capacity of a building to generate income. It also recognises that rent received from an existing lease might be a poor signal of a sustainable rent in markets where the lease structure fixes the sum to be paid over long periods. The UK is a prime example of this as long leases of 20-25 years were common in the earlier part of our study period, and these leases fixed the rent to be paid for at least a five-year interval, but sometimes longer in situations where the market had fallen owing to use of an upward-only rent review mechanism (see Crosby et al., 2005, 2006). We return to the possible implications of this in the data section below.

Estimates of sustainable rent may be made by analysing observed market rents and deriving a long-run average or trend real rent, or through estimation of an equilibrium rent – the rent which would be consistent with demand and supply at that point. Cardozo et al. (2017) argued that exploring sustainable rent was necessary to progress research on sustainable capital values and that the use of contemporaneous market rental values to represent levels of sustainable rent was inadequate. They found that a trend-based approach to estimating sustainable rental value was effective, but this was not tested against alternative models. Therefore, several models are tested here to identify when market rental values deviate from sustainable levels, contributing to disequilibrium in capital values. Sustainable rents need not be constant, as structural changes in the economy, the stock of CRE and the fortunes of specific locations can lead to long-term shifts in market rental values and, hence, what can be regarded as sustainable. Ideally, any model used should be sensitive to this.

Sustainable rental values should generally be modelled in real terms so that movements can be related to shifts in underlying demand and supply (whether these are formally incorporated into the model specification or not). A very simple hypothesis might be that sustainable rental value will be constant in real terms. This approach has been used in some studies of commercial real estate pricing to provide an indicator of the prospects for future cashflows (Chervachidze et al., 2009; Chervachidze & Wheaton, 2013). Average real rent is measured at each point using observations of real rent up to that date and the ratio of real rent to this average at any point in time is then measured as follows:

$$\text{Real Rent Ratio}_{\text{t}} = \frac{\text{Real Rent}_{\text{t}}}{\text{Average Real Rent}_{\text{t0}-\text{t}-1}}$$

where t_0 is the start of the measurement window and t is the time point of interest. A ratio over one indicates that real rental values are above a sustainable level, while a ratio under 1 signals that they are below that sustainable level. A preliminary examination of our data on real rental values did not support the contention that, over the long-term, these revert to a stable average level. Therefore, in-depth results based on this model are not presented, but we do use it to represent a naïve approach against which the ability of our other models is formally tested.

Another possibility is that there are long-term economic processes which are leading real rental values to become either more expensive or less expensive relative to prices overall. In this case, sustainable real rental values might then follow a trend path either upwards or downwards as the characteristics of the economy and stock of real estate change through time. One way of capturing this could be to model a log-linear trend in real rental values, such that the compound growth rate in real rental values is stable. Implementing this approach involves regressing real rental values (in log form) on to a time trend and predicting the trend path in real rents using the coefficients obtained from that estimation:

$$\text{Ln}(\text{Trend Real Rent}_{\text{T}}) = \beta_0 + \beta_1 \text{Time}$$

where β_0 is the intercept from the regression and β_1 is the slope coefficient. β_1 captures the trend growth (or decline) in sustainable real rental values so that, as time increases by one period, the sustainable real rental value changes by a factor of β_1. A positive error term from estimation of this model suggests that real rental values are above trend and so above their sustainable level and a negative residual suggests the opposite. For consistency of presentation, the real rental value at time t can also be related to the predicted long-term trend value in ratio form, as follows:

$$\text{Real Rent Ratio}_{\text{t}} = \frac{\text{Real Rent}_{\text{t}}}{\text{Predicted Trend Rent}_{\text{t}}}$$

where a ratio over one indicates that real rental values are above their sustainable level and a ratio under one signals that they are below their sustainable level. Subtracting one from this ratio indicates the extent to which real rental values have deviated from their sustainable level and the correction required to restore the ratio to one. Deviations from a log-linear trend have been used in some studies of commercial real estate pricing as an alternative indicator of the prospects for future cash flows (see Hendershott & MacGregor, 2005a, 2005b). However, this approach would be inappropriate if there were long run changes in underlying economic drivers or structural breaks in how real rents relate to their underlying economic drivers.

Another approach that is more explicit as to the influence of economic drivers on rents is to build an econometric model whereby variables representing such drivers are regressed on real rental values. The coefficients may then be used to predict an equilibrium rent given the values of the independent variables at any point. An error correction model (ECM) for modelling real rental values was proposed in Hendershott et al. (2002) and in P. Hendershott et al. (2002). Since then, this approach has been adopted by numerous other studies.[6] A long-run relationship is posited between rental values, demand and supply, and deviations from this relationship may then be used to explain short-run adjustments in rental values and other indicators such as vacancy rates. The long-run equation typically takes the following form:

$$\mathrm{Ln}(\text{Real Rental Value}_T) = \beta_0 + \beta_1 \mathrm{Ln}(\text{Demand proxy}_T) + \beta_2 \mathrm{Ln}(\text{Stock proxy}_T) + \varepsilon$$

where β_0 is the intercept from the regression and β_1 and β_2 are slope coefficients measuring the relationship between real rental values and the independent variables. The fitted values generated from estimation of this model can be used as an estimate of the equilibrium real rental value at each time point. ε measures the deviation of real rental values from their equilibrium value. A positive error term indicates that real market rental values are above their equilibrium level in that period, while a negative error term indicates the opposite. In an ECM framework, changes in market rental values are then regressed on changes to the demand and supply proxies and the residual ε, with the coefficient for that residual representing the speed of adjustment.

It is important to consider whether an equilibrium real rent measured in this manner is the same as a sustainable rent. The long-run model estimates the real rent that should clear the market given levels of demand and supply at different times. It does not indicate whether demand or supply themselves are in equilibrium. It is possible that one or both input variables are not at their sustainable levels in any given period. In that case, rather than use fitted values from the regression model, a sustainable rental value could be estimated using independently determined figures for the inputs. For instance, one could take trend values for the input variables and use these with the model coefficients to predict a sustainable real rental value each period (tested later and described as the trend-input approach). Yet this assumes that a trend gives an appropriate long-run equilibrium path for each input and so is subject to the criticisms of the trend-based model for real rents. Alternatively, explicit models for each input variable could be estimated as part of a system of equations.[7]

Whichever inputs are used to infer a sustainable equilibrium rental value (contemporaneous values of the variables, trend values or some other assumption), the reported real rental value at time T can be related to the equilibrium real rental value in ratio form, as follows:

$$\text{Real Rent Ratio}_{\,t} = \frac{\text{Real Rent}_t}{\text{Equilibrium Real Rental Value}_{\,t}}$$

where a ratio over one indicates that real rental values are above their sustainable level and a ratio under one signals that they are below their sustainable level.

An error correction model allows changes to economic fundamentals to inform the measurement of sustainable real rental values. It does not assume that sustainable real rental values are constant or follow a constant trend and it should provide more information about how rental values respond to fundamentals. Yet, in common with the simpler models, the error correction models are estimated from historical data. They also require more data to operationalise than the average rent or trend rent approaches, even if the specification is reasonably parsimonious.

How should the outputs from the different approaches be compared? It is presumed that, where there are deviations from the trend value or equilibrium value, real market rental values will adjust back to that figure over subsequent periods, further shocks notwithstanding. The extent to which rents revert to these figures can be explored empirically, but the time period over which it will occur is undefined. Essentially, a sustainable rental value should be a long-run equilibrium value that reflects structural rather than cyclical characteristics of the market being studied. The time horizon is therefore one of years rather than months or quarters. We adopt a five-year horizon in our empirical testing to reflect the lengthy adjustment processes associated with commercial real estate cycles (on which, see Barras, 2005, 2009). This also matches typical CRE loan lengths, which is valuable for practical applications and aligns with the motivation for our research.

Since deviations from sustainable rental value can be construed as medium- or long-term forecasts of how real rental values will change, evaluation techniques used in real estate forecasting studies are relevant, albeit this literature often examines shorter time horizons. There are numerous studies on real estate forecasting and its accuracy (e.g., Chaplin, 1999, 2000; Ling, 2005; McAllister & Nasr, 2020; McAllister et al., 2008; Papastamos et al., 2015, 2018; Stevenson & McGarth, 2003; Tsolacos, 2006). This research suggests that rental value forecasts have been more accurate than capital value forecasts. Nonetheless, it also finds that real estate forecasts tend to be smoothed, underestimating upturns and downturns, and that models struggle to identify turning points. The metrics used in these studies to assess forecast accuracy are discussed later in this paper.

A further theme in this literature is the comparative performance of simple versus complex forecasting models. Hendry and Clements (2003) note how extrapolative techniques have tended to outperform econometric systems when forecasting macroeconomic time series, although they caution against the conclusion that simpler models are better. In the real estate literature, Brooks and Tsolacos (2000) found a simple autoregressive approach outperformed a more complex VAR method for forecasting retail rents, while Jadevicius and Huston (2015) reached a similar conclusion when comparing VAR to simpler regression approaches. In contrast, Stevenson and McGarth (2003) found that a Bayesian VAR model overcame limitations of conventional VAR and outperformed simpler models, while Brooks and Tsolacos (2000) observe that the relative accuracy of different models varies according to the horizon for the forecast. The implication is that the econometric approach set out above might not outperform a simpler trend model despite its stronger theoretical underpinnings.

Data and measurement process

Measures of sustainable rental value for the UK commercial real estate market were derived from and then compared to market rental value indexes from two sources: the MSCI UK real estate indexes and the JLL *UK Property Index*. The MSCI series are generally accepted as the principal indicators of UK CRE performance owing to the number of contributors and large sample of assets on which they are based, but the JLL indexes are also used as they provide a much longer time series. Both sets of indexes are appraisal-based and so may be subject to appraisal smoothing. However, unlike in the case of capital values, there is no published transaction-based index of rents for UK CRE. Our focus is on sustained deviations from an underlying fundamental level of rental value, which we expect to observe in both appraisal-based and transaction-based series. We acknowledge that the timing of peaks and troughs and the magnitude of booms and slumps may not be fully captured. This will remain an issue until transaction-based series of UK CRE rents are available.

Both MSCI and JLL track market rental value growth for UK commercial real estate at an aggregate (All Property) level and for three main property types in this market: office, retail and industrial. The start date for the MSCI series is 1980 Q4 for annual observations and 1986 Q4 for quarterly observations.[8] The JLL indexes begin in 1967 Q2 at an annual frequency (mid-year to mid–year) and 1977 Q2 at a quarterly frequency. The UK GDP deflator was used to convert the market rental value series into real terms.[9] Except for the MSCI retail series, the deflated indexes indicate that real rental growth has been negative over the long term. The lowest real rental values for office and industrial property were seen in the years following the GFC (2011–14), while the highest values were in 1973-74 for the JLL series and 1990 for the shorter MSCI series. Across all sectors, the largest year-on–year rises were observed in 1988-89 and the largest falls in 1991–93.

For much of this period, lease structures in the UK were very different to other parts of the world. Up to 1990, around 90% of leases recorded in the MSCI (previously IPD) database were 20-25 years long with a five-year upwards-only rent review clause and with full repairing and insuring obligations placed on tenants. Following the sharp downturn in CRE rental and capital values in the early 1990s, and with Government pressure to reform, new leases became shorter, with five-year and ten-year lease lengths becoming common. Break options and incentives to tenants such as rent-free periods became more common, but five-year upwards-only rent reviews and tenant responsibility for repairs and insurance remained the norm.[10]

Therefore, an important question for this study is whether these changes affected the market rental value series used in the analysis. It is possible that changes to lease terms through time have affected the rents negotiated for new leases that, in turn, underpin estimates of market rent at different time points. Yet, there is only very limited evidence in the UK context for any systematic pricing of lease terms (Bond et al., 2008). The more widespread use of lease incentives is of greater concern as these might have cushioned declines in market rents over time and during market downturns. The indexes used here are based on estimates of headline rent that are not adjusted for lease incentives (but see Crosby & Murdoch, 2001). This is an important limitation, but, aside from this, we believe the series used offer the best available indexes for operationalising the measurement of sustainable rental value over time.[11]

Descriptive statistics for movements in the MSCI and JLL market rental value series are shown in Table 1, with year-on-year growth rates analysed to allow for those periods where only annual observations were available. The averages confirm that the UK CRE market has generally experienced negative real market rental growth over the long term. The office sector has had the highest standard deviation and widest range in real market rental growth, and the distribution of growth rates differs from the retail and industrial sectors, which exhibit positive skewness and leptokurtosis in real growth. Based on the Jarque-Bera test, a null hypothesis of a normal distribution in real growth cannot be rejected at a 95% confidence level either for the aggregate All Property series or for the office sector, but it can for the retail and industrial series.

Both anchored and rolling windows for the modelling were tested and a minimum window of fifteen years was adopted after experimenting with different window lengths. Based on index start dates and window lengths, measurements of sustainable rental value were made from 1995 Q4 using MSCI data and 1982 Q2 using JLL data. Some of the measurements of sustainable rental value were based on estimation windows where there are missing observations in some quarters, as both the MSCI and JLL series begin with annual frequency data. This is not an issue for either the trend models or the chosen long-run econometric model, but it would create issues for an econometric model with long-run and short-run elements. The measurements are made to 2019 Q1 in the MSCI case and 2018 Q1 for the JLL series, which reflected a delay in production of the JLL index at the time of analysis.

The trend approach can be implemented using the real rental value series alone. The error correction model required proxy variables for demand and supply. Office sector studies using the ECM approach such as Hendershott et al. (2002) and Brounen and Jennen (2009a, 2009b) have used financial or service sector employment as a proxy for office demand, though some studies have used output-based series (e.g., McCartney, 2012; Mouzakis & Richards, 2007). Consumer expenditure and retail sales have been used for retail (e.g., Hendershott et al., 2013; P. Hendershott et al., 2002). Data availability plays a key role in the identity and form of the chosen variables.

Several national output measures were examined for the purpose of selecting a consistent proxy for demand to be used for all estimation windows. These included GDP, gross value added, household consumption and household disposable income, which were all available at quarterly frequency from the mid-1950s. While indexes of production and manufacturing were available from the mid-1950s onwards, retail sales series could only be obtained from the mid-1980s. Similarly, total employment was available from the late 1950s onwards, but separate series for manufacturing and service sector employment could only be obtained from 1978. Hence, we used real GDP as a demand proxy for office and industrial real estate, and real household consumption as a demand proxy for retail. This enabled a consistent and parsimonious version of the error correction model to be estimated for every window possible.

Finding long-run series for stock and supply was more challenging. Floorspace statistics produced by the Valuation Office Agency were consulted first but these statistics

Table 1. Descriptive statistics for cumulative growth and year-on-year changes in real rental value series.

	Date range	Total growth	% p.a. growth	Arithmetic mean	Standard deviation	Skewness	Kurtosis	Min y-o-y change	Max y-o-y change
MSCI All Property	1980.4–2019.1	−11%	−0.3%	−0.3%	5.4%	0.18	3.73	−13%	15%
MSCI office	1980.4–2019.1	−23%	−0.7%	−0.5%	8.4%	−0.37	2.95	−20%	18%
MSCI retail	1980.4–2019.1	12%	0.3%	0.1%	4.0%	0.69	3.81	−7%	13%
MSCI industrial	1980.4–2019.1	−26%	−0.8%	−0.5%	5.1%	0.58	5.11	−14%	17%
JLL All Property	1967.2–2018.1	−37%	−0.9%	−0.8%	6.2%	0.01	3.86	−17%	15%
JLL office	1967.2–2018.1	−32%	−0.7%	−0.8%	8.4%	−0.29	3.10	−23%	20%
JLL retail	1967.2–2018.1	−22%	−0.5%	0.1%	5.7%	1.12	7.39	−20%	24%
JLL industrial	1967.2-2018.1	−52%	−1.4%	−1.0%	5.6%	0.71	6.87	−17%	23%

Date range shows maximum span of series to include both annual and quarterly frequency observations.

posed problems for econometric modelling owing to issues with data availability and consistency given changing classifications through time. Floorspace statistics were produced from the mid-1960s to the mid–1980s, then discontinued. Publication of floorspace estimates recommenced from 1998, but there are issues of comparability with the older figures, as discussed in ODPM (2006). The latest floorspace estimates for different types of commercial property are available online and cover 2001-2019.[12] While these are easily accessible, they are affected by further revisions as to how floorspace is captured and reported.

An alternative source of data relates to construction orders and output. These series offer advantages in terms of their availability, frequency and length of time series, as quarterly data exist for both back to the 1950s.[13] Orders and output are recorded in both nominal and real values at national level, but a long-time series in real terms is now only available for orders, reflecting revisions to deflators and other aspects of the series. Private commercial and private industrial orders are separately identified, but data on property types within these categories is limited. These series do not provide information on the size of the stock or the effects of depreciation and demolition on supply (see Ball and Tsolacos, 2002, for other criticisms).

Difficulties with supply side data are common in real estate market modelling. Some studies attempt to overcome the problem by taking available data on stock and using measures of the flow of activity to interpolate for periods where stock is not observed (e.g., Englund et al., 2008; P. Hendershott et al., 2002; Mouzakis & Richards, 2007). Here, figures for the retail, office and industrial stock of floorspace, respectively, were interpolated between early and recent estimates using data on real construction orders. More specifically, after adjusting for differences in definitions and coverage, compound growth in floorspace was calculated between the two time points for which floorspace figures were available and the growth rates for individual periods were adjusted with reference to deviations from a trend in real construction orders, assuming a three-year lag from recording of orders to completion of new stock. This is similar to the approach taken by P. Hendershott et al. (2002).

This resulted in stock series for the office and industrial sectors that ran from 1969 to 2019 and a stock series for retail that ran from 1974 to 2019. Hence, the first measurements of sustainable rental value using an econometric approach begin in 1984 for offices and industrial property and in 1989 for retail property. Although this is a later start than for the trend-based approach, it still enabled estimates of equilibrium rent to be compared with trend-based measures across an extended period spanning two major cycles and several minor cycles in rental values. Descriptive statistics for the floorspace series and proxy demand variables are displayed in Table 2. These indicate that growth in real GDP and real household consumption have outstripped growth in floorspace over the long term and that these have had far greater variation in their year-on-year changes. While we believe that the approach taken to create floorspace series captures changes in development activity through time, it is possible that the scale of these changes is understated.

Sustainable rental values and implied market corrections

This section examines where market rental values lie relative to estimates of sustainable rental value produced by different approaches. Results are presented for all commercial real estate (termed All Property in both the MSCI and JLL series of indexes) and also for the office, retail and industrial sub-sectors. The MSCI series are not long enough to allow estimation of sustainable rental values for the late 1980s/early 1990s cycle in occupier markets, but the JLL series enable such estimates to be made from 1982 Q2 onwards.

In the case of the econometric models, figures at the All Property aggregate level are not estimated directly, but are constructed by weighting sector-level outputs.[14] This is because different drivers of demand and different levels of stock in each sector make a single ‘All Property’ model inappropriate. In our application of the econometric models, it is the predicted rent that is of most interest, but it is necessary to check that coefficients for the demand and supply variables are significant and correctly signed, and that the model is generally well-behaved. Table 3 presents summary figures that give some indication of how the underlying regression models performed over the windows used in our analysis. The performance of the models appears acceptable for the office and retail property types, but their explanatory power for industrial property is less strong and there are specific problems for models where estimation windows either start or end in the early 1990s.

Figure 1 displays the ratio between market rental value and sustainable rental value estimates based on the series for all commercial property. The left-hand side shows results from using rolling windows while the right-hand side shows results from anchored windows. All methods indicate periods where real market rental values deviated from their sustainable levels. Based on the JLL data, the ratios of actual to sustainable rental values were much higher in the late 1980s and much lower in the early 1990s than for subsequent years, but the methods are in broader agreement than for later periods. For both the MSCI and JLL series, the linear trend model suggests that market rental values were above sustainable levels from ca. 1999 to ca. 2004 and below sustainable levels from ca. 2009, but econometric-based results are more erratic, with a noticeable spike at end-2008. This might reflect difficulties in weighting sector-level

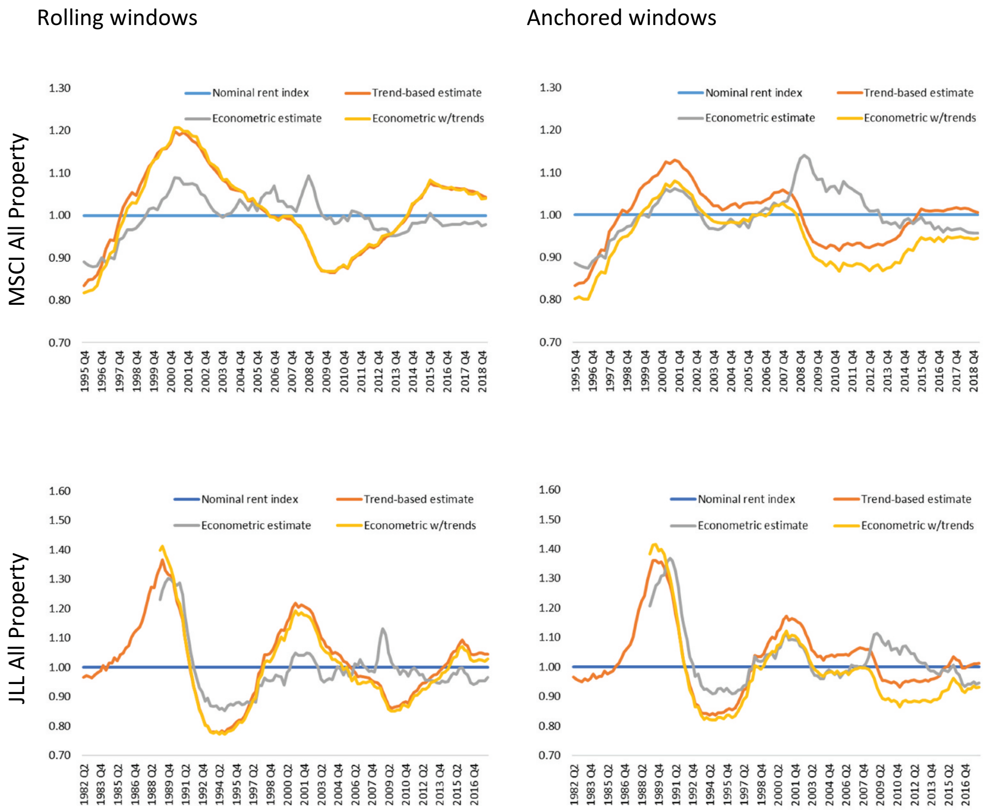

Figure 1. Ratio of all property rental value series to sustainable rental value estimates. The charts above show the ratio of actual rents to the sustainable rents implied by each of the models. for example, a ratio of 1.3 indicates the actual rent is 30% above the estimate of sustainable rents.

outputs satisfactorily, so analysis of the individual property types is required to test the approaches more thoroughly.

Figure 2 shows the corrections required to restore real market rental values to sustainable levels as implied by the ratio between them at each point in time, and presuming no further shocks to the fundamental drivers or other structural changes.[15] The methods do not predict how long a correction might take, but figures are benchmarked to outturn for each published rental series over the five years following each measurement of a sustainable rental value. Outturn is measured in real terms and no inflation prediction is added to the implied correction at each date. The blue series tracks the growth of the index from each date to a date five years hence, with the final value in that series showing real rental growth from 2013 Q4 to 2018 Q4. This then can be compared to the implied correction from the results of different models as at 2013 Q4.

Based on the JLL series, the implied corrections in real market rental values correspond well to subsequent real rental value growth through the 1980s and 1990s. The models do not signal the magnitude of the boom in the late 1980s, but they do capture the extent of the downturn in the early 1990s. After this, results for the rolling windows suggest that the implied corrections based on the conventional econometric approach

Table 2. Descriptive statistics for cumulative growth and year-on-year changes in demand and supply proxy variables.

	Date range	Total growth	% p.a. change	Arithmetic mean	Standard deviation	Skewness	Kurtosis	Min y-o-y change	Max y-o–y change
Floorspace mill. m^2 – office	1969.1–2019.1	144%	1.8%	1.8%	0.8%	–0.09	2.56	0.2%	3.6%
Floorspace mill. m^2 – retail	1974.1–2019.1	65%	1.1%	1.1%	0.4%	–0.30	1.77	0.3%	1.9%
Floorspace mill. m^2 – warehouse	1969.1–2019.1	121%	1.6%	1.6%	0.4%	–0.63	2.87	0.5%	2.4%
Real GDP £bn	1969.1–2019.1	202%	2.2%	2.3%	2.3%	–0.91	5.35	–6.1%	9.7%
Real household consumption £bn	1974.1-2019.1	202%	2.5%	2.5%	2.3%	–0.38	3.77	–4.9%	9.2%

Floorspace data constructed as described in text. Economic data obtained from Office for National Statistics as seasonally adjusted chained volume measures. Real GDP series ID = ABMI. Real household consumption series ID = ABJR.

Table 3. Summary statistics for econometric modelling of real rent.

	Rolling windows		*Anchored windows*	
	MSCI	JLL	MSCI	JLL
A: Office sector				
No of regressions	95	138	95	138
Average β real GDP	2.83	2.87	2.84	2.45
% correctly signed	100%	100%	100%	100%
% correct sign and significant	100%	93%	100%	100%
Average β office floorspace	−3.96	−4.33	−3.85	−4.02
% correctly signed	100%	100%	100%	100%
% correct sign and significant	100%	100%	100%	100%
Average adjusted R^2	0.67	0.63	0.69	0.69
% significant F-statistic	100%	100%	100%	100%
B: Retail sector				
No of regressions	95	118	95	118
Average β real HH consumption	1.67	1.84	1.66	1.81
% correctly signed	99%	97%	100%	100%
% correct sign and significant	94%	96%	100%	100%
Average β retail floorspace	−3.26	−3.69	−3.14	−3.69
% correctly signed	100%	97%	100%	100%
% correct sign and significant	100%	91%	100%	100%
Average adjusted R^2	0.82	0.80	0.78	0.72
% significant F-statistic	100%	100%	100%	100%
C: Industrial sector				
No of regressions	95	138	95	138
Average β real GDP	1.03	1.02	1.16	0.93
% correctly signed	92%	98%	100%	100%
% correct sign and significant	84%	70%	100%	88%
Average β warehouse floorspace	−2.11	−2.47	−2.41	−2.69
% correctly signed	92%	98%	100%	100%
% correct sign and significant	87%	86%	100%	100%
Average adjusted R^2	0.54	0.48	0.50	0.66
% significant F-statistic	92%	83%	100%	100%

% of significant coefficients is based on testing the null hypothesis that the coefficient in question is equal to zero. % of significant F–statistics is based on testing the null hypothesis that coefficients on all independent variables are jointly equal to zero. In each case, the figure reported shows the proportion of times that the respective null hypothesis was rejected at a 95% confidence level.

most closely resemble subsequent outturn. Results for anchored windows are more mixed, suggesting initially that outputs from the trend approach are better. In both cases, the approaches do well with signalling the growth and decline in rental values for the late 1990s and early 2000s. By contrast, they perform less well for periods that include the GFC years, failing to predict the extent of the decline in market rents as the UK economy slowed. This suggests the specific triggers for growth and decline are important, but it requires further study of individual property types to ensure that the aggregation of data into 'All Property' does not distort the picture.

Figure 3 shows the ratios of actual to sustainable rental value at sector level for the MSCI series. The patterns in the office results are similar to those for All Property. The retail series are less cyclical in the period studied, with a prolonged period of growth from the mid-1990s to the mid-2000s that the sustainable rental values broadly follow. There is a divergence between sustainable rental values and the actual index in the latter part of the period that is only corrected in results for trend-based models using rolling windows from 2016 onwards. This may reflect the structural changes currently affecting UK retail and all models that are

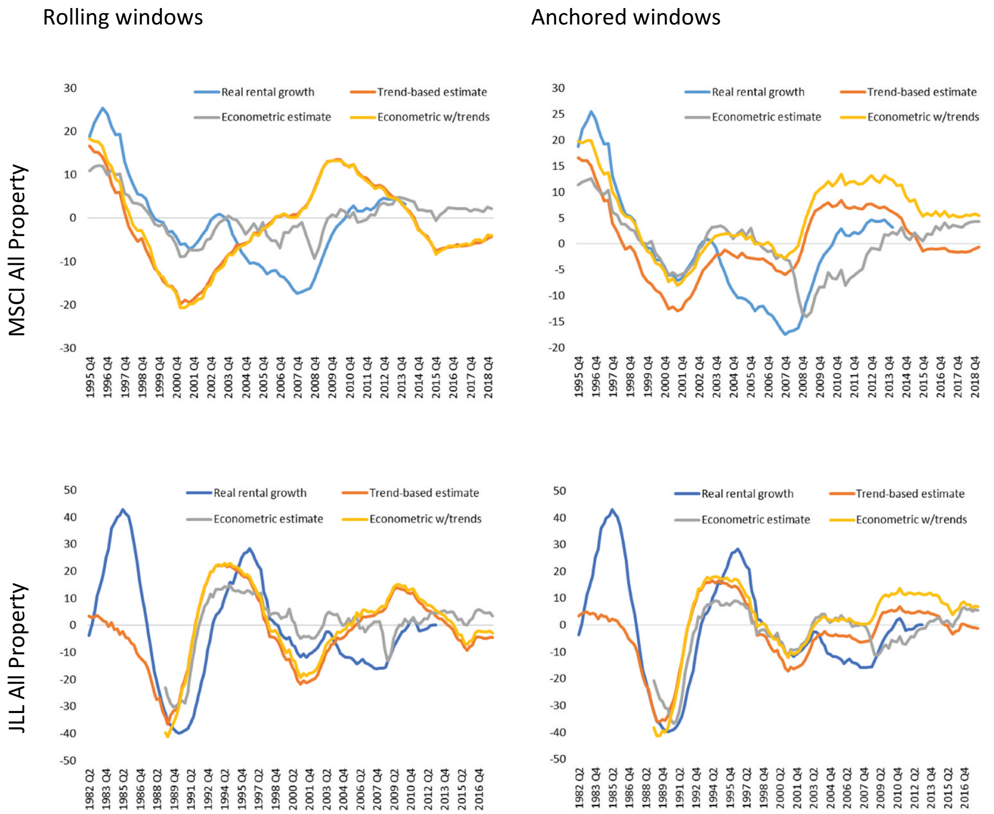

Figure 2. Implied correction in all property rental values vs. subsequent five-year outturn. The charts above show actual real rental growth over the following five years and the real rental growth implied by each of the models if actual rents corrected to the sustainable levels implied by the models.

calibrated on historical data will have difficulty in gauging sustainable values and possible market adjustments in the presence of structural change.[16] Trend-based models identify periods of prolonged under and over valuation in all cases, as does the trend-input approach, but results from the standard econometric approach are more erratic.

Figure 4 illustrates whether the corrections in market rental values for individual property types that are implied by different models are borne out by subsequent real rental growth. This appears to be the case for the late 1990s and early 2000s in the office and industrial sectors, and to a lesser extent for the office sector post-GFC. However, implied corrections do not match subsequent outturn post-GFC for retail and industrial real estate which, once again, might reflect ongoing structural changes in these sectors.

Figures 5 and 6 show the sector level results for the JLL dataset. These results echo patterns found in the earlier analyses. For all three sectors, the implied corrections map on well to the downturn in real market rental values for the early 1990s. This holds both for trend-based and econometric approaches. For later years, similar patterns to those observed from the MSCI series emerge such

Figure 3. Ratio of MSCI sector rental value index to sustainable rental value. The charts above show the ratio of actual rents to the sustainable rents implied by each of the models. for example, a ratio of 1.3 indicates the actual rent is 30% above the estimate of sustainable rents.

as the substantial divergence in market rental values from sustainable rental values in the case of retail that could reflect longer-term structural change not captured in the model specifications. Nonetheless, the JLL-based models perform better than those derived from MSCI rental values over the GFC period.

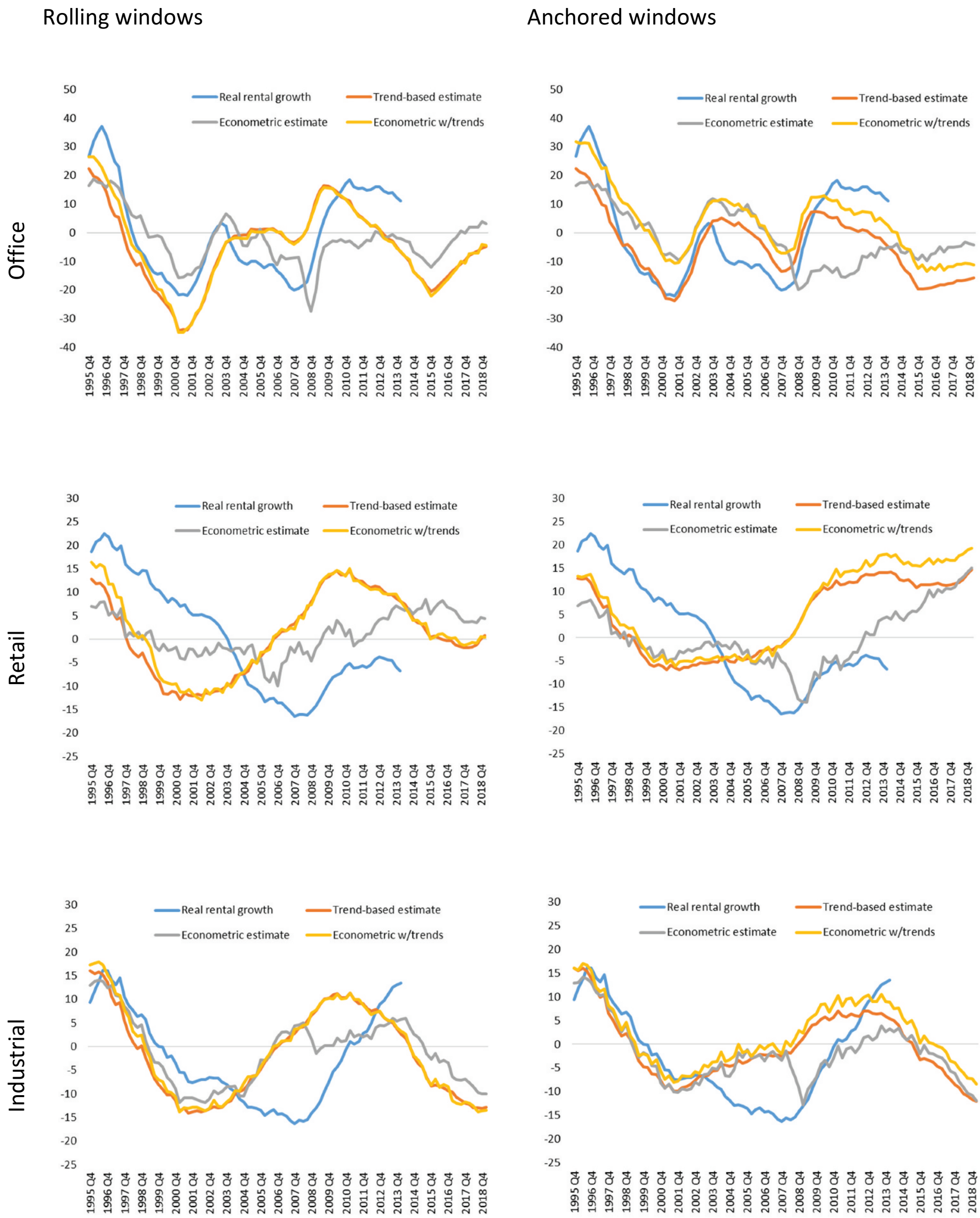

Figure 4. Implied correction in MSCI sector rental values vs. subsequent five-year outturn. The charts above show actual real rental growth over the following five years and the real rental growth implied by each of the models if actual rents corrected to the sustainable levels implied by the models.

The results presented so far show that sustainable rental values produced by the trend-input approach are like those from the simpler trend-based approach. In contrast, the conventional econometric approach produces measurements of sustainable rental value that work better than the trend-based series in a number of periods. All approaches performed reasonably well for the 1980s and 1990s, but all

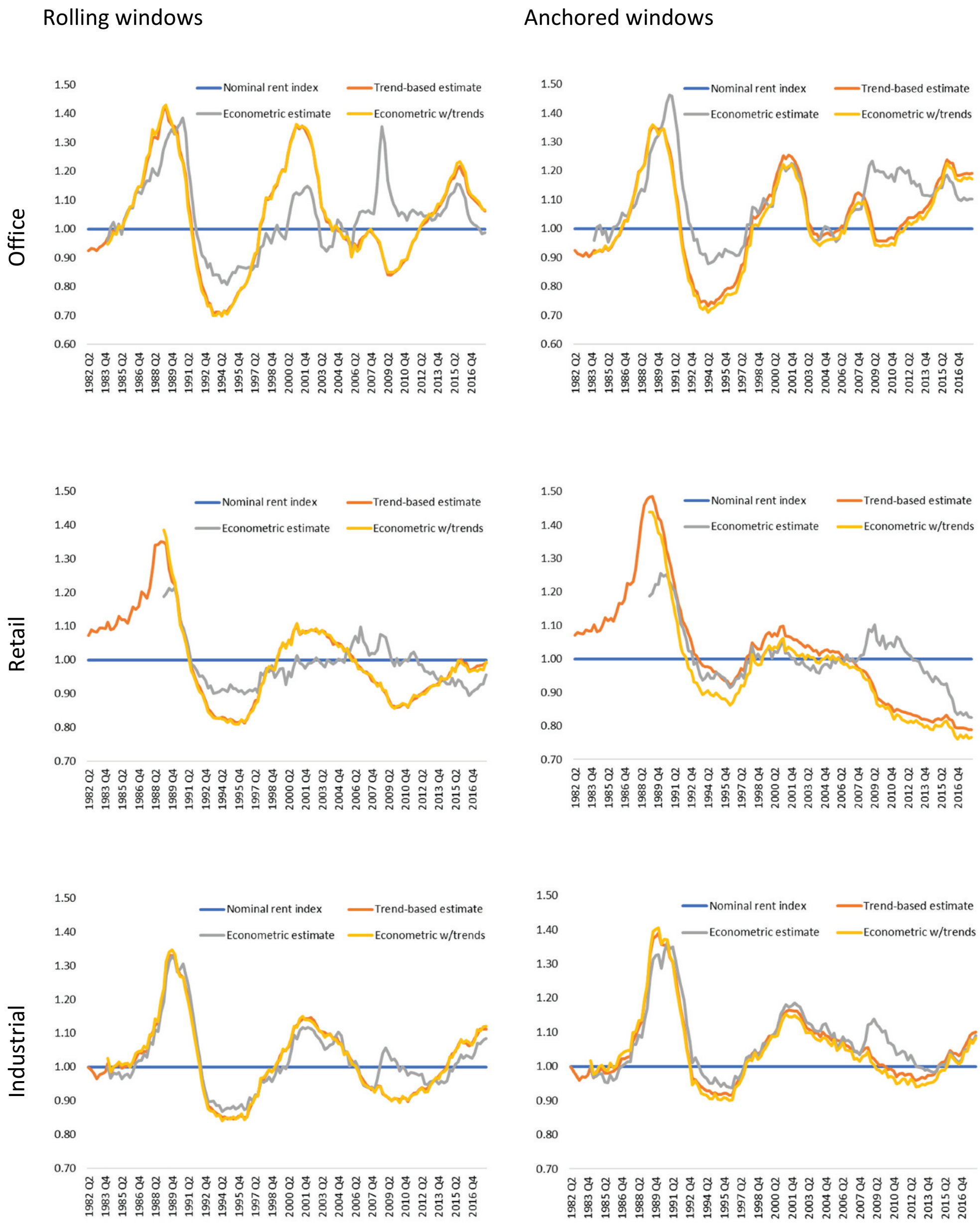

Figure 5. Ratio of JLL sector rental value index to sustainable rental value. The charts above show the ratio of actual rents to the sustainable rents implied by each of the models. for example, a ratio of 1.3 indicates the actual rent is 30% above the estimate of sustainable rents.

had difficulty in signalling the post-GFC drop in market rental values. Yet, it is not easy from a visual comparison to discern whether any approach was statistically superior, so formal tests of the ability of each model to capture subsequent changes in real market rental values are required.

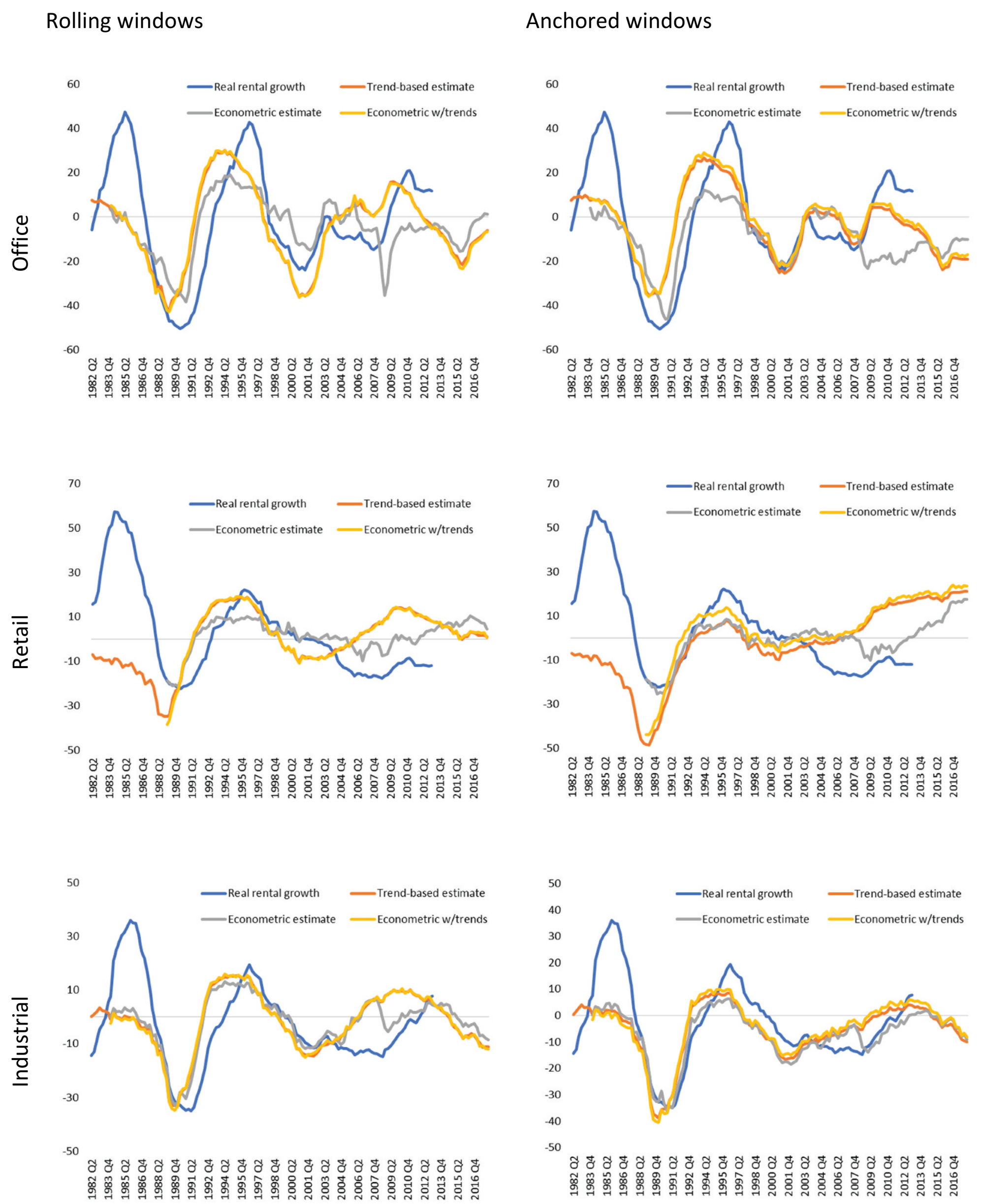

Figure 6. Implied correction in JLL sector rental values vs. subsequent five year outturn. The charts above show actual real rental growth over the following five years and the real rental growth implied by each of the models if actual rents corrected to the sustainable levels implied by the models.

Statistical testing of market correction forecasts

Sustainable rent measures are meant to function as signals or warnings in relation to current market conditions rather than precise forecasts, but measures and tests of forecast accuracy provide a formal framework for comparing the different models. These can measure the size of any errors in assessing subsequent market outcomes and whether there are tendencies by the models to either understate or overstate future market movements, as well as the ability of a model to outperform naïve forecasts or a competing approach.

Standard measures of forecasting accuracy are adopted here (see Fildes & Stekler, 2002). These are the Mean Error (ME), Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE). Formulas for these metrics are set out in Tsolacos (2006), Papastamos et al. (2015), and McAllister and Nasr (2020), so for brevity we do not repeat them. Theil (1966, 1971) proposes two metrics that are also regularly used. The U1 metric scales the RMSE to the root of the average squared outturns plus the root of the average squared forecasts. The closer the U1 metric is to zero, the better the accuracy of the forecast. The U2 metric compares the mean squared error for a set of forecasts to that of an alternative set of forecasts, usually a naïve model. The naïve model used here assumes a reversion in real rental values to the average real rental value observed for the estimation window. If the U2 metric is below 1, then the forecasts from the model are better than the naïve (or alternative) approach.

We also use the test proposed by Diebold and Mariano (1995) (hereinafter DM test) to compare the forecasts of a selected model against those of an alternative. The null hypothesis of the DM test is that there is no difference in the accuracy of two sets of forecasts as captured by the errors. The alternative hypothesis is that one set of forecasts is more accurate than the other. This is assessed by calculating the loss differential, which is the difference between the forecast errors from one model and those from another. In this case, absolute errors have been used. The loss differential is then regressed onto a constant term and the statistical significance of the resulting coefficient is tested using conventional standard errors and standard errors adjusted for serial correlation.

All tests are used to compare the required market correction implied by each model to the subsequent five year outturn in real market rental growth.[17] Table 4 presents tests for the MSCI indexes. For All Property, the retail sector and the industrial sector, MAE and RMSE indicate that the conventional econometric approach produced the smallest errors on average. This approach also produced the best U1 and U2 scores, with U2 below 1 in all cases, indicating better performance than a naïve approach of assuming reversion to mean. The econometric estimates also had smaller mean errors in these cases, indicating less bias. For the office sector, the conventional econometric approach performed no better than the trend-based and trend-input approaches, the trend-based model estimated using anchored windows being the strongest.

DM tests were conducted comparing the econometric approach with the naïve approach and linear trend approach. For All Property (rolling windows), retail property (rolling and anchored windows) and industrial property (rolling windows), tests suggest that the difference in predictive accuracy between the econometric model and linear trend approach is statistically significant at the 1% level in favour of the former. The tests are also favourable to the econometric approach when comparing it against the naïve model. Only in the office sector are results more mixed, with the trend model significantly better than the econometric approach at a 1% level when anchored windows are used. The remaining cases are either weakly significant or show no statistically significant difference between the methods examined.

Table 5 provides comparable results for the JLL indexes. Once again, for All Property and for the retail and industrial sectors, the econometric approach had smaller forecast errors than other approaches and produced the lowest scores for U1 and U2 metrics. For the office sector, though, results are much more mixed, with trend-based models superior when anchored windows are used, but no approach superior when rolling windows are used. These results are corroborated by the DM tests, which show a statistically significant difference at the 1% level in favour of a conventional econometric approach for All Property (rolling windows), retail (rolling and anchored) and industrial (anchored windows), but a significant difference at the 1% level in favour of linear trend models for the office sector (anchored windows).

Robustness checks– exploration of alternative demand proxies

As outlined above, the requirement for historical quarterly data back to the 1960s constrained the choice of demand proxies to broad measures of demand based on overall economic activity and overall consumer spending. To explore the potential impact of alternative demand proxies further analysis was undertaken to identify whether these would be useful in identifying periods when real market rental values deviated substantially from sustainable levels.

For offices, the use of an office employment variable in place of real GDP did not improve the results. Employment tends to lag output changes. For the retail sector, two alternatives to consumer spending were explored: first, retail sales adjusted for internet-based sales and second, consumer spending adjusted for internet-based sales. Retail sales data was only available from 1988 and did not improve the results for the period where this series was available. Adjusted consumer spending data produces similar results to unadjusted consumer spending. More years of data are needed to assess whether a model explicitly incorporating the impact of internet-based sales into the demand proxy is more useful than one without its inclusion (but where its impact can

Table 4. Forecast accuracy for models based on MSCI rental value indexes.

	Rolling windows					*Anchored windows*				
	ME	MAE	RMSE	U1	U2	ME	MAE	RMSE	U1	U2
A: All Property										
Trend	−0.3	10.8	12.0	0.57	1.46	−1.3	7.2	7.8	0.43	0.72
Econometric	−0.7	5.0	6.5	0.41	0.80	−0.1	6.3	7.8	0.47	0.72
Econ w/trends	−0.5	10.3	11.7	0.55	1.42	−5.7	7.3	9.1	0.47	0.84
Naïve	−6.5	7.3	8.2	0.42	1.00	−8.3	9.1	10.8	0.52	1.00
B: Office										
Trend	3.3	11.7	12.5	0.41	0.72	2.0	8.1	9.7	0.36	0.45
Econometric	2.3	10.2	11.6	0.45	0.67	0.9	15.8	17.4	0.65	0.80
Econ w/trends	2.3	10.4	11.5	0.37	0.66	−6.8	10.5	11.7	0.41	0.54
Naïve	−13.9	14.3	17.5	0.54	1.00	−19.2	19.5	21.8	0.59	1.00
C: Retail										
Trend	−1.1	15.6	16.6	0.79	1.37	−2.3	13.0	13.8	0.71	1.15
Econometric	0.1	9.5	10.3	0.66	0.85	2.2	7.9	9.2	0.55	0.77
Econ w/trends	−2.1	14.6	15.7	0.74	1.30	−3.4	12.8	14.0	0.69	1.17
Naïve	2.9	11.0	12.0	0.59	1.00	5.0	10.6	12.0	0.57	1.00
D: Industrial										
Trend	−2.6	8.8	10.4	0.53	0.79	−3.0	6.2	7.5	0.44	0.45
Econometric	−2.1	6.1	8.2	0.47	0.62	−0.6	5.1	6.4	0.38	0.38
Econ w/trends	−3.2	8.4	10.2	0.52	0.77	−5.0	6.5	8.5	0.48	0.50
Naïve	−12.2	12.2	13.2	0.61	1.00	−15.4	15.4	16.9	0.69	1.00

Comparison based on forecasts dated 1995 Q4 to 2014 Q1. Final forecast relates to outturn over 2014.1–2019.1.

be adjusted for outside of the model). At the time of writing, it seems that the latter approach will probably prove to be more useful in identifying the current downturn in retail rents than explicitly integrating this structural change into the available demand proxy.

Conclusions

Previous research into long-term or fundamental values of commercial real estate has often exhibited weaknesses in the treatment of the income component. A common approach has been to use current levels of market rent, with more focus placed on calibrating the discount rate or capitalisation rate in such models. This is despite separate and extensive research on how occupier markets deviate from, and return to, equilibrium. This paper has presented different models of sustainable rental value and has examined whether these models provided adequate signals of corrections in market rents when applied to historical data for UK CRE markets. If an effective model can be found, this has implications for how CRE markets might be monitored in future by investors, lenders, regulators and policy makers.

Informed by previous research, three basic approaches for measuring sustainable rental values were investigated. The first assumed simply that real market rents revert to a long-term average level, but this performed so poorly that the results were not presented. The second approach assumed that real market rents revert to a long-term trend. This equates to the first approach if the long-run growth rate is zero, but can work if real rents trend either upwards or downwards. The third approach assumed that real market rents revert to a long-run equilibrium figure produced by an econometric model that incorporates demand and supply side drivers. Sustainable real rental values were then predicted with reference to both actual values and trend values of the relevant input

Table 5. Forecast accuracy for models based on JLL rental value indexes.

	Rolling windows					*Anchored windows*				
	ME	MAE	RMSE	U1	U2	ME	MAE	RMSE	U1	U2
A: All Property										
Trend	−0.1	14.7	18.2	0.53	1.25	1.4	10.5	14.0	0.43	0.71
Econometric	−6.3	9.1	10.8	0.36	0.75	−1.7	7.6	9.5	0.30	0.48
Econ w/trends	−7.6	12.2	14.5	0.41	1.00	−7.0	9.6	11.7	0.34	0.59
Naïve	−8.8	13.2	14.5	0.44	1.00	−14.3	18.0	19.7	0.53	1.00
B: Office										
Trend	1.6	16.1	20.0	0.46	0.98	0.7	12.8	16.6	0.41	0.61
Econometric	2.8	16.6	19.9	0.51	0.98	7.1	16.0	20.4	0.50	0.75
Econ w/trends	1.5	16.8	20.8	0.47	1.02	−1.2	13.4	17.3	0.43	0.63
Naïve	−13.2	17.4	20.3	0.47	1.00	−21.5	24.8	27.3	0.55	1.00
C: Retail										
Trend	4.0	19.4	25.8	0.76	1.22	8.7	20.5	26.6	0.72	1.34
Econometric	−5.0	7.9	9.4	0.34	0.45	−2.0	7.6	9.2	0.32	0.46
Econ w/trends	−7.5	12.5	14.8	0.45	0.70	−6.0	12.2	15.3	0.44	0.77
Naïve	8.8	17.6	21.1	0.59	1.00	11.9	16.6	19.9	0.56	1.00
D: Industrial										
Trend	−1.7	11.1	14.3	0.51	0.94	2.7	8.9	11.6	0.41	0.52
Econometric	−0.7	8.9	12.6	0.47	0.83	5.0	7.6	10.7	0.37	0.48
Econ w/trends	−1.5	11.7	15.0	0.53	0.98	2.5	9.5	12.4	0.42	0.55
Naïve	−11.9	14.0	15.3	0.52	1.00	−19.4	21.0	22.4	0.63	1.00

Comparison based on forecasts dated 1984 Q1 to 2013 Q1 for office and industrial sectors, and 1989 Q1 to 2013 Q1 for All Property and the retail sector. Final forecast relates to outturn over 2013.1-2018.1.

variables. In the latter case, this was to address concerns about whether the input variables were in equilibrium.

Over the period studied, all the models used were most successful at modelling the 1990s downturn in UK real estate rents, and gave signals of the impending fall in real rental values as at 1988 and 1989. The cycle of the early 2000s is also captured well by some approaches. The models were less successful at predicting the rental downturn in the UK that followed the GFC. However, this was not an occupier-led real estate market correction, but came about as the result of the economic downturn caused by collapses in asset values, among other factors.

The analysis showed that conventional application of the econometric model to estimating sustainable rental values outperformed other approaches in signalling medium-term corrections. These findings suggest that there is merit in exploring and refining the econometric approach further. While all the models tested here are susceptible to error in the face of structural changes to real estate markets, as best illustrated by the retail sector, the econometric approach offers the possibility of refinement if variables can be found to represent how economic drivers have changed. Incorporating the impact of sentiment in addition to fundamentals might also be useful in identifying sustainable levels of rent. Nonetheless, such models can only be developed further if good quality data on real estate stock and supply becomes available on a more frequent and consistent basis. This is where public domain data both within and outside the UK remains fragmented and weak.

The results of the paper indicate that it is useful to estimate measures of sustainable rental value for monitoring real estate market conditions. However, sustainable rental value measures cannot predict all real estate market corrections, as some do not have their origin within occupier markets. Therefore, they should be used in conjunction with the monitoring of pricing in CRE markets and other factors that present risks such as growth in and levels of bank lending. In this regard, they have the potential to provide valuable insights for market participants and regulators subject, of course, to the Lucas critique.[18]

Notes

1. In the UK and much of mainland Europe there were comparatively few residential mortgage defaults with bad loans concentrated in the commercial sector, which exhibited larger value falls. Clarke (2018) estimated that UK banks wrote off £19 billion of real estate lending losses in the 2008 downturn, with substantially larger exposure to CRE losses.
2. We use 'valuations' rather than 'appraisals' throughout to be consistent with international regulatory, accounting and professional terminology.
3. In a survey of 21 countries, the European Mortgage Federation (EMF-ECBC, 2017) found that 14 used only Market Value (MV) as the basis for their lending valuations, four used MV in conjunction with a form of long-term valuation (LTV) and only two used solely LTV, while one response was impossible to interpret.
4. The debate around the use of MV, which is a proxy for the exchange price, and a more 'sustainable', long-term assessment of value is not recent (Bienert & Brunauer, 2007; Crosby et al., 2000), but the GFC re-energised it (Crosby & Hughes, 2011; Quentin, 2009; Tajani & Morano, 2018).
5. See Hendershott (1996), Hendershott et al. (2002), Englund et al. (2008), Hendershott et al. (2010), and Hendershott et al. (2013).

6. See Mouzakis and Richards (2007), Englund et al. (2008), Brounen and Jennen (2009a, 2009b), Adams and Fuss (2012), Ibanez and Pennington-Cross (2013) and Chau and Wong (2016).
7. This issue parallels that in conventional forecasting where future values for some or all independent variables may be needed to produce out-of-sample predictions, but external forecasts/assessments for those variables might not be available.
8. The MSCI UK quarterly index begins in 2000 Q4. For this study, earlier quarterly observations are constructed from the smaller sample but closely correlated UK monthly index, which begins in 1986 Q4.
9. The UK Retail Price Index (RPI) was also employed as a deflator to check our findings. Stronger inflation in RPI meant that real rental value growth was lower than when the GDP deflator was used, but the results in relation to model performance were consistent with those presented.
10. These changes might have also been influenced by foreign investors and occupiers, used to more flexible lease arrangements in other markets, and by (slowly) changing attitudes among lenders, as well as by pressure from tenants and the UK Government. See Crosby et al. (2005, 2006) as well as the UK Lease Events Review published periodically by MSCI.
11. Given the use of a fifteen-year rolling window in the analysis and that the major changes in lease terms in the UK were completed by the mid-2000s, lease structure change will have little impact on any current modelling of sustainable rents.
12. See www.gov.uk/government/collections/non-domestic-rating-business-floorspace-statistics
13. See www.ons.gov.uk/businessindustryandtrade/constructionindustry
14. The weighting is based on the share of each sector within the All Property index in terms of value. Technically, we create a weighted growth rate using the percentage changes in sustainable rental values for each sector. This allows for more reliable projections of an All Property sustainable rental value than by weighting the outputs for each quarter in levels.
15. This is an important proviso given the potential impact of COVID-19 (see footnote 16).
16. The modelling precedes the impacts of the coronavirus pandemic. While it is too early to judge the effects of this, it may serve to exacerbate some of the structural changes occurring at sectoral level. Extending the data collated for this research should enable further research into the impact of COVID–19 in the longer term and enable a comparison of these longer term effects against short term fluctuations.
17. Note that while sustainable rental values and implied market corrections may be measured up to the end of 2018, testing can only be done for the implied corrections measured up to 2013, with these measurements then compared to real rental value growth over 2013-18.
18. The research for this paper was undertaken well before the pandemic and so we have not addressed the issues raised specifically in the paper apart from a couple of footnotes. The Lucas critique supports the view that it is impossible to predict unforeseen events by examining past data and while we have not collated or tested the most recent data illustrating the effects of the pandemic, we are sure the modelling we have undertaken would not predict the extent of the impacts of COVID-19 on rental values in the UK. But what these models can do (and are doing within the UK central bank) is form the basis of stress testing markets for unforeseen events. By their nature we do not know what the next unforeseen event will be after COVID-19, we can be fairly sure there will be one.

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