Efficiency in the UK commercial property market: A long-run perspective

Steven Devaney, Oliver Holtemöller, and Rainer Schulz*

February 15, 2011

*Devaney and Schulz: University of Aberdeen Business School, Edward Wright Building, Dunbar Street, Aberdeen AB24 3QY, United Kingdom. Holtemöller: Martin-Luther-University Halle-Wittenberg and Halle Institute for Economic Research (IWH), Kleine Märkerstr. 8, 06108 Halle (Saale), Germany. Contact: oliver.holtemoeller@iwh-halle.de. The authors are grateful for permission from CBRE to use their unpublished historical rent series in the analysis and to Barclays Capital for permission to use data from the Equity Gilt Study 2010. Help from the UK Office for National Statistics and from IPD in regard to data from those sources is also acknowledged.

Efficiency in the UK commercial property market: A long-run perspective

Abstract

Informationally efficient prices are a necessary requirement for optimal resource allocation in real estate markets. Prices are informationally efficient if they reflect buildings' benefit to marginal buyers, thereby taking account of all available information. We examine the efficiency of the UK commercial property market and the interaction between prices, construction costs, and new supply. We collated a unique data set covering the years 1920 onwards. First, we assess if real estate prices are in accordance with present values, thereby testing for informational efficiency. Second, we apply a structural vector autoregressive model to assess if developers reacted correctly to price signals.

Keywords: Fundamental real estate prices, informational efficiency, real estate investment decisions, vector autoregressive models

JEL Classification: C32, E27, G11, G12, R31

1 Introduction

According to Fama (1970, p. 383), "a market in which prices provide accurate signals for resource allocation [...] [and] always 'fully reflect' available information is called 'efficient'." In the context of asset markets, some authors prefer to call this a definition of 'informational efficiency', because it leaves the resource allocation part rather unspecified. A more general definition of efficiency in an asset market would state that the asset price reflects the true marginal benefit and that this price—at least in the long run—equals the cost required to produce the asset. Obviously, this corresponds to the well-known Pareto efficiency condition.

The existing literature on informational efficiency of commercial real estate markets suggests that the market in the UK is informational efficient, whereas the market in the US is not. In common with all studies on informational efficiency, results can be questioned due to the data used, the assumptions made on the required return rate, and the statistical methodology used to conduct the analysis. Studies that replicate the analysis for a given market based on different data, assumptions, and methodology can therefore contribute to the knowledge on informational efficiency.

This is the first motivation for our paper: We provide an analysis of the London City office market over a long time period and for different assumptions on the required return rate. The second motivation is the analysis of real effects of informational inefficient prices. The existing literature focuses exclusively on informational efficiency of prices for existing commercial buildings and does not consider the reaction of developers to these price signals. According to the standard investment theory, developers should start new projects when the market value of existing buildings is above replacement cost. This is not only profit maximizing, but also socially efficient, because a erected building has a higher value than the resources going into it. Obviously, if prices of existing buildings traded in the market are distorted (informational inefficient), the above reasoning no longer holds. If developers react to inflated prices then resources are misallocated. It therefore becomes an important question if informational inefficiency (if it exists) has consequences for the real economy.

The real consequences of mispricing have been explored for corporate investment in several studies. The analysis of corporate investment is complicated by the fact that a company's interests are not automatically aligned with a second best social outcome. Intuitively, when a company's share price is inflated, investment opportunities that have a lower true value than they cost may seem attractive. Stein

(1996) provides a theoretical analysis on when a company's manager, knowing the true value, should go ahead with such inefficient investments. Stein shows that this will be more likely the shorter manager's time horizon and the tighter company's financing constraints. Obviously, if company managers do not know the true value and rely only on the market valuation, then they will go ahead with inefficient investments anyway. Empirical studies on corporate investment have established that mispricing can have an effect on real investment, see Blanchard et al. (1993), Chirinko and Schaller (2001), and Baker et al. (2003).

In this paper, we provide further evidence on the efficiency for the UK office market starting from the standard perspective that building prices should, in an informational efficient market, be equal to the present value of expected future cash flows. We consider many different scenarios for the required return rate to make our results as robust as possible. By studying informational efficiency of the London office market over the period 1920-2008, we provide long-run evidence, extending the already existing knowledge on this market. Moreover, we assess whether mispricing may have led to real misallocation of resources, at least for years from 1952 when additional development data becomes available.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 presents the empirical methodology used in this paper. Section 4 presents the data and Section 5 the results of our empirical analysis. The final Section 6 concludes.

2 Literature review

Within the real estate literature, numerous studies have explored whether commercial real estate markets are efficient. Amongst these studies, a subset has specifically examined whether or not real estate prices exhibit informational efficiency. This subset has recently been reviewed and critiqued by Hendershott et al. (2006), with a focus on what this evidence suggests about rationality in real estate markets. Their review includes discussion of several articles that analyse capitalisation rates (the ratio of initial income to price, also known as initial yield), which are of interest here given that this study also analyses capitalisation rates, albeit over a much longer time frame than has been studied previously.

These articles often begin with the concept of the equilibrium value of a property being equal to the present value of its expected future cash flows. From this starting point, an equilibrium expression for capitalisation rates can be derived. However, a

key empirical issue is that expectations cannot often be observed and so proxies for them must be used, as well as for the elements that make up discount rates with which future cash flows are evaluated. A second issue is that data and forecasts for cash flows or income are far less common than for market levels of rent, which differ from income owing to vacancies and because lease structures typically prevent contract rents from adjusting to market levels for a certain number of years.[1]

Sivitanides et al. (2001) analysed capitalisation rates at the MSA level for selected US MSAs over the period 1984-1999 and for the office, retail, industrial and apartment sectors. Their theoretical determinants included the yield on ten year US Treasury Bills (as the risk free rate proxy), a proxy for expected inflation and two variables representing rational expectations of future market rents based on their observed past behaviour. The first of these variables was the ratio of rent in a period to the historical average for that market. Given mean reversion in rents, a high value of this variable would signal lower future income and should lead to higher capitalisation rates. The second variable was rental growth from the previous period, allowing for an extrapolative element to expectations.

The main finding in this study was that coefficients on the mean reversion variable generally took the opposite sign to that expected, i.e. capitalisation rates were falling and thus prices were rising as rents rose further above their long run mean. This led the authors to suggest that either investors or appraisers (given appraisal-based data) were myopic rather than rational in terms of expectations about income. However, this interpretation has been criticised owing to the number of lags used for the variable concerned, which makes their conclusions less convincing (see Hendershott et al. (2006)). Subsequently, though, Chen et al. (2004) found a similar relationship using a contemporaneous version of this variable and an alternative dataset for a similar group of US MSAs.[2]

Hendershott and MacGregor (2005a) attempted to improve on previous analyses of US markets by using NCREIF appraisal-based estimates of capitalisation rates for selected MSAs and data on net operating income (NOI). They undertook substantial data cleaning to remove stale appraisals from the underlying asset data (on which, see Geltner (1993)) and they filtered out locations with extreme deviations in NOI. Computed capitalisation rates were then regressed onto three proxies for income

[1]Depending on the country concerned, rent may be fixed in nominal terms in the interim (as in the UK case) or in real terms, with provision for annual inflation-linked adjustments.

[2]It should be noted that Chen et al. (2004) interpreted their finding as indicative of correct pricing based on a questionable argument regarding lower risk premiums being required in the boom phase of a real estate cycle compared to the trough, an idea critiqued in Hendershott et al. (2006, p. 157).

growth expectations, plus dummies for different locations. The first two proxies were variants of the variables used by Sivitanides et al. (2001), whilst the third was the ratio of NOI to market rent, to account for expected reversionary uplifts upon releasing. Despite these steps, as with the previous studies, signs on the estimated coefficients were inconsistent with rational pricing.

Hendershott and MacGregor (2005b) also analysed capitalisation rates in UK office and retail real estate markets over the period 1973-2001, employing a cointegration methodology. Their model for (real) capitalisation rates included the risk free rate, an expression for the real estate risk premium that related this to expected returns in the equity market, and expected future growth in market rents. Like earlier studies, proxies for the latter included previous growth and measured deviations from trend (rather than mean) levels of rent. Results for the long run model showed both the rent proxies to be significant and correctly signed, with a positive coefficient in the mean reversion case indicating higher capitalisation rates as deviations from trend became larger.

Two other features of this study are noteworthy. First, the predicted capitalisation rates from the rational model are plotted against actual rates, with the two showing a close correspondence, even through the pronounced UK real estate cycle of the late 1980s and early 1990s. Second, the authors found plausible relationships between capitalisation rates and equity market variables, with, ceteris paribus, high real estate yields when dividend yields were low and when expected dividend growth was high (i.e. lower property prices when prospects for the competing asset were good). In contrast, their proxy for the risk free rate performed poorly and was omitted from the final models. Despite this, the overall results led the authors to conclude that capitalisation rates in the UK changed in a manner consistent with rational expectations over this time frame.

These findings advanced earlier research on the UK market by McGough and Tsolacos (2001), which was conducted on IPD appraisal-based capitalisation rates for the period 1987-2000. These authors successfully identified a long run cointegrating relationship between initial yields for commercial real estate, the yield on ten year government bonds and the dividend yield on UK equities.[3] The resulting VECM model, though, did not find as strong a role for these variables in explaining short run change and the error correction variable was insignificant. Nonetheless, the authors found relatively small differences between forecast and actual capitalisation rates except at the very end of their study period when a marked divergence

[3]Rental growth was not found to cointegrate with these variables and does not feature in this model, although it was used in an alternative regression model tested in the same paper.

between the two occurred.

Finally, a recent study by Clayton et al. (2009) has used standard cointegration and VECM models to explore national level capitalisation rates for different types of property in the US over 1996-2007. One difference from earlier literature was that two of their fundamental variables expected rental growth and the required return for investment in each property type were measured using survey evidence rather than researcher constructed proxies. They then used these alongside a risk free rate proxy in a long run model of capitalisation rates and added further variables measuring sentiment in estimation of the short run model in order to see if these had a role in explaining capitalisation rate movements. This last step required orthogonalisation of the survey variables to control for the fact that these contained elements of sentiment themselves.

The results indicate that sentiment does have an impact on short run changes in capitalisation rates, but the authors argued that fundamentals remained the primary determinants. Yet, given the way in which the expected growth and required return variables are measured, it is not clear from this study whether long run pricing was efficient or rational it merely shows that it was consistent with market participants assumptions. Thus, sustained deviations from equilibrium values may have been possible within this period after all.

In summary, the literature above suggests that conventional theoretical drivers of capitalisation rates can explain their levels and movements to some extent, but that more evidence for efficiency of pricing exists for UK real estate markets than US markets. This paper will add further evidence for the UK office market starting from the standard perspective that values should, in an informational efficient market, be equal to the present value of expected future cash flows. However, it differs from previous literature in two important respects. First, it studies a much longer period, using data on key variables for 1920-2008. Second, it formally assesses whether deviations from present values values may have led to misallocation of resources in the form of increased office development, at least for years from 1952 when additional development data becomes available.

3 Empirical methodology

3.1 Testing for informational efficiency

Rational investors will use the present value to assess how much they are willing to pay for an asset. The present value discounts an asset's expected future income with the required return rate, which is the return rate investors can expect from investing in other assets with the same risk characteristics. If different investors are taxed differently, then the equality of price and present value must hold for the marginal investor. Rationality means that investors use all information relevant for predicting future cash flows correctly. Said differently, rational investors use information efficiently and prices will reflect this. Our test of informational efficiency is based on this identity of price and present value. Both should be statistically indistinguishable.

Matters are complicated, however, by the fact that the present value is not observed directly. Two strategies exist to deal with this problem. Strategy 1 works with one-period return rates and Strategy 2 estimates the present value and compares it with observed prices. We explain both strategies by starting with the definition of the present value

$$P_t = \mathrm{E}\left[\frac{P_{t+1} + D_{t+1}}{1 + H_{t+1}}\middle|\Omega_t\right] \ . \tag{1}$$

Here, P_t is the price a rational investor would pay for the office building in period t, D_{t+1} is the rental income, H_{t+1} the required return rate (known in t) and Ω_t the information set available in t. The information set may contain information on interest rates, inflation, and GDP growth. By conducting repeated substitution and assuming that the transversality condition holds (income does not grow faster than the required return rates), we obtain

$$P_t = \mathrm{E}\left[\sum_{j=1}^{\infty} \frac{D_{t+j}}{\prod_{k=1}^{j}(1 + H_{t+k})}\middle|\Omega_{t-1}\right] \ . \tag{2}$$

Dividing the present value by the current rent gives the qualitatively equivalent expression

$$M_t = \mathrm{E}\left[\sum_{j=1}^{\infty} \frac{\prod_{i=1}^{j}(1 + G_{t+i})}{\prod_{k=1}^{j}(1 + H_{t+k})}\middle|\Omega_{t-1}\right] \ , \tag{3}$$

where G_t is the rental growth rate. We call this the rational multiplier.

Strategy 1 uses (1), the assumption that the required return rate H_{t+1} is given

at the end of t, and $x_{t+1} = \mathrm{E}[x_{t+1}|\Omega_t] - \varepsilon_{t+1}$ (with $\mathrm{E}[\varepsilon_{t+1}|\Omega_t] = 0$ and ε_{t+1} is not correlated over time) to derive

$$\frac{P_{t+1} - P_t + D_{t+1}}{P_t} - H_{t+1} = \varepsilon_{t+1} \ .$$

The left hand side can be calculated with actual prices, income, and by making assumptions on H_{t+1} (for example that it is constant). It can then be tested if the computed ε_{t+1} really behave as required under rationality (the computed ε_{t+1} must be orthogonal to information in Ω_t). Strategy 2 computes the present value (rational multiplier) and compares it with actual prices (multipliers). Early implementations of this strategy used the realized income series to compute the perfect foresight fundamental value and compared the volatility of this series with the volatility of the realized series, later tests computed the present value as the conditional expectation of a fitted VAR model, for details see Campbell et al. (1997, Chapter 7) and Cuthbertson and Nitzsche (2004, Chapters 10-12).

3.2 Our test procedure

The first step of our analysis examines if observed prices paid for London office buildings are in accordance with present values. We use the test procedure proposed by Campbell and Shiller (1988). With this procedure, both test strategies can be implemented. The procedure is based on an approximation of the one-period return rate and the present value. We start with the approximation of the ex post one-period return rate, thereby omitting the constant term,

$$r_{t+1} = \rho m_{t+1} - m_t + g_{t+1} \ , \tag{4}$$

where $g_t \stackrel{\text{def}}{=} \ln(1 + G_t)$ and $\rho \stackrel{\text{def}}{=} \frac{1}{1+\theta}$.[4] θ is the inverse of the long-run multiplier. For details on this approximation, see Campbell et al. (1997, p. 261).

Taking expectations and assuming rational investors gives

$$h_{t+1} = \rho \mathrm{E}[m_{t+1}|\Omega_t] + \mathrm{E}[g_{t+1}|\Omega_t] - m_t \tag{5}$$

with $h_t \stackrel{\text{def}}{=} \ln(1 + H_t)$. The assumption of rational investors implies that they can expect to receive on average the required return rate from their investment. This is not true for irrational investors, who will be 'surprised' by the systematic average

[4] In empirical applications, all series will be in deviations from their respective mean, which justifies the omission of the constant term in the approximation above.

difference between realized and required return rates. Combining (4) and (5) shows this directly: It holds for excess return rates in a market with rational investors

$$\begin{aligned} r_{t+1} - h_{t+1} &= \rho(m_{t+1} - \mathrm{E}[m_{t+1}|\Omega_t]) + (g_{t+1} - \mathrm{E}[g_{t+1}|\Omega_t]) \\ &= \varepsilon_{t+1} \ . \end{aligned}$$

where ε_{t+1} is a forecast error. This is equivalent to $r_{t+1} = h_{t+1} + \varepsilon_{t+1}$, where the latter term stands for the unexpected return rate component, which has a conditional expectation of zero and is uncorrelated with past unexpected components. ε_{t+1} is therefore a forecast error with all its characteristics. Making assumptions on required return rates, the realized forecast errors can be computed and tested for their characteristics.[5] This is Strategy 1 as explained above.

Rearranging (5) and solving forward leads to

$$m_t = \sum_{j=0}^{\infty} \rho^j \mathrm{E}[g_{t+1+j}|\Omega_t] - \sum_{j=0}^{\infty} \rho^j \mathrm{E}[h_{t+1+j}|\Omega_t] \ . \tag{6}$$

As is the case for the untransformed rational multiplier (3), the rational log multiplier m_t (6) will be higher when the expected rental growth rate g_t is higher and will be lower the required return rate h_t is lower.

To estimate the expectation terms in (6), and therefore to estimate the approximate present value, a reduced form VAR model is estimated. The VAR model always includes the observed multiplier and the rent growth rate. Further variables can be (linear) components of the required return rate, and other variables that help forecasting future required return rates and rental growth. The VAR in its VAR(1) companion form is

$$x_{t+1} = Ax_t + \varepsilon_{t+1} \ . \tag{7}$$

The vector x_t contains the variables and lags thereof. The first element of x_t is m_t, the second g_t. Other possible elements will be discussed below. The information set consists of $\Omega_t = \{\rho, A, x_t\}$. The only restriction we impose is that the VAR is stable. Using (7), the conditional expectation of x_t is then

$$\mathrm{E}[x_{t+1+j}|\Omega_t] = A^{j+1} x_t \ . \tag{8}$$

The expectation of the ith variable in x_t is obtained by multiplying (8) with the

[5] It should be clear that realized return rates cannot be used as required return rates. In this case the approximation becomes an accounting identity, see Campbell and Shiller (1988, pp. 200). The forecast error would always be zero.

column unit vector e_i, which has a 1 in row i and 0s in all others. For example, the computation of the expectation term for the rental growth rate in (6) is thus

$$\sum_{j=0}^{\infty} \rho^j \mathrm{E}[g_{t+1+j}|\Omega_t] = e_2^\top A(I - \rho A)^{-1} x_t \ .$$

The required return rate h_t is not a direct element of x_t (because it is not directly observed) and has to be 'constructed'. This is the point where the researcher has to make assumptions. For the moment, we assume a constant required return rate, but come back to this important point below. Using the VAR model and assuming a constant required return rate, equality between the observed multiplier and the rational multiplier implies

$$e_1^\top x_t = e_2^\top A(I - \rho A)^{-1} x_t \qquad \Rightarrow \qquad e_1^\top = e_2^\top A(I - \rho A)^{-1} \ . \tag{9}$$

This leads to nonlinear restrictions, which can be tested with the estimated VAR parameter matrix.

Although we have discussed Strategy 1 above, we only implement Strategy 2 in the empirical section. As Campbell and Shiller (1988, p. 206) write, there are two important reasons to favor Strategy 2 over Strategy 1:

1. "it may have more power to detect long-lived deviations of stock prices from the 'fundamental value' [present value] implied by the model", which corresponds to Summers (1986) observation that Strategy 1 may lack power and direct testing of the equality of prices and fundamental values is required.

2. it is easier to interpret when informational efficiency is rejected, because it also allows to gauge by which extent prices deviate from present values.

We now come back to the required return rate. The assumptions on this rate can be wrong and therefore cause false rejection of informational efficiency. Because assumptions on the rate have to be made, this aspect needs careful consideration. We consider this with different scenarios, to make our results as robust as possible. Specifically, we consider the following. (a) The nominal required return rate is constant, in which case $h_{t+1} = 0$.[6] This assumption is not very appealing for the UK with its periods of high inflation over our sample period. Testing informational efficiency under this assumption uses (9). (b) The real required return rate is constant.

[6]Recall that we work with variables in deviations form, so that any constant cancels out.

The nominal required return rate is in this case[7]

$$h_{t+1} \quad = \quad \mathrm{E}[\pi_{t+1}|\Omega_t] \ .$$

Assuming that the inflation rate is the third element in x_t, the test equation becomes

$$e_1^\top = (e_2 - e_3)^\top A(I - \rho A)^{-1} \ . \tag{10}$$

(c) The nominal required return rate equals the return rate of some substitute asset. This asset could be government bonds. The interest rate for period $t+1$ is already known at the end of period t. Assuming that this interest rate is the fourth element in x_t, the test equation becomes

$$e_1^\top = e_2^\top A(I - \rho A)^{-1} - e_4^\top \{I + \rho A^2 (I - \rho A)^{-1}\} \ . \tag{11}$$

3.3 Modeling the effect of mispricing on real investment

The second step of our analysis examines the effect of possible mispricing on new construction and construction costs. For this purpose we use a structural vector autoregressive model (SVAR)

$$x_t = \nu + \sum_{i=1}^{k} A x_{t-i} + B e_t, \qquad e_t \sim N(0,1), \tag{12}$$

which includes log completions, log real construction costs, log rational multiplier and mispricing, which is the difference between the observed and the estimated rational multiplier. e_t is a vector of independent structural economic shocks. The mispricing term is taken from scenario (c), which we think is the most relevant case. An Appendix, which is available upon request, shows additionally the results for the mispricing term from scenario (a); results for scenario (b) are not reported because they are very similar to those of scenario (c).

We identify the contemporaneous impact matrix B by imposing a recursive identification scheme (Cholesky decomposition). New completions are assumed not to be affected contemporaneously by shocks to the other variables because planning and building takes time. Real construction costs are assumed not to respond immediately to shocks in the fundamental multiplier and the mispricing term since

[7] If p denotes the constant real risk premium, then the corresponding nominal risk premium is $p + \mathrm{E}[\pi_{t+1}|\Omega_t]p$. The second term will be small and we ignore it.

prices exhibit a certain degree of rigidity. Finally, we suppose that the fundamental multiplier is not affected by contemporaneous mispricing shocks. Of course, this identification scheme is rather restrictive and it cannot be excluded that there are simultaneous effects at work, which we exclude by our identification scheme. In order to check the robustness of our results with respect to these assumptions, we have also applied the more general procedure suggested by Pesaran and Shin (1998). The corresponding results are presented in the Appendix. The main qualitative results are identical for both identification schemes.[8]

From the identified SVAR model we compute impulse response functions and forecast error variance decompositions. The impulse response functions show if and how each of the endogenous variables is affected by shocks to the other variables. For the assessment of the significance of the estimated effects we use two standard error confidence bands from a Monte Carlo simulation (5000 replications). The forecast error variance decomposition reveals how important a certain shock is for the dynamic behavior of the endogenous variables. The corresponding standard errors are also computed from a Monte Carlo simulation with 5000 replications.

4 Data

The dataset used in this study was collated from a variety of sources. In overview, it consists of office market, financial and economic variables and all variables are observed at an annual frequency over the period 1920-2008, with the exception of the office stock and office completions variables, which are only available from 1951 and 1952, respectively. The different series used are listed in Table 1, along with their definitions and sources.

[Table 1 about here.]

The office market variables include rental growth for office space in the City of London, the office stock and completions for the same geographical area, a measure of office yields that is national in scale until 1980 and specific to the City thereafter, and a construction cost indicator that relates to commercial property in general. Taking the rental series first, this is based on the index produced by Devaney (2010) for years up to 1959 and on data supplied to the authors by CBRE for 1960 onwards. In the latter case, the underlying frequency of the data is quarterly, but an average

[8] As a further robustness check we repeated the calculations using first differences of log completions and log real construction costs instead of log levels. Results were qualitatively unaltered.

of the quarterly figures was taken for each year to make this data consistent with the earlier index, whose values are based on transactions occurring throughout the year in question.[9]

The yield variable is the average initial yield for office buildings that transacted in each year or, from 1980, a valuation based proxy. The pre-1980 data has been compiled by Scott (1996), with the series drawing on earlier work by the surveying firm Allsop & Co for most of the values from 1933 onwards. One drawback with this series is that yields have been rounded to the nearest quarter of one percent. Thus, for consistency, later data on yields was rounded in the same manner. A second drawback is that there are no observations for 1939-1945. To enable use of the methods outlined above, yields had to be interpolated across this period with reference to figures on prime shop yields presented in Crosby (1985).[10] This solution was not particularly satisfactory, but it has little impact on findings for years outside the Second World War period.

An important issue is that the yield series reflects lease structures that do not permit changes in rent to market level on an annual basis. Hence, even if vacancies could be ignored, rental growth would not be equal to income growth. However, the rental growth series can be adjusted in the light of information on typical lease structures during the period. In Devaney (2010), the average length of new office leases up to 1960 is documented as ranging between 5 and 7 years on an unweighted basis and 10 and 12 years on a rent weighted basis. From the 1960s, any longer leases then usually contained either a 5 or 7 year rent review clause. Thus, a five-year moving average of rental growth goes some way to capturing the profile of income growth in an office portfolio, where 20% of leases might be expected to fall due either for renewal or rent review in any one year.

The stock, completions and construction cost variables were included in the dataset in order to examine the reaction of office supply to deviations of actual from fundamental values. From 1960, both stock and completions are based on figures from Development Schedules produced by the City of London Corporation. These figures were sourced indirectly from Barras (1979) in the case of the earlier years; he reproduces official data on completions and the net gain of office space occasioned by new development that together allow withdrawals of space in earlier years to be estimated. For years before 1960, further extrapolation of the stock variable was

[9]Rental growth for one year (1960 itself) had to be interpolated from a third source, a series for London offices recorded in Rose (1985).

[10]This data was rescaled according to the median differential between office and prime shop yields over the period 1920-1938. For three years (1941-1943), no yields were available from any source and so observations were fixed at the 1940 value of 9%.

possible using completions data from Investors Chronicle (1959). This is under the assumption that most new development in these years was on cleared sites.

Meanwhile, construction costs were proxied using the implied deflators from private commercial construction output data (after 1955) or gross fixed capital formation for all non-residential buildings (earlier years). Unfortunately, more specific figures for the office sector alone were not available and neither was data on land costs.

It will be apparent from this discussion that assembling real estate variables on a consistent basis over the long period studied here was difficult. By contrast, in the case of the financial and economic variables, a large amount of previous research has led to long run series being more accessible. The main source used here for such variables was the annual publication on historical investment returns by Barclays Capital (2010). This provided data on the gross redemption yield for UK government bonds, used here as a proxy for the risk free rate of interest. The bonds used to create the series are undated gilts up to the year 1962 and a representative selection of long dated gilts for years after this date. This source also provided data on price changes and dividend yields for UK equities, and a cost of living index that is used as the main measure of the rate of inflation.

Finally, the economic history website www.measuringworth.com provided additional variables, though these were ultimately not used in the final set of models. Such variables included the interest rate on 3 month UK Treasury Bills, a different (but generally consistent) series for redemption yields on long dated gilts, and historical GDP estimates that allowed calculation of GDP growth and a GDP deflator as an alternative measure of inflation.

Summary statistics for the variables are given in Table 2. Panel A of the table presents statistics for all the observations available in each case, which amounts to 89 annual observations for most of the variables, but only 57 in the case of stock growth and the completions ratio, as these are only observed from 1952 onwards. Real series were computed by deflating the relevant nominal figures with the cost of living series. Panel B then shows arithmetic means of the variables in different sub-periods that loosely correspond with different economic environments and which serve to illustrate how the values of the variables have varied over time.

[Table 2 about here.]

Looking first at Panel A, the final column discloses that real office rental growth in the City of London has outstripped real growth in construction costs, but has

been below real growth in GDP. Real rental growth was also more volatile than the other variables, with the exception of real returns for equities. In comparison, the yield variables appear relatively stable, but it should be recognised that even small movements in yields can have large impacts on asset prices. Meanwhile, most of the variables are highly autocorrelated and some exhibit notable skewness, though the latter is partly explained by some variables being bounded at zero (e.g. the initial yield series and the completions ratio).

The arithmetic mean column shows that office yields have, on average, been higher than those for gilts and equities across the whole period. However, these averages mask some substantial changes that occurred over this time frame. For instance, Panel B shows that, in a period of deflation prior to the Second World War, gilt yields were, on average, lower than those for equities and office buildings and they continued to be even with moderate postwar inflation, although the gap between gilt yields and those on other asset types narrowed. These trends are further illustrated in Figure 1, which graphs these three yield series over time.

[Figure 1 about here.]

By the end of the 1950s, though, gilt yields had risen above those on equities and they remained higher throughout the interval 1966-1985, during which time they also rose above those for office property. This switch is not surprising in the light of the sub-period rates of inflation documented in Table 2, which increased the value of investments offering potential income growth relative to those whose cash flows were fixed. As can be seen, over 1966-1985, the average rate of inflation was 9.8% p.a. compared to 3.7% in the previous interval and -0.1% before the war. Yet, in the final sub-period, office yields rose back above those of gilts in a climate of lower inflation, whilst it is also notable that real rental growth in the City market over this interval is absent.

Thus, at a very broad level, it can be seen that changes in yields can be explained in terms of the wider economic environment, but it is not possible to determine from a purely descriptive analysis as to whether episodes of mispricing in the office market occurred and whether or not this led to overinvestment in this sector. This is the subject of the econometric analysis that follows, for which the next section presents empirical results.

5 Empirical results

5.1 Results on informational efficiency

We use ordinary least squares for fitting the VAR to the data. We include the observed multiplier, the rental growth rate, the inflation rate and the gilt interest rate. The estimated VAR includes $p = 1$ lags of x_t.[11]

Table 3 presents the results of the informational efficiency tests for the three different scenorios on the required return rate. In all three cases the estimated VAR model is stable, as indicated by the maximal root below one.

[Table 3 about here.]

The Wald test statistic at the bottom is for the nonlinear restrictions for scenarios (a) (9), (b) (10), and (c) (11), respectively. The null hypothesis of investor rationality and informational efficiency can be rejected for all three scenarios at the 5% significance level. At the 1% level, however, the null hypothesis cannot be rejected for scenario (a). In this scenario, the rental growth rate is discounted at a constant rate and the multiplier is effectively the smoothed future rent growth. Figure 2 shows both series in one graph and it seems that both the multiplier and the current rental growth rate move together.

[Figure 2 about here.]

However, because the rational multiplier is forward-looking, expectations about future rent growth have an impact too. Figure 3 plots the rational multiplier under scenario (a) together with the observed multiplier and it still appears that they move together. The positive correlation coefficient in Table 3 supports this visual appearance. The variation of the observed and the rational multiplier and the variation of the realized return rates are of similar magnitude too, as the standard deviation ratios reveal.

[Figure 3 about here.]

We find, however, scenario (a) to be unappealing. Figure 4 plots the inflation rate, and from this it is obvious that the inflation rate varies a lot over the sample

[11] This is unanimously indicated by the information criteria according to Schwarz and Hannan-Quinn.

period and a constant nominal required return rate would either imply that the real required return rate moves counter-cyclically with the inflation rate or that investors only consider nominal return rates. Regarding the first case, we are not aware of any model of rational investor behavior that could justify such behavior of the real risk premium; regarding the second case, this would point towards irrational money illusion on the investors' side.

[Figure 4 about here.]

The remaining more realistic scenarios for the required return rate both produce very similar outcomes. Again, this is to be expected from the close relationship between the inflation rate and the interest rate, which points towards a constant real risk premium.

Figure 5 plots the misspricing, which is the difference between the observed and the estimated rational multipliers. Because the results for scenarios (b) and (c) are very similar, we do not plot (b).

[Figure 5 about here.]

Given the scenarios considered, we find evidence that London office buildings'prices were informationally inefficient over our sample period. If this informational inefficiency had real effects will be examined next.

5.2 Results on the real effect of mispricing

The effects of the mispricing on the construction sector are analzyed by applying the SVAR procedure described in section 3.3. The construction sector is characterized by the number of office completions per year and the corresponding real construction costs. Figure 6 shows (a) new floor space completed and (b) real construction costs (nominal construction cost deflated by the cost of living index).

[Figure 6 about here.]

We next present our SVAR analysis. The Schwarz criterion and the Hannan-Quinn criterion both suggest a lag length of three for the SVAR model. However, for this lag length a residual Portmanteau test indicates remaining autocorrelation of order four in the residuals. Therefore, we choose a lag length of four.

Figure 7 depicts the impulse response functions to one standard error shocks together with two standard error confidence bands. The upper row shows the response of log completions to shocks to log completions, log real construction cost, rational multiplier and mispricing (scenario (c)). In addition to the effect of own shocks there is a significant positive effect of mispricing on completions after three to four years (1 indicates the contemporaneous effect in the graphs, 2 year one and so on) and a slightly significant effect of shocks to the rational multiplier. Assuming it takes about three years for a building to be completed, this indicates that developers react both positively to the true value and mispricing (difference between observed and rational multiplier) when deciding on new projects. We cannot identify, however, if the effect of mispricing is driven by strategic market timing or because developers are also prone to misperceptions.

The second row shows the responses of log real construction costs to shocks. Own shocks, rational multiplier shocks and mispricing shocks have a significant positive impact on construction costs. The effect of mispricing on construction costs is largest in the first year after the shock occurred. In line with our explanation above, the start of new projects will pull construction cost. Accordingly, mispricing shocks first lead to an increase in construction costs and then to an increase in completions. The third row shows that the rational multiplier is negatively affected by shocks to construction costs and the fourth row reveals that the mispricing term reacts positively to shocks to construction costs. These opposite effects are hard to interpret and might be due to effects of general inflation (which is used to deflate nominal construction costs).

[Figure 7 about here.]

Figure 8 presents the forecast error variance decomposition, which indicates how much of the variance in the endogenous variables can be attributed to the different shocks. It can be seen that fluctuations in completions and construction costs can only be explained to a rather small extent by mispricing (fourth column). On the other hand, shocks to construction costs explain a substantial share (about 40%) of the variance of the rational multiplier and the mispricing term.

[Figure 8 about here.]

The analysis indicates that mispricing has real effects. Both completions and construction costs are affected by deviations of actual building prices from their

corresponding present values. However, these effects are small in the sense that they can only account for a small share in the variance of completions and construction costs. Therefore, whereas these effects are statistically important, their economic importance might be negligible.

6 Conclusion

The analysis of the London office multiplier series and the corresponding rent series indicates that prices were not informationally efficient over the period of study. Because we had to make specific assumptions on the required return rate, the results have to be qualified insofar that the assumption of a constant nominal required return rate does not allow the rejection of the hypothesis of an informationally efficient market at the one percent level but at the five percent level. However, given the periods of high inflation, this assumption does not have much economic appeal to us. We favor the assumption of a required return rate equal to the gilt interest rate plus a constant real risk premium. With this scenario we can reject the assumption of an informationally efficient market at the 1 percent level.

We then examine if mispricing has real effects and find that both the rational multiplier and mispricing have an effect. It is known from the corporate investment literature that company managers can react to mispricing even if they know that the market price does not represent the true value of companies investment opportunities. However, it is difficult to separate such rational responses to mispricing from the wrong perception of the true value of investment on managers side. The same applies to our case: developers might react positively to mispricing because they want to exploit extra profit opportunities or simply because they have the wrong perception of the long-run value of their investments. This aspect certainly needs further analysis.

Future work should consider the influence of the equity market on the required return rate (an aspect currently ignored), thereby extending the number of scenarios. Further, if this extended analysis leaves the outcomes on informational efficiency unaffected, an investigation into investors' misconception will be required. We assume that the role of inflation will be important here.

A Appendix

An appendix including additional impulse response figures for szenario (a) and (c) is avaible upon request.

References

Baker, M., Stein, J. C. and Wurgler, J.: 2003, When does the market matter? stock prices and the investment of equity-dependent firms, *Quarterly Journal of Economics* **118**, 969–1005.

Barclays Capital: 2010, *Equity Gilt Study 2010*, Barclays Capital, London.

Barras, R.: 1979, *The Development Cycle in the City of London*, Research Series 36, Centre for Environmental Studies, London.

Blanchard, O., Rhee, C. and Summers, L.: 1993, The stock market, profit, and investment, *Quarterly Journal of Economics* **108**, 115–136.

Campbell, J. Y., Lo, A. W. and MacKinlay, A. C.: 1997, *The Econometrics of Financial Markets*, Princeton University Press, Princeton, New Jersey.

Campbell, J. Y. and Shiller, R. J.: 1988, The dividend-price ratio and expectations of future dividends and discount factors, *Review of Financial Studies* **1**, 195–228.

Chen, J., Hudson-Wilson, S. and Nordby, H.: 2004, Real Estate Pricing: Spreads and Sensibilities: Why Real Estate Pricing is Rational, *Journal of Real Estate Portfolio Management* **10**, 1–21.

Chirinko, R. S. and Schaller, H.: 2001, Business fixed investment and "bubbles": The Japanese case, *American Economic Review* **91**, 663–680.

Clayton, J., Ling, D. C. and Naranjo, A.: 2009, Commercial Real Estate Valuation: Fundamentals Versus Investor Sentiment, *Journal of Real Estate Finance and Economics* **38**, 5–37.

Crosby, N.: 1985, *The Application of Equated Yield and Real Value Approaches to the Market Valuation of Commercial Property Investments*, PhD thesis, University of Reading.

Cuthbertson, K. and Nitzsche, D.: 2004, *Quantitative Financial Economics: Stocks, Bonds & Foreign Exchange*, second edn, John Wiley & Sons, Chichester.

Devaney, S.: 2010, Trends in office rents in the City of London: 1867-1959, *Explorations in Economic History* **47**, 198-212.

Fama, E. F.: 1970, Efficient capital markets: A review of theory and empirical work, *Journal of Finance* **25**, 383–417.

Geltner, D.: 1993, Estimating Market Values from Appraised Values without Assuming an Efficient Market, *Journal of Real Estate Research* **8**, 325–345.

Hendershott, P. H., Hendershott, R. J. and MacGregor, B. D.: 2006, Evidence on Rationality in Commercial Property Markets: An Interpretation and Critique, *Journal of Real Estate Literature* **14**, 149–172.

Hendershott, P. H. and MacGregor, B. D.: 2005a, Investor Rationality: An Analysis of NCREIF Commercial Property Data, *Journal of Real Estate Research* **27**, 445–475.

Hendershott, P. H. and MacGregor, B. D.: 2005b, Investor Rationality: Evidence from U.K. Property Capitalisation Rates, *Real Estate Economics* **33**, 299–322.

Investors Chronicle: 1959, The Worlds Greatest Office Centre, *Investors Chronicle*, March 27th, 1097.

McGough, T. and Tsolacos, S.: 2001, *Do Yields Reflect Property Market Fundamentals?*, Real Estate Finance and Investment Research Paper No. 2001.01, City University Business School, London.

Pesaran, M. H. and Shin, Y.: 1998, Impulse Response Analysis in Linear Multivariate Models, *Economics Letters* **58**, 17–29.

Rose, J.: 1985, *The Dynamics of Urban Property Development*, E & FN Spon, London.

Scott, P.: 1996, *The Property Masters: a History of the British Commercial Property Sector*, E & FN Spon, London.

Sefton, J. and Weale, M.: 1995, *Reconciliation of National Income and Expenditure: Balanced Estimates of National Income for the United Kingdom, 1920-1990*, Cambridge University Press, Cambridge.

Sivitanides, P., Southard, J., Torto, R. G. and Wheaton, W. C.: 2001, The Determinants of Appraisal-Based Capitalization Rates, *Real Estate Finance* **18**, 27–37.

Stein, J. C.: 1996, Rational capital budgeting in an irrational world, *Journal of Business* **69**, 429–455.

Summers, L. H.: 1986, Does the stock market rationally reflect fundamental values?, *Journal of Finance* **41**, 591–601.

Figure 1: Investment yields.

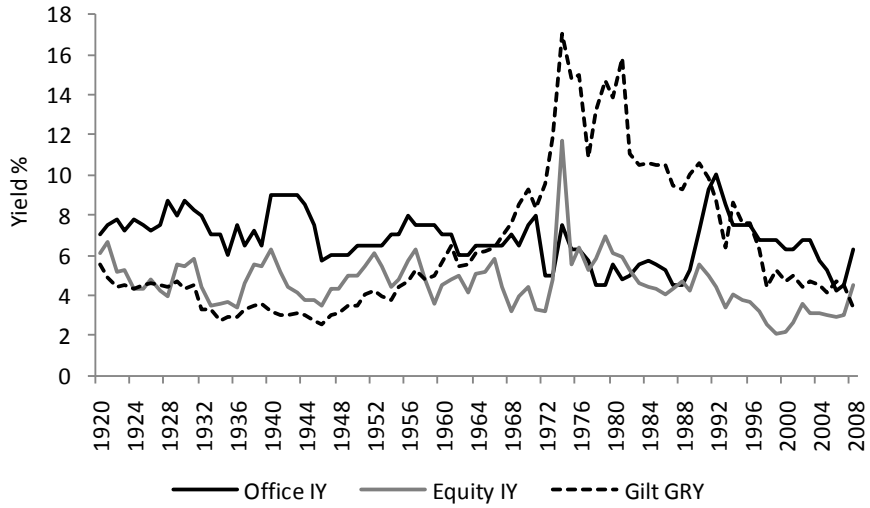


Figure 2: Log multiplier (right scale) and office rent growth rate (difference of log office rent, left scale).

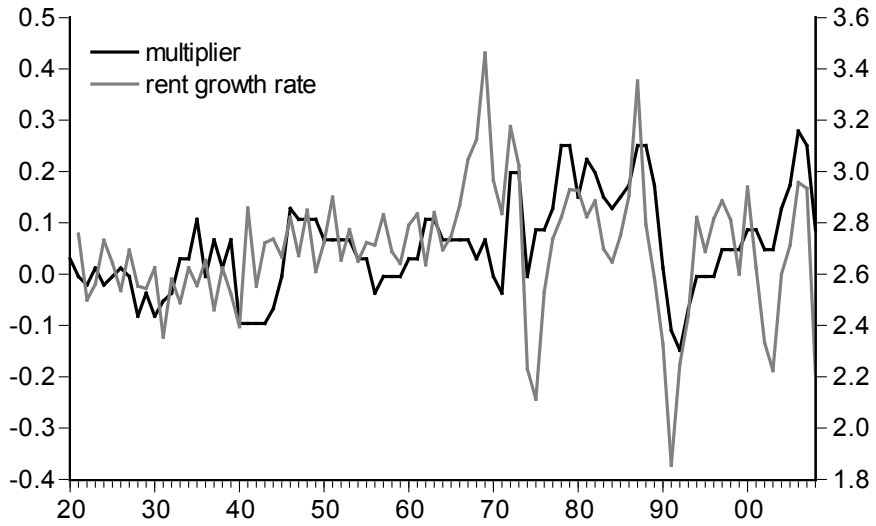


Figure 3: Observed and simulated multipliers, scenario (a): required return is constant, scenario (c): required return rate equals the nominal interest rate), series are demeaned.

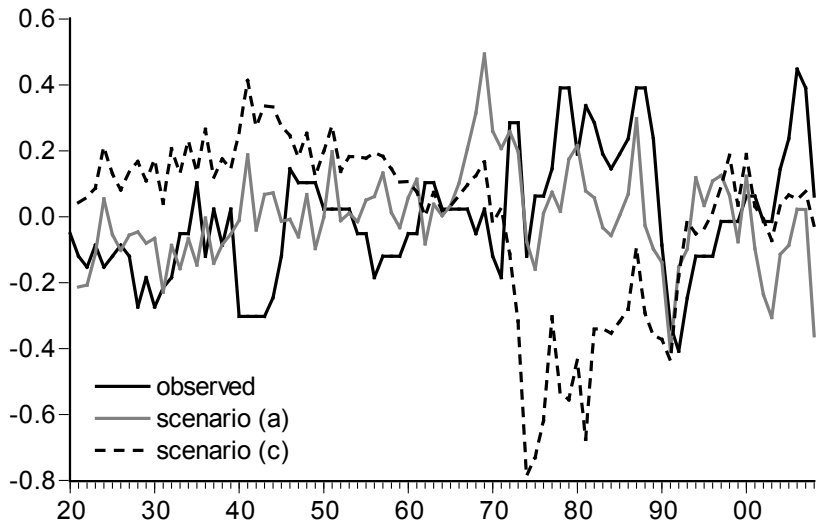


Figure 4: Interest rate (gilt yield) and inflation rate.

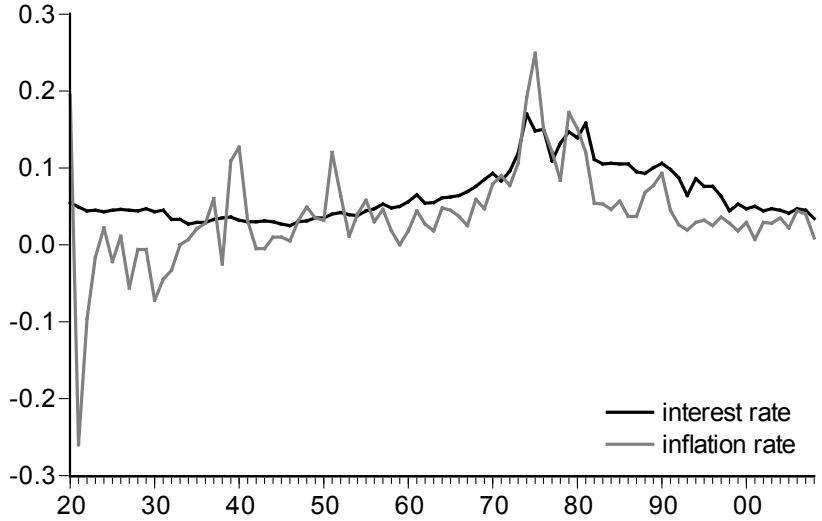


Figure 5: Mispricing (difference between observed and simulated multipliers, scenario (a): required return is constant, scenario (c): required return rate equals the nominal interest rate).

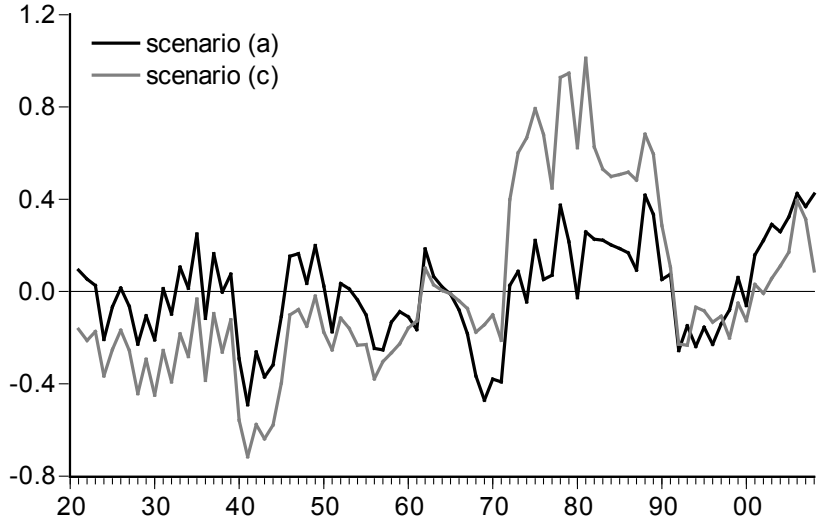
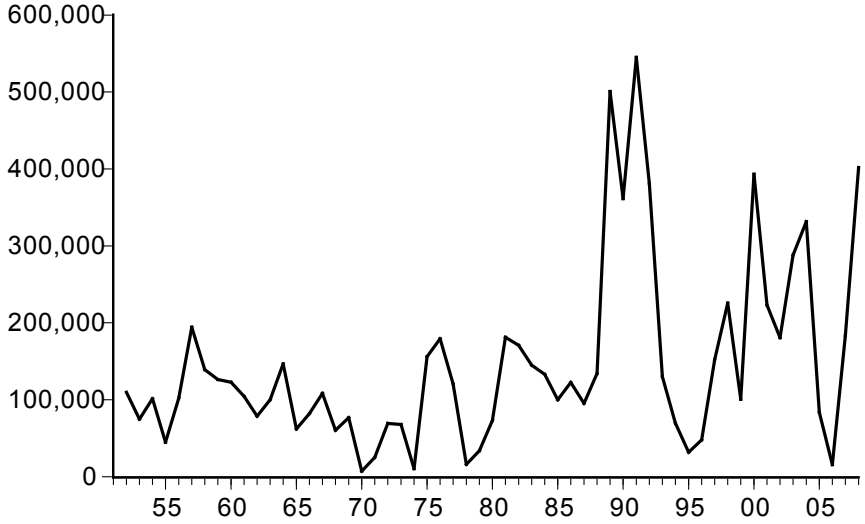


Figure 6: (a) New completions and (b) real construction costs.

(a)



(b)

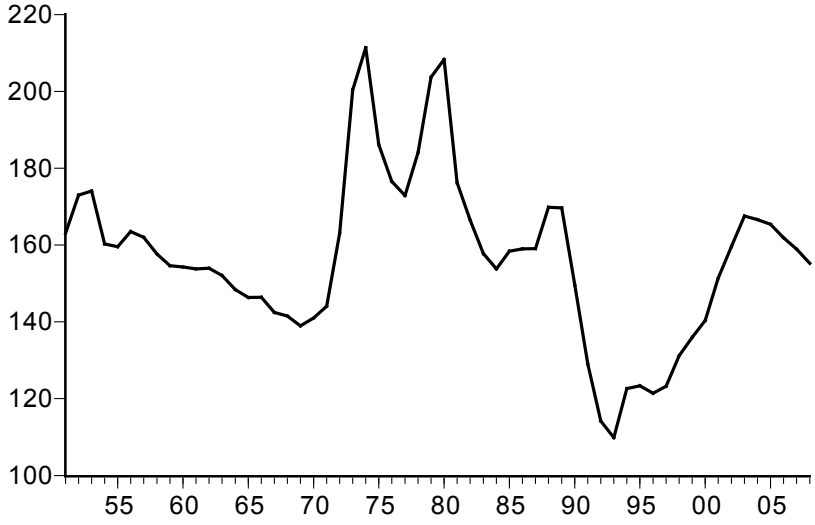


Figure 7: Impulse responses (scenario (c), completions (*compl*) and real construction costs (*cost*) in log levels, log rational multiplier (*msim*) and mispricing (*misp*), recursive identification scheme).

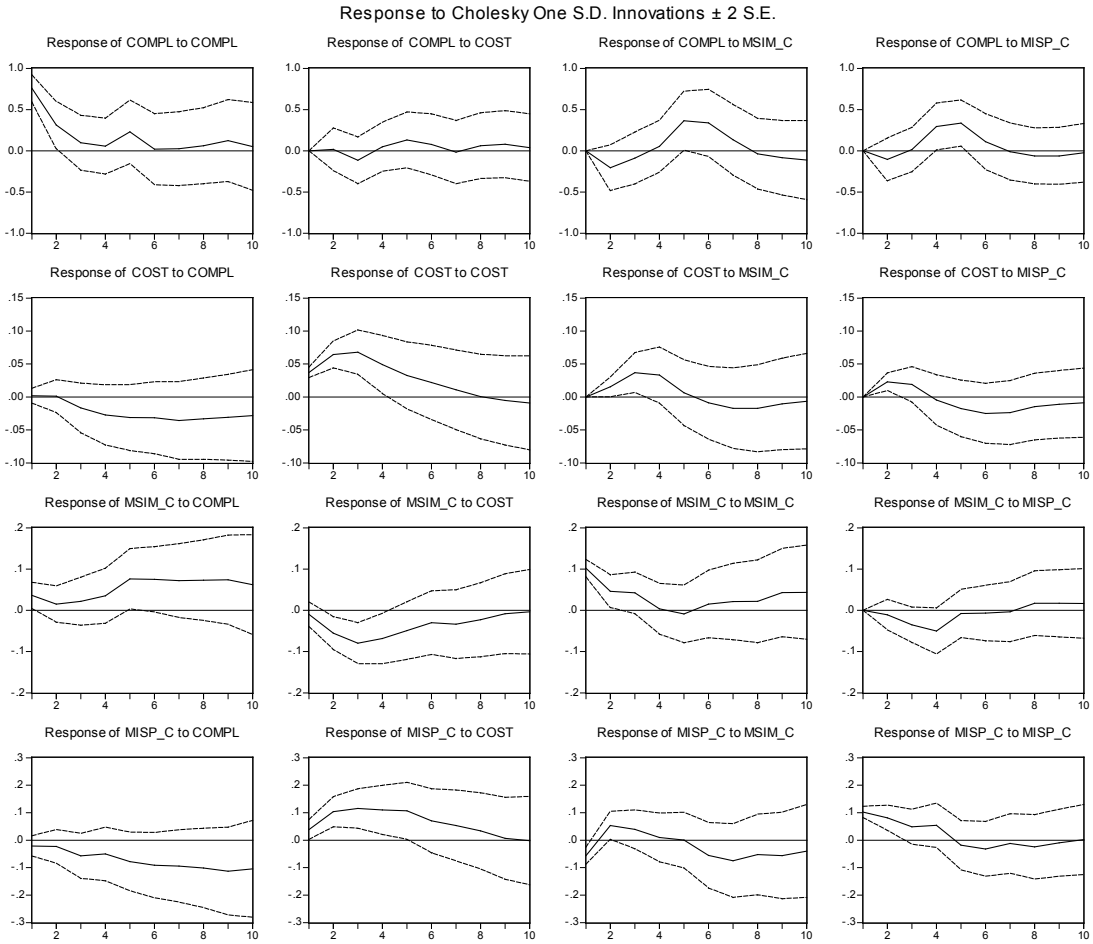


Figure 8: Forecast error variance decompositions (scenario (c), completions (*compl*) and real construction costs (*cost*) in log levels, log rational multiplier (*msim*) and mispricing (*misp*), recursive identification scheme).

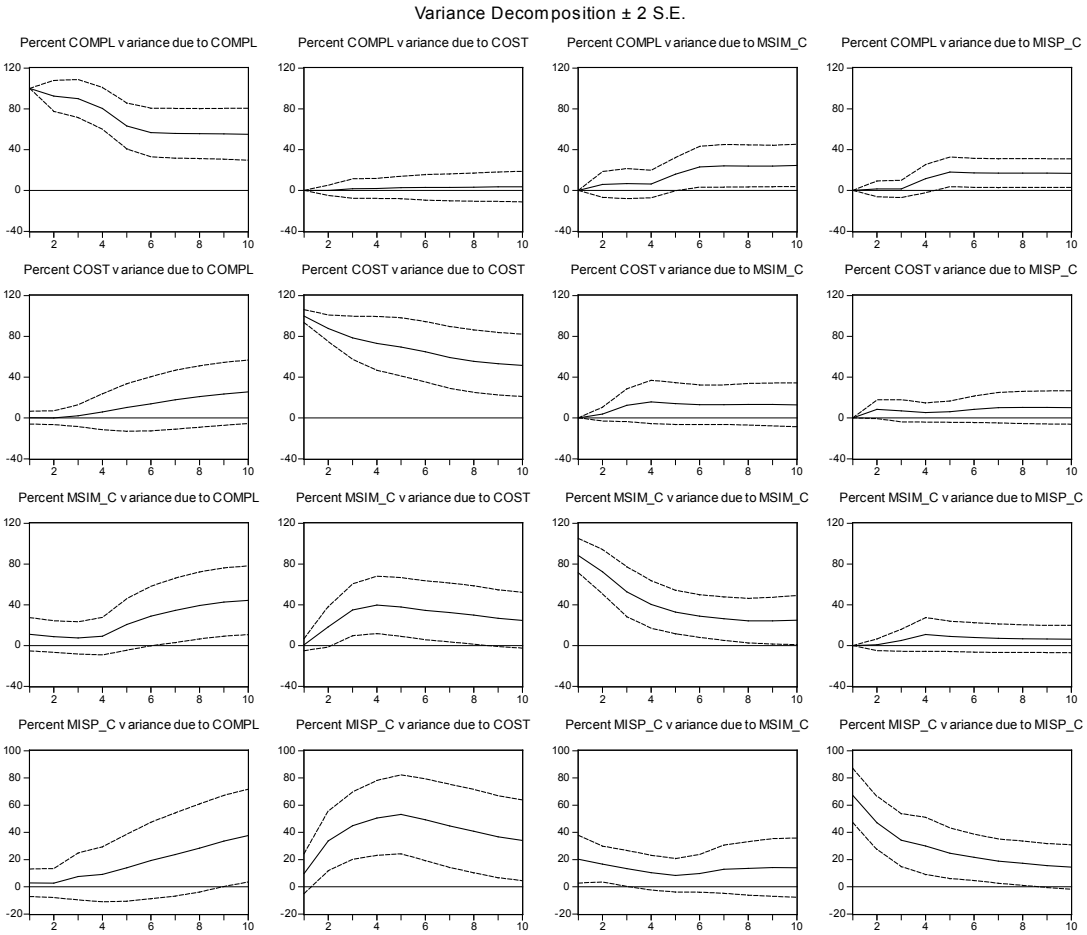


Table 1: List of variables in dataset.

Variable	Description of variable	Sources
Panel A: Office market variables		
Completions	Gross floorspace of offices completed during year in sq m.	Investors Chronicle (1959), Barras (1979), City of London Corporation
Construction Cost	Implied deflator from non-residential gross fixed capital formation and then (from 1955) private commercial construction output.	Sefton & Weale (1995), ONS
Initial yield	Current rent / price. To 1980: (net) yield for offices transacted in year. Post 1980: yield from portfolio appraisals, net of ground rent but not other costs.	Scott (1996), IPD
Rental growth	% change in market rent for new office space. To 1959: based on actual lettings. Post 1959: based on judgemental assessment of transaction evidence.	Devaney (2010), Rose (1985), CBRE
Stock	Total gross floorspace of offices in sq m. To 1981: extrapolated based on completions and net gain figures. Post 1981: direct estimates.	Author calculations, City of London Corporation
Panel B: Financial and economic variables		
Equity return	Computed as equity price change over year plus income yield at year end.	Author calculations, Barclays Capital (2010)
Equity yield	Dividend income / price.	Barclays Capital (2010)
GDP growth	% change in nominal GDP from year to year.	measuringworth.com
GDP deflator	First calculated as nominal GDP / real GDP x 100. Change in this index then computed.	measuringworth.com
Gilt yield	Gross redemption yield on representative portfolio of UK government gilts.	Barclays Capital (2010)
Inflation	% change in retail price index ultimately sourced from ONS.	Barclays Capital (2010)
T Bill rate	Interest rate on three month UK Treasury Bills.	measuringworth.com

Table 2: Summary statistics for variables in dataset.

Panel A: Statistics for all observations							
	Arithmetic mean	Standard deviation	Minimum	Maximum	Skewness	First order autocorr.	Geometric mean
Real rent growth	2.3	13.2	-38.9	46.1	0.27	0.44	1.4
Stock growth#	1.1	2.0	-3.9	6.3	-0.09	0.51	1.0
Completions (as % of stock)#	2.4	1.8	0.1	8.3	1.55	0.51	n/a
Real c cost gr.	0.7	6.5	-15.4	22.9	0.26	0.43	0.5
Real GDP growth	2.7	3.5	-8.9	16.9	0.50	-0.01	2.6
Real eq. returns	7.9	20.7	-52.7	93.6	0.52	-0.08	5.9
Inflation	3.9	6.4	-26.0	24.9	-0.39	0.48	3.7
Office initial yield	6.8	1.2	4.3	10.0	0.09	0.76	n/a
Equity initial yield	4.6	1.3	2.1	11.7	1.78	0.54	n/a
Treasury Bill rate	5.2	3.7	0.5	15.1	0.70	0.93	n/a
Gilt GRY	6.4	3.5	2.5	17.0	1.22	0.94	n/a
Gilt real GRY	2.7	5.8	-11.7	41.8	3.32	0.18	n/a

Panel B: Sub-period arithmetic means				
	1920-1945	1946-1965	1966-1985	1986-2000
Real rent growth	1.9	3.9	3.9	0.0
Stock growth#	-	2.1	0.7	0.8
Completions (as % of stock)#	-	2.3	1.6	3.2
Real c cost gr.	1.8	0.0	0.7	0.1
Real GDP growth	2.9	2.9	2.3	2.6
Real eq. returns	8.0	7.6	9.8	6.4
Inflation	-0.1	3.7	9.8	3.5
Office initial yield	7.7	6.7	5.9	6.5
Equity initial yield	4.7	4.9	5.3	3.6
Treasury Bill rate	2.3	3.0	9.3	6.9
Gilt GRY	3.8	4.6	11.3	6.7
Gilt real GRY	4.6	0.9	1.5	3.1

observed over 1952-2008

Table 3: Tests of investor rationality. Realized return rates are computed according to (4), using either the observed or the rational multiplier.

	Scenario		
	(a)	(b)	(c)
VAR lag length	1	1	1
Max. AR root	0.9380	0.9380	0.9380
Std. dev. ratio of observed and rational multiplier	1.2990	0.7277	0.7337
Std. dev. ratio of observed and rational return rate	0.9810	1.1259	1.1218
Correlation between observed and rational multiplier	0.2282	−0.5326	−0.4476
Correlation between observed and rational return rate	0.7091	0.5440	0.6041
Wald Test Statistic	11.0531	18.4391	16.9955
p-value	0.0260	0.0010	0.0019