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ABSTRACT

Rental adjustment equations have been estimated for a quarter century. In the U.S., models have used the deviation of the actual vacancy rate from the natural rate as the main explanatory variable, while in the UK, drivers of the demand for space have dominated the estimation. The recent papers of Hendershott (1996) and Hendershott, Lizieri and Matysiak (HLM, 1999) fall into the former category. We re-estimate these equations using alternative formulations but can do little to improve them overall. However, we identify econometric concerns with the specifications.

We then derive a model incorporating both supply and demand factors within an Error Correction framework, and show how the U.S. and UK traditions are special cases of this more general formulation. We next estimate this equation using data from the City of London office market. Our initial specification of this more generalized model is greatly superior to the vacancy rate model. Finally, we estimate a two-equation variant with a separate vacancy rate equation; this model also performs much better than that of HLM. Importantly, our model passes standard modern econometric requirements for unit roots and co-integration. We find little evidence of special or temporal variation in natural vacancy rates.

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Estimating the Rental Adjustment Process

1. Introduction

Rental adjustment equations have been estimated for a quarter century. The primary focus in U.S. research has been adjustments to deviations of the vacancy rate from the natural or equilibrium rate. Not surprising given this focus, significant emphasis has been directed towards how or whether the natural rate varies spatially or temporally. Given the greater tendency of office markets toward overbuilding and thus to wider swings in office than in retail, industrial or residential vacancy rates, it is also not surprising that most research has been directed to this property type.

Over time, U.S. researchers have begun to realize that the simple vacancy rate model is inadequate and that more structure is needed. The current state of the art was illustrated recently in the Hendershott, Lizieri and Matysiak (1999) -- hereafter HLM -- study of the London office market. U.K. researchers, on the other hand, have estimated reduced form demand-supply equations, finding drivers of the demand for space, in particular, to be important determinants of real rents. While this gives added structure, it seems inappropriate to give up the obvious explanatory power of the vacancy rate.

In section 2, we review the key literature on rental adjustment models based on the vacancy rate. In section 3, we consider the addition of the deviation of actual rent from equilibrium rent term in earlier studies of the London and Sydney markets, and in section 4, we test alternative specifications to improve the HLM model. We derive an Error Correction Model (ECM) for rental adjustment in section 5. This model requires estimating a long run rent equation from the underlying supply and demand for space and a difference equation including the error from the long run equation as a regressor. In section 6, we estimate this model using the HLM London data. While the vacancy rate (and the supply of occupied space) is a key component of the equation, financial and business services employment is even more important. Further, the explanatory power of this equation is far greater than that of the HLM equation, reducing the unexplained variance by 30 percent.

2. Estimation of Vacancy Rate Models

Rental adjustment equations, linking rental change in real rents to deviations in the vacancy rate from the equilibrium or natural vacancy rate, are a well-established part of the modeling of property markets.[1] This approach has its origins in labor economics, where real wage inflation has been related to deviations of the employment rate from the natural or full employment rate. Possible application to the rental housing market was first noted by Blank and Winnick (1953).

The basic relationship may be written as:

$$\%\Delta R_t = \lambda(v^* - v_{t-1}) \qquad (1)$$

where: $\%\Delta R$ is the percentage change in real rents; v^* is the natural vacancy rate; v_{t-1} is the lagged vacancy rate; and λ is the adjustment factor. In the estimation v^* is calculated from the constant in the regression. Smith (1974) was the first to provide empirical support for the vacancy rate model. Using data from five Canadian cities, he regressed the rate of change in rents on the vacancy rate, lagged vacancy rate, and the current and lagged rate of change in property taxes. The vacancy rate and its lagged value were usually significant but the impact of tax changes was less clear.

Eubank and Sirmans (1979) added $\Delta OE_t/OE_{t-1}$, the rate of change in operating expenses, to the model to capture cross-section variation in these. They consider four U.S. cities and four apartment building types in each city. Overall, the vacancy rate variables worked poorly and the operating expenses worked well. The authors use nominal data but state in a footnote that estimations using real data produce 'substantially unchanged' results. In contrast, Rosen and Smith (1983), also using nominal

[1] For full reviews of the early literature, see Eubank and Sirmans (1979), Rosen and Smith (1983) and Shilling *et. al.* (1987).

data, find vacancy rates, and not operating expenses, to be the important explanatory variable. They then estimate a pooled model for their 17 U.S. cities with fixed city effects. In the pooled estimation, all three variables were significant. Their estimates of natural vacancy rates by city vary from six to over 23 percent, certainly an implausible range. Using real housing rents, Gabriel and Nothaft (1988), investigating 16 cities over the shorter 1981-85 time frame, obtain a more reasonable natural vacancy rate range of four to ten percent.[2]

Shilling, Sirmans and Corgel (1987) consider office markets and also employ the pooled approach for 17 U.S. cities. They use *real* values for current rental change and current change in operating expense and estimate the city natural vacancy rates. The expenses variable is significant in only four cities and the vacancy rate is in 11 (at the 10 percent significance level). Here, too, the variation in natural vacancy rates is implausible, ranging from one to 21 percent.

The natural vacancy rate can vary across time as well as space. Wheaton and Torto (1988) use real rents and estimate the basic model (with the current vacancy rate but without operating expenses) for the US office market over the period 1968-86. They introduce a linear trend to accommodate a hypothesized rise in the natural rate, and estimate a six percentage point rise, which they attribute to the spatial expansion of office centers, the broader base of tenants, increases in tenant turnover and a shortening of the average length of lease. Although this formulation results in a better fit, the six point rise is implausibly large and is clearly period specific; their data cover a cycle and a half, with the vacancy rate starting at four percent and ending at 18 percent. The linear trend increase arguably reflects the overbuilding associated with government mismanagement of the 'saving and loan' problem (Hendershott and Kane, 1992), rather than the factors Wheaton and Torto suggest.

Grenadier (1995), building on Voith and Crone (1988), analyzes office vacancy rates directly, using semiannual data for 20 cities over the period 1960-91. Variances in individual city vacancy rates are decomposed into a common time-varying component and city-specific fixed effects. City-specific persistence terms are also included to allow for lagged adjustment toward equilibrium.

Grenadier's estimates a statistically significant common time varying component, but the magnitude is minor, a rise from the mid1970s of less than a full percentage point. This is the magnitude of increase that the factors Wheaton and Torto identify would reasonably explain. Grenadier also estimates a

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[2] Gabriel and Nothaft have a second estimation in which the natural vacancy rate is treated as endogenous, being related to such factors as the growth in rental units and population and the level and dispersion of rents in the city. Here the range in average natural vacancy rates is 7 to 12 percent.

wide variance in city natural vacancy rates. Excluding Houston and Dallas, whose high rates are almost certainly attributable to the saving and loan problem, the rates vary from two to twelve percent. This ten point variation, while still surprisingly large, is more plausible than a twenty point variation.

3. Equilibrium Rents

The basic vacancy rate model is fundamentally deficient for two reasons. First, equilibrium real rents are unspecified and can, if fact, end up anywhere depending only on the pattern of past shocks. Second, there is no role for shocks during the current period; only those reflected in the beginning period vacancy rate matter.

Consider a market starting in full equilibrium being hit with a supply shock that raises the vacancy rate above the natural rate. Over time, demand for space grows, returning the vacancy rate to the natural rate. During the period the vacancy rate is above the natural rate, the model suggests a monotonic decline in real rents. Thus, when the vacancy rate returns to the natural rate, real rents will be far below their initial, presumably unchanged, equilibrium value. The only way the model can get real rents back to equilibrium is for the vacancy rate to overshoot the natural rate, and there is no obvious mechanism for this.

In full equilibrium, the vacancy rate will equal the natural rate, real rent will be at its equilibrium level, capital values will equal replacement costs and little development will take place. If vacancies fall below the natural rate, real rents will rise above their equilibrium level and induce development that will continue until vacancies *and* real rents return to equilibrium. Similarly, if the vacancy rate rises above the natural rate, rents will fall below their equilibrium level and development will stop until demand and rents increase and the vacancy rate falls.

Hendershott (1996) proposed and estimated a model for Sydney that both allows a more general rental adjustment path and constrains rents to return to their equilibrium level:

$$\%\Delta R_t = \lambda(v^* - v_{t-1}) + \beta(R_t^* - R_{t-1}) \qquad (2)$$

where $\%\Delta R_t$ is the percentage change in real effective rents and R_t^* is the time varying equilibrium (natural) real rent. HLM (1999) estimate the same equation for London.[3] The equilibrium rent in

[3] Both Hendershott (1996) and HML adjust headline rents to take account of letting incentives and use the GDP deflator to convert to real rents. The HLM model has equations for completions, net absorption and rental adjustment). Here we concentrate solely on the rental adjustment equation.

equation (3), R^*, is the user cost of capital -- the product of replacement cost and the sum of the real interest rate (from the capital market), the depreciation rate (δ) and the operating expense rate (θ). Thus, the identity is:

$$R_t^* = (r_t + RP + \delta + \theta)RC \qquad (3)$$

where r_t is real risk-free interest rate, *RP* is the risk premium and *RC* is replacement cost. In practice, equilibrium rent varies only with the long-term real default-free rate; *RP*, δ, θ and *RC* are taken to be constant.[4] For Sydney, Hendershott uses 3% for *RP,* 2.5% for δ, and 5% for θ. For London, HLM set these parameters at 2%, 2%, and 1.5%, respectively. The large difference in the operating expense ratio is due to the fact that tenants pay many of these expenses directly in the UK (the full insuring and repairing lease) but not in Australia.

In both studies the nominal default-free rate was taken to be a long-term Treasury rate and the expected inflation rate was calculated as a simple average of the rate of change in the GDP deflator in the current and two previous years. Unfortunately, this led to substantially negative estimates of the real default-free Treasury rate during the middle 1970s. In the later London study, the negative real default-free interest rates were truncated -- this real rate being set at the maximum of the calculated rate and one per cent -- whereas in the Sydney study they were not. The source of the negative rates is clearly the OPEC oil shock. In the UK, inflation leapt from 8 percent in 1973 to 19 percent in 1974 and 26 percent in 1975, before receding to 9 percent in 1976. To build this surge in inflation into long-term expected inflation estimates requires one to presume that investors believed that oil prices were going to continue *rising* at the 1974-75 rate over the next decade. Because this is implausible, the London truncation seems quite reasonable.

Setting *RC* is more difficult. In both studies, the authors determine *RC* by selecting a year in which actual and equilibrium rents are likely to have been equal (1986 and 1983, respectively, in Sydney and London), substituting actual rent for equilibrium rent in equation (3), and solving. The real value of *RC* is assumed to be constant over time. Given that replacement cost must include real land costs, this assumption is rather strong.[5]

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[4] The depreciation rate is likely to vary with the building cycle, older buildings being discarded at a more rapid rate when property is overbuilt, and the risk premium is also likely to be time-varying, with the premium growing when property markets are weak. Measuring these variations empirically is a nontrivial task.

[5] In U.S. cities, with relatively available land supply and possible long-term rental growth in land values of zero, this may not be a problem. In contrast, in a constrained market with strong planning controls, there may be an upward trend in land costs that should be in the cost of capital (equ 3).

4. A Closer Look at the Estimation

The results for Sydney and London are reproduced in Table 1. The coefficients have the expected signs and are significant. The implied natural vacancy rates for the two markets are 6.4 and 7.1 per cent, respectively, i.e., there is trivial difference. To make the estimates more comparable, the Sydney equations are re-estimated with the real interest rate set at the maximum of the calculated rate and one percent, as was done in the London study. This adjustment improves the fit, raising the adjusted R^2 above that of the London model and producing a natural vacancy rate of 5.1 percent (see Table 1, Sydney equation (a)).

The HLM formulation resembles an Error Correction Model (ECM) in that rents are specified as adjusting to the difference between long run and actual rents. But, rather than estimating a long-run relationship, they define it as equation (3). As an alternative, we relate actual rents to the primary driver of equilibrium rents, their estimate of the real default-free Treasury rate, and a constant to reflect the risk, depreciation and expense parameters. Unfortunately, the equation has *zero* explanatory power. Of course this may be partially due to our short estimation period and lags in the relationship. This raises the possibility that the explanatory power of the rent gap variable comes entirely from the lagged rental rate. To test this, we break the $R_t^* - R_{t-1}$ variable into its two components. Table 1 presents the results for Sydney (using the original data – equation (b) – and the recalculated equilibrium rent – equation (c)) and London. In all cases, both components are statistically significant with their expected signs and are not significantly different in absolute value. Real rents do seem to be reverting toward a level driven by the real default-free interest rate. (Because rents are an index, the magnitudes of the coefficients do not indicate the speed of reversion.) Nonetheless, the fact that no statistical relationship exists between actual rents and the estimate of equilibrium rents is disturbing.

There is a further concern with this specification. The dependent variable is integrated of order zero (I(0)) while both explanatory variables are I(1) (see Table A1). Moreover, the evidence for a co-integrating relationship is weak and the single vector that can be determined has incorrectly signed coefficients (using the Johansen cointegration test within *Eviews* a cointegrating relationship cannot be detected with a one period lag on the first difference in the VAR but appears with two lags).

Table 1: London and Sydney rental adjustment equations

	Sydney				London	
	Original model	Re-estimated model (a)	Re-estimated model (b)	Re-estimated model (c)	Original model	Re-estimated model
Constant	0.112	0.139	0.409	0.282	0.201	0.0945
	(0.033)	(0.029)	(0.097)	(0.12)	(0.046)	(0.16)
v_{t-1}	-1.76	-2.71	-2.53	-2.89	-2.83	-2.87
	(0.46)	(0.42)	(0.49)	(0.44)	(0.54)	(0.55)
$R_t^*-R_{t-1}$	2.57	3.85			3.72	
	(0.61)	(0.71)			(0.57)	
R_t^*			1.86	2.86		4.68
			(0.78)	(1.07)		(1.47)
R_{t-1}			-3.64	-3.76		-3.45
			(0.72)	(0.70)		(0.69)
Adj-R^2	61%	71%	70%	71%	69%	68%
DW	1.87	1.92	2.04	2.09	1.61	1.69
v*	6.4%	5.1%	16.1%	9.8%	7.1%	3.3%

Notes: standard errors are in brackets; DW is the Durbin-Watson statistic; original models were re-estimated and validated from original data sets and rescaled for comparison; Sydney models (a) and (c) are based on a lower bound of 1% for the default free real rate.

5. An Expanded Formulation

As an alternative to the rental adjustment models discussed above, we derive an estimation equation from the occupied space market. Market clearing directly gives us a long run relationship between real rent and the underlying supply and demand for space. The short-run relationship is a difference equation of the long run, including the lagged error from the long run equation as a regressor.

Let the demand for space be a function of rent (*R*) and employment (*E*):

$$D = \lambda_0 R^{\lambda_1} E^{\lambda_2} \tag{4}$$

where the λ_i are constants (the 'price' elasticity being negative and the 'income' elasticity being positive). The market clearing rent for a given level of vacancy is that which solves

$$D(R, E) = (1-v)SU \tag{5}$$

where *SU* is supply and *v* is the vacancy rate. Substituting equation (4) in (5) and solving for R

$$R = \gamma_0 E^{\gamma_1}[(1-v)SU]^{\gamma_2}\,. \tag{6}$$

The underlying elasticities are obtained as $\lambda_1 = 1/\gamma_2$ and $\lambda_2 = -\gamma_1/\gamma_2$. Taking logs of both sides of equation (6) gives:

$$\ln R = \ln\gamma_0 + \gamma_1 \ln E + \gamma_2 \ln(1-v) + \gamma_2 \ln SU \tag{7}$$

The coefficients on the vacancy rate and supply variables should not differ.

This type of equation, without the vacancy rate, has been estimated mainly by UK researchers. Demand drivers used in the literature include retail sales, consumer expenditure, financial and business services output and employment, manufacturing output and employment and GDP, depending on the property type under consideration. These variables are typically highly significant. In contrast, decent quality supply and vacancy data are rarely available. Some studies use construction orders (a flow variable) rather than a stock, some use proxy variables and some omit supply altogether. Most studies that test supply proxies find them to be insignificant. Vacancy rate data are even more difficult to obtain in Europe, and we know of no estimation of a variant of equation (8) that uses vacancy rates.

The residual in the estimation of equation (7) is

$$u_t = \ln R_t - \hat{\beta}_0 - \hat{\gamma}_1 \ln E_t - \hat{\gamma}_2 \ln[(1-v_t)SU_t], \tag{8}$$

the difference between the observed and the estimated long run value. If the levels variables are integrated of order one (I(1)) and are co-integrated, this error is stationary and its lagged value can be used in a short run dynamic model as an adjustment process.[6]

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[6] Formally:

A series with no deterministic trend and which has a stationary and invertible autoregressive moving average (ARMA) representation after differencing d times, but which is not stationary after differencing *d*-1 times, is said to be integrated of order *d*.

The components of a vector $\boldsymbol{x}_t$ are said to be co-integrated of order *d, b,* if $\boldsymbol{x}_t$ is *I(d)* and there exists a non zero vector $\boldsymbol{\alpha}$ such that $\boldsymbol{\alpha}^T\boldsymbol{x}_t$ is *I(d-b)*, *d*>=*b*>0. The vector $\boldsymbol{\alpha}$ is called the co-integrating vector.

In our models, we are looking for co-integrating relationships among variables that are individually integrated of order one, so the deviation from the equilibrium relationship is integrated of order zero, that is, it is stationary. (Banerjee *et al.*, 1993)

The short run model is a difference equation with an Error Correction term, namely the lagged error described by equation (9):

$$\Delta \ln R_t = \alpha_0 + \alpha_1 \Delta \ln E_t + \alpha_2 \Delta \ln[(1 - v_t)SU_t] + \alpha_3 u_{t-1} \tag{9}$$

Thus, rent adjusts to short run changes in the causal variables and also to lagged market imbalances, measured by deviations from the long run equilibrium. In the estimations, it is expected that α_0 will be approximately zero, α_1 will be positive, and α_2 and α_3 will be negative. $\alpha_3 = -1$ means complete or full adjustment.

A problem with this structure is that the vacancy rate is an endogenous variable; both it and rent operate to 'clear' the space market [equation (5)].[7] In effect, we have a two-equation model. To explain the vacancy rate, we first tested an analogue to equation (3), using the gaps between the natural and lagged vacancy rate and equilibrium and lagged rents. While tracking the general directional movement in the vacancy rate, this was very poor at estimating the magnitudes of changes to the vacancy rate. Regressions of the vacancy rate on lagged values were then estimated in the spirit of Grenadier (1995), with much greater success. The best fitting relationship is

$$\underset{}{v_t} = \underset{(0.68)}{0.95} + \underset{(0.22)}{1.84 v_{t-1}} - \underset{(0.36)}{1.38 v_{t-2}} + \underset{(0.21)}{0.42 v_{t-3}} \tag{10}$$

The adjusted R^2 is 0.90, and the equation standard error is 1.62. This AR(3) process allows for both persistence and time variation in the natural vacancy rate. We use the predicted rate from this equation in explanations of real rental changes.

6. Estimations of the new model

The series used are all I(1), and for all the equations estimated there exists a co-integrating vector with correctly signed coefficients (see the Appendix). Table 2 presents the results of our estimations. There are four basic models: two using the actual vacancy rate and two using our predicted rate. In each case there are versions with supply and vacancy rate separate and with them combined as a single variable. The upper part of the table presents the results of the long run

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[7] It can also be argued that the vacancy rate is partly determined by exogenous variables. Several studies have developed cross sectional models linking the natural vacancy rate to exogenous variables [see, for example, Rosen and Smith (1983) for housing and Shilling *et al*. (1987) for offices]. Arnott and Igarashi (2000) consider the demand for vacant space in the context of search models.

models and the lower part presents the short run models.

For the long run models, all coefficients are correctly signed and significantly difference from zero. When the vacancy rate and supply variables are entered separately, their coefficients are not statistically different from each other. The explanatory powers are high, and no explanatory power is lost by replacing the actual vacancy rate change with the predicted change. The implied “price” elasticities of the demand for space (for models 2 and 4, respectively) are –0.19 and –0.24, and the “income” elasticities are 0.67 and 0.92.

In the short-run models, all coefficients are correctly signed and significant except for the stock variable when the predicted vacancy rate is employed. In this case, the coefficient is not significantly different from zero. This variable is dropped in Model 5.

The demand coefficients are close to those in the long run models, but the supply coefficients are significantly lower. In all cases, the constant term is not significantly different from zero, and the ECM coefficient is not significantly different from negative unity, implying full adjustment in one year to the gap between long run and actual rents. The explanatory power is high, but, not surprisingly, is lower for the models using the predicted vacancy rate than those using the actual rate.

For proper comparison of our model with HLM, both need to be estimated over a common period. This requires re-estimation of the HLM (1999) model. These results are shown in the HLM column in Table 2. Our model 5 reduces the unexplained variance of the HLM model by 30 per cent. Figures 1 and 2 plot the actual percentage change in effective rents and the predicted values from the two models.

7. Conclusions

In this paper, we discussed the development of the vacancy rate model in the U.S. and the latest extension and estimation of it by Hendershott *et al*. (1999). This estimation introduces the deviation from a time varying equilibrium rent as a variable and in doing so creates a link between the capital and space markets. Estimates of the model using London and Sydney office market data show the equilibrium rent variable to be significant and have similar coefficients.

We then derived a more general model based on the supply and demand for occupied space. Using the same London data, we estimated both a long-run equation and a short-run Error Correction

Table 2: The Error Correction Models

Variable	Model 1 1975-96	Model 2 1975-96	Model 3 1977-96	Model 4 1977-96	Model 5 1977-96	HLM 1977-96
Long run						
Constant	18.55	17.75	16.07	15.90	15.90	
	(2.11)	(1.74)	(2.22)	(1.73)	(1.73)	
Employment	3.74	3.58	3.84	3.80	3.80	
	(0.52)	(0.45)	(0.58)	(0.47)	(0.47)	
Stock	-5.69		-4.21			
	(0.90)		(0.91)			
(1 – v)	-6.18					
	(1.40)					
Stock*(1 – v)		-5.37				
		(0.76)				
(1 – predicted v)			-4.31			
			(1.50)			
Stock*				-4.14	-4.14	
(1 – predicted v)				(0.75)	(0.75)	
Adjusted R^2	80%	80%	79%	80%	80%	
DW	1.46	1.34	1.09	1.06	1.06	

Short run	1976-96	1976-96	1978-96	1978-96	1978-96	1978-96
Constant	-0.046	-0.023	-0.047	-0.005	-0.028	0.201
	(0.029)	(0.023)	(0.034)	(0.026)	(0.024)	(0.046)
Employment	3.75	2.59	3.37	2.09	2.80	
	(0.80)	(0.54)	(0.96)	(0.68)	(0.71)	
Stock	-2.07		1.70			
	(2.29)		(2.25)			
(1 – v)	-4.26					
	(1.44)					
Stock*(1 – v)		-3.91				
		(1.37)				
(1 – predicted v)			-2.00		-2.16	
			(0.98)		(0.90)	
Stock*				-1.72		
(1 – predicted v)				(1.01)		
ECM	-0.95	-0.95	-0.87	-0.72	-0.83	
	(0.17)	(0.17)	(0.23)	(0.23)	(0.22)	
v_{t-1}						-2.77
						(0.55)
$R_t^* - R_{t-1}$						3.58
						(0.84)
Adjusted R^2	79%	79%	72%	69%	73%	61%
DW	1.90	1.51	1.79	1.39	1.62	1.37
						v*=7.3%

Notes: standard errors are in brackets; DW is the Durbin-Watson statistic.

Model. In the short-run model, the rate of change in real rents was related to rates of change in the supply and demand variables and the vacancy rate and to the difference between the actual and fitted long-run rent values. This equation was shown to be greatly superior to the HLM estimates.

The ECM model has a number of clear advantages over the vacancy gap models. It is based on a structural model of the space market, and the coefficients have useful economic interpretations. Moreover, it is based on sound econometrics. On the other hand, it requires both stock and vacancy rate data, and these are not available in many markets.

In contrast, the basic vacancy rate model is conceptually much simpler and does not require stock data. However, its theoretical underpinnings are weak. The introduction of the deviation of actual real rent from equilibrium rent is conceptually elegant but creates measurement difficulties in the absence of a market-based real, default-free interest rate and data on risk premia and land costs. Further, from our evidence, this model produces poorer estimates and may have problems of levels of integration and co-integration. Thus, where data permit, the ECM space market approach appears to be far superior.

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Figure 1: Actual and fitted values, model 5

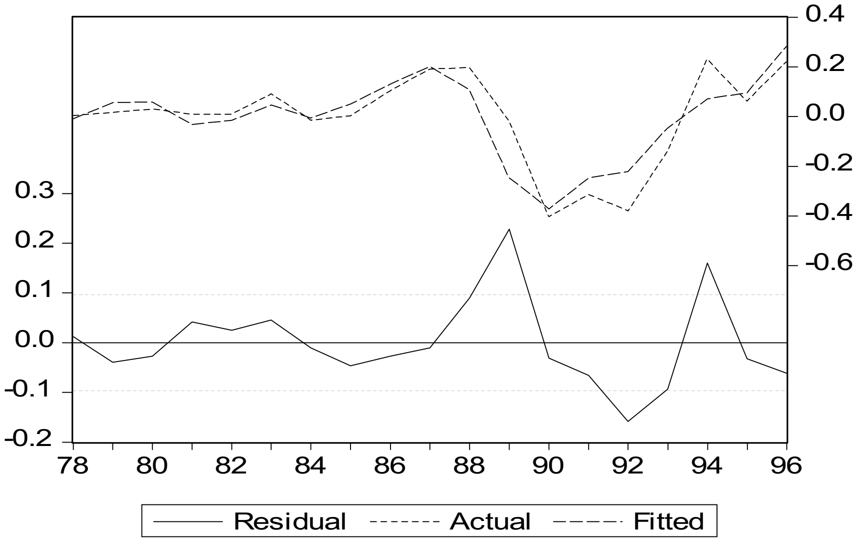
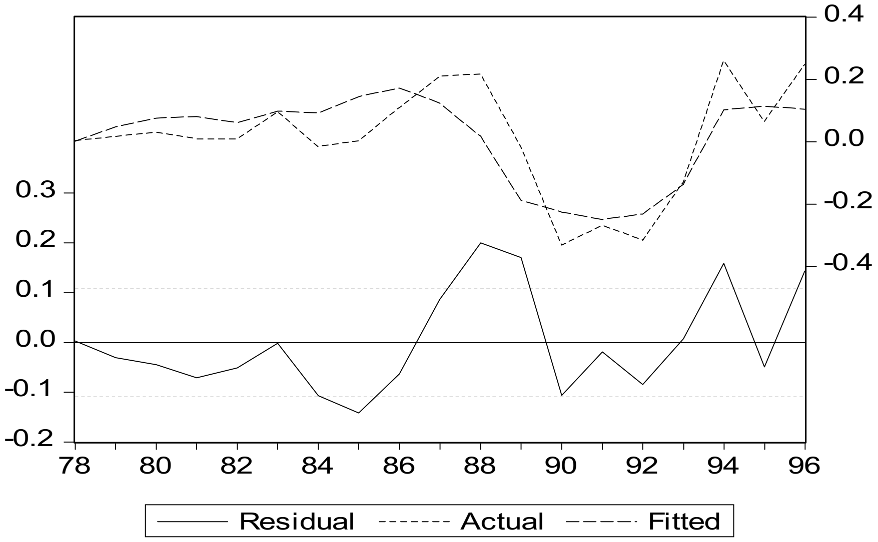


Figure 2: Actual and fitted values, HLM



Appendix

Table A1: Unit Root Tests

	Augmented Dickey-Fuller test	Phillips-Perron test
Effective rents	Accept 5%	Accept 10%
D(Effective rents)	Reject 1%	Reject 5%
Employment	Reject 5% Accept 1%	Accept 10%
D(Employment)	Reject 1%	Reject 5%
Stock	Reject 5% Accept 1%	Accept 10%
D(Stock)	Reject 5%	Reject 5%
1 – v	Reject 5% Accept 1%	Accept 10%
D(1 – v)	Reject 1%	Reject 5%
Stock*(1 – v)	Accept 10%	Accept 10%
D(Stock*(1 – v))	Reject 1%	Reject 1%
1 – predicted v	Accept 5%	Accept 10%
D(1 – predicted v)	Reject 1%	Reject 1%
Stock*(1 – predicted v)	Reject 5% Accept 1%	Accept 10%
D(Stock*(1 – predicted v))	Reject 1%	Reject 1%
v_{t-1}	Reject 5% Accept 1%	Accept 10%
D(v_{t-1})	Reject 1%	Reject 5% Accept 1%
(R_t*-R_{t-1})	Accept 10%	Accept 10%
D(R_t*-R_{t-1})	Reject 1%	Reject 1%

Notes: All series can be assumed I(0); all variables in logs; D is the first difference; results with null hypothesis of a unit root (non stationary); all levels tests with a trend and constant; differences tests with neither.

Table A2: Co-integration tests

Variables	Null hypothesis and result
Rents, Employment, Stock, (1 – v)	None: reject at 1% At most 1: reject at 5% At most 2: accept One vector correctly signed
Rents, Employment, Stock*(1 – v)	None: reject at 5% At most 1: accept One vector correctly signed
Rents, Employment, Stock, (1 – predicted v)	None: reject at 1% At most 1: reject at 5% At most 2: accept One vector correctly signed
Rents, Employment, Stock*(1 – predicted v)	None: reject at 5% At most 1: accept One vector correctly signed
Percentage rental growth, lagged v, (current equilibrium rent – lagged rent) (*)	None: reject at 1% At most 1: accept One vector incorrectly signed

Notes: in all cases Johansen test used with constant and assumption of linear deterministic trend in the data; one lag of first difference, except (*) where two lags had to be used to obtain a cointegrating relationship.