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An econometric analysis and forecasts of the office rental cycle in the Dublin area

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Summary

This paper presents an econometric investigation of office rent determination in Dublin, a small European market, over the twenty eight year period 1970–1997. Using a single equation specification based on demand and supply interactions, changes in real GDP lagged one period and changes in the office stock lagged three periods were found to be the most important determinants of changes in real rents in this market. When the forecasting adequacy of the estimated model was tested and compared with forecasts derived from commonly used alternative statistical methodologies, the forecasts based on the estimated model outperformed the alternatives.

Keywords: office rents, rent forecasting, Dublin

1. Introduction

Existing quantitative research on office markets has produced a variety of econometric models, estimated for different spatial levels of analysis, to investigate intertemporal rental movements. Most of this research has been carried out for North American office markets for example Rosen (1984), Hekman (1985), Wheaton (1987), Shilling *et al*. (1987) and Pollakowski *et al*. (1992). Methodologies developed to model rental movements in these markets have also been applied to markets outside the US for example in Sydney by Hendershott, (1995; 1996) and in London by Wheaton *et al*. (1997) and Hendershott *et al*. (1997). In Europe the majority of the quantitative research on office rents has been performed for markets in the United Kingdom. This work includes the studies of Tsolacos *et al*. (1998) and McGough and Tsolacos (1994) at the national level, Gardiner and Henneberry (1988, 1991) at the regional level and both Wheaton *et al*. (1997) and Hendershott *et al*. (1999) for the London office market. In contrast office markets in other European countries remain relatively under-researched reflecting significant problems associated with data availability. However, some exceptions to this trend exist most

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notably the comparative studies of office rent determination in European markets by Giussani *et al*. (1993) and D'Arcy *et al*. (1997).

Many of these models have also been used to generate rental forecasts (Wheaton, 1987; Gardiner and Henneberry, 1991; McGough and Tsolacos, 1994; Wheaton *et al*., 1997). However, very few rigorously evaluate the forecast performance of the specifications. Some exceptions to this trend exist for example, McGough and Tsolacos (1994) compare their dynamic forecasts with the actual values of office rents as does McClure (1991) in his assessment of alternative forecast methodologies for estimating occupied office space. Other methodologies which follow a more qualitative approach have also been used for forecasting the office market. These studies utilize local economic and property market trends as a basis for making projections of the demand for and supply of office space.[1] Examples include the studies of Kelly (1983) and Birch (1986) in the US and Morrison (1997) in the UK.

This paper examines the short-run office rental cycle in a small European market, Dublin over the twenty-eight year period 1970 to 1997. The principal objectives of this paper are twofold. First, to extend further relevant econometric research on European office markets and in this instance to assess the suitability of received theoretical frameworks in the context of a market which is small in absolute terms and which can therefore experience large swings in supply in any one year due to one or two large individual new completions. Second, to provide an assessment of the suitability of alternative forecast methodologies in the context of the Dublin office market.

The paper is divided into three further sections. Section two outlines the specification of the model and discusses the data used to estimate it. The results of the estimated model are set out in section three. The forecasting adequacy of the model is then examined by producing in sample forecasts which are compared with the actual values of office rents. The model is then used to predict office rents for the next three years. Finally an assessment of alternative forecast methodologies is carried out by comparing the forecasts produced by the model to those derived from other statistical methods. The paper concludes with an assessment of the importance of the results obtained for quantitative research on office markets.

2. Methodology

2.1. *Model specification*

A single equation model of office rent determination which incorporates variables capturing the demand for and supply of office space is constructed. The variation in office rents will reflect changes in market conditions caused by the interaction of these demand and supply variables. This approach has methodological linkages with other specifications used in existing work (Gardiner and Henneberry, 1988; Tsolacos *et al*., 1998). Office rents can, of course, be estimated within a system of equations which describe the overall workings of the office market for example, Wheaton (1987) and Wheaton *et al*. (1997). This approach, however, requires a very well developed theory of how the office market works. If certain functions of the market are not described adequately by the system of equations the results will be spurious. In comparison a well specified reduced form model

[1] See Clapp (1993) for a review of this literature.

(single equation model) is less intensive of *a priori* information, since it requires theoretical inputs specific to rent determination and provides an appropriate tool for forecasting if it is well specified, that is passing a range of relevant diagnostic tests.

Within the single equation model of office rent determination two economic variables are used to capture the demand for office space, gross domestic product (*GDP*) and service sector employment (*SSE*). The demand for office space is a derived demand reflecting the demand for the services produced by office based activities. Therefore broad indicators of the demand for these services, such as *GDP* and service sector employment, should exert a proportionate influence on the demand for office space. Significant empirical support exists for the importance of changes in real *GDP* as a determinant of real office rents across European office centres (Giussani *et al*., 1993; D'Arcy *et al*., 1997). A range of service sector employment measures from total service sector employment, to measures such as employment in finance, insurance and real estate (FIRE) in US studies and employment in banking, finance and insurance in UK studies, have received empirical support (Wheaton, 1987; Wheaton *et al*., 1997; Tsolacos *et al*., 1998). However, existing office rent research across continental European cities has provided at best only weak support for employment variables (Giussani *et al*., 1993). In the current study, both *GDP* and *SSE* are included as indicators of office demand with their relative significance determined by the data.

Two principal variables have been used to proxy supply side influences on office rents: the total stock of office floorspace and the flow of new space completed. In their regional model of office rent in the UK, Gardiner and Henneberry (1988) included the changes in the total stock of office floorspace but overall they did not find any significant effects. Tsolacos *et al*. (1998) incorporated a measure of the volume of new office construction supplied to the market but found it exerted proportionately less influence on rents compared to demand side variables. RICS (1994) examined both the influence of the stock of office floorspace and changes in this stock (proxied by new construction orders) and found both statistically significant. However, the estimated equation in this study contained lagged office rents the presence of which requires a number of diagnostic tests to be considered before the validity of these findings can be confirmed. Hekman (1985) used the actual vacancy rate to capture supply side effects on office rents in 14 US cities. The results while significant demonstrated a very marginal impact of supply side effects on rents (the size of the coefficient obtained was very small). In the current study, the variation in the supply of office space, which is assumed to have a negative impact on the growth of rents, is measured by the volume of new office building completions (*OFNC*).[2] Although, this series does not account for a part of the overall supply, that reflecting existing buildings returning to the letting market, the use of a more appropriate variable is restricted by data availability at the present time. At a wider level the dearth of appropriate series which measure effectively the supply of office space through time is a common problem across European markets.

A variable which is commonly used in US studies of office rent determination, but also in a number of non-US studies is the vacancy rate or the gap between the actual and

[2] OFNC between January 1960 and December 1997 account for a total stock of 1.4 million m^2 of space. This compares with an estimated total stock of office space in the Dublin market of 1.49 million m^2 (Jones Lang Wootton, 1998).

natural vacancy rates[3] (see Wheaton, 1987; Shilling *et al*., 1987; Wheaton and Torto, 1988; Hendershott, 1995; 1996; Wheaton *et al*., 1997). Authors have adopted different methodologies to measure this variable and as a consequence the results obtained are conditioned by the exact measurement used. Irrespective of measurement the use of any vacancy variable raises an important econometric issue. Vacancy variables can be considered endogenous variables in a rent equation, that is they are determined by other common variables, and as a consequence any results obtained could be spurious. This necessitates careful interpretation of the estimated coefficients obtained supported by appropriate misspecification tests. The fact that other variables cause simultaneous adjustments in both vacancy and rents is acknowledged by Hendershott and Haurin (1988). Despite these shortcomings, given the significance attached to vacancy variables by several existing studies, it may be useful to include them and test their significance in a wider range of market types and circumstances. However, the lack of a sufficiently long vacancy series for Dublin precludes their inclusion in the current model.

A single equation model of office rents (*RENT*) which allows the interaction of both demand and supply variables can be specified as a function of gross domestic product (*GDP*), service sector employment (*SSE*), the two drivers of the demand for office space, and the stock of office floorspace (*OFS*), a measure of the supply (Equation 1):

$$RENT = f\,(GDP,\ SSE,\ OFS) \tag{1}$$

If a model based on Equation 1 is estimated in levels of the variables it is subject to misspecification problems in particular serial correlation (as initial estimates in this case proved). A main reason for this is the presence of long-term trends in the data series. In order to overcome these problems Equation 1 is reformulated in changes of the variables. This removes the problem of trends to an extent but it requires appropriate diagnostic testing to ensure that trends do not have an influence on the final results. A possible restriction imposed by estimating a model of rents in changes is that long-run information about movements in rents could be lost. This possibility arises only if these variables exhibit long-run relationships (cointegrate). However, the relatively small number of observations in this case negates appropriate testing for cointegration.

Therefore, changes in office rents are modelled as responding to changes in *GDP* and employment, and the volume of new office completions (*OFNC*), a proxy for changes in the gross office stock in Dublin. The regression form of the relationship between office rents (*RENT*) and these pre-specified variables is given as Equation 2:

$$\Delta rent_t = \alpha_0 + \Sigma\alpha_{1i}\Delta gdp_{t-i} + \Sigma\alpha_{2i}\Delta sse_{t-i} + \Sigma\alpha_{3i}ofnc_{t-i} + e_t \qquad \text{for } i = 0,\ 1\ \ldots\ I \tag{2}$$

Lower case characters denote the natural logarithms of the original series; Δ is the first difference operator; $\Delta rent$ represents the changes of the logged series of real rents; Δgdp and Δsse are the changes of the logged series for *GDP* and *SSE* respectively; *ofnc* is the log of *OFNC*; $t - i$ denote lags and I is the maximum lag length. This specification reflects the common assumption made in similar studies that the effects of past changes in the demand and supply side variables may induce rent changes over a number of periods. On the demand side this lag mainly reflects the time taken to recognize the direction,

[3] The natural vacancy rate is defined as the optimal or long-run rate of vacancy in the market. Vacant space becomes an inventory which is either withheld from, or released to, the market depending on the perception of landlords as to the gap between the actual vacancy rate and that markets natural rate of vacancy. For an extensive discussion of the concept and its application to the office market see Clapp (1993).

magnitude and persistence of changes in economic activity and translate them into expressions of demand for space in the market and thus exert an influence on rents. On the supply side the lags show that completed buildings in one period can affect current or future rents depending on the speed at which the market absorbs new supply. The most significant lags and maximum lag length are expected to be different for each variable and will be determined by the data.

2.2. *Data*

The property data used in this study of the Dublin office market is provided by Hamilton Osborne King. The data on office rental values used is an index (1990 = 100) of prime rack (effective) rents[4] revalued in constant prices using the annualized consumer price index. Figures for the volume of new office building construction are calculated as the annual total amount of office space completed in both central and suburban locations in County Dublin. This includes all completions in incentive areas and from 1989 all new space completed in the Custom House Dock financial services centre[5]. Again the series is indexed (1990 = 100). All variables are available for the entire 28 year study period 1970–1997. Since changes are used the sample period becomes 1971 to 1997. However, this sample period may become even shorter if lags of the explanatory variables appear to be important.

The non-property variables used, real *GDP*, *SSE* and the consumer price index were supplied by the Irish Central Statistics Office (CSO) databank in Cork and are indexed (1990 = 100) national series. The use of national data reflects the lack of appropriate regional series for the Dublin region throughout the entire study period. However, given that just under one third of the Irish population live in Dublin and even higher proportions of total *GDP*[6] and service sector employment are generated in the region, the use of national series are appropriate in this case.

3. Results and forecasts

3.1. *Empirical results*

The estimation of Equation 1 followed a general to specific approach. Initially three lags of each explanatory variable were included. This means that changes in rents in the current period are related to changes in *GDP*, changes in service sector employment and new office construction in the past three years. Longer lags were tested as required in order to

[4] Rents are based on a full repairing and insuring lease with the tenant responsible for all fitting out costs. Rent free allowances have not been common in the Dublin market and have conventionally been limited to a maximum of three months.

[5] Since the Finance Act of 1986 various property development urban renewal incentives have been available. The majority of these has been related to residential development. However, some have also been applicable to commercial buildings in the designated areas of the city and specifically the Customs House Docks. These have taken the form of capital and rental allowances. The net effect of these incentives has been to bring about a significant change in the geographical distribution of office locations in Dublin over the last ten years specifically a movement towards the area in and around the Customs House Dock development in the north inner city.

[6] Figures based on the 1995 regional accounts (CSO, 1998) indicate that Dublin generates 38.4% of national Gross Value Added (*GVA*) and 48.7% of service sector *GVA*.

ensure that terms with significant information were not excluded. The selection procedure comprised a number of tests. Contemporaneous and lagged values of the explanatory variables which did not take the *a priori* sign and were not statistically significant, based on the *t*-ratio, were dropped from the estimates. The number of terms in the estimated equation was also guided by the application of the Akaike Information Criterion (AIC) which imposes a penalty on extra coefficients and in particular on superfluous terms. The results of estimating Equation 1 over the period 1971 to 1997 are given below as Equation 3:

$$\Delta rent_t = \underset{(1.5)}{0.17} + \underset{(3.4)}{1.75}\Delta gdp_{t-1} - \underset{(2.2)}{0.06} ofnc_{t-3} \qquad (3)$$

R-bar squared = 0.49 DW-statistic = 2.17

t-ratios are given in parentheses; sample period: 1973–1997.

According to Equation 3 current changes in real office rents in Dublin are explained by changes in real *GDP* the previous year[7] and the volume of new construction three years in the past. The second lag of *gdp* also seems to explain changes in real rents but in the presence of gdp_{t-1} it becomes insignificant. This is a result which conforms with the findings of research across European city markets that changes in real *GDP* appears to be a statistically significant variable in explaining office rent movements. The results for employment were disappointing. None of the lags of this variable appeared to affect rent changes. Given these results an alternative national measure of service sector employment was examined. This series, employment in commerce, finance and insurance (*CFIE*) again supplied by the Irish CSO, when tested did not produce any significant effects on rent changes. Finally, changes in the volume of building construction took the *a priori* negative sign when lagged two years. However, this lag is not statistically significant. The index of new office completions only becomes significant when lagged three years. This means that the change in the level of real rents between period $t-1$ and t are influenced by the volume of new construction at period $t-3$. This lagged response may reflect the sluggish absorption of the stock produced in the three principal development cycles in Dublin over the study period.

Equation 3 explains 49% of the changes in real office rents in Dublin. This is a satisfactory explanatory ability given that changes in rents are modelled. The actual and fitted values are shown in Fig. 1. The fitted values are the predicted values from the regression equation (Equation 3) computed by applying the estimated coefficients to the independent variables. Equation 3 captures very well the long run pattern of changes in real rents. However, in 1989 there is a spike in the actual series which is not replicated by the model. The increase in real rents between 1988 and 1989 was 47.9%, by far the largest changes in real rents over the sample period (the second largest changes were a fall of 17.4% in 1974–75 and an increase of 17.4% in 1978–79). This increase in rents cannot be explained by changes in *GDP*. It is more likely that the historically low volume of new

[7] Large differences exist in recent years between Irish *GDP* and *GNP* due to the significant outflows of repatriated profits associated with the high level of inward investment in the Irish economy. As a consequence, from an *a priori* perspective it might be reasonably argued that *GNP* would be a better indicator of office demand than *GDP*. However, when tested changes in real *GDP* marginally outperformed changes in real *GNP* as a determinant of changes in real rents.

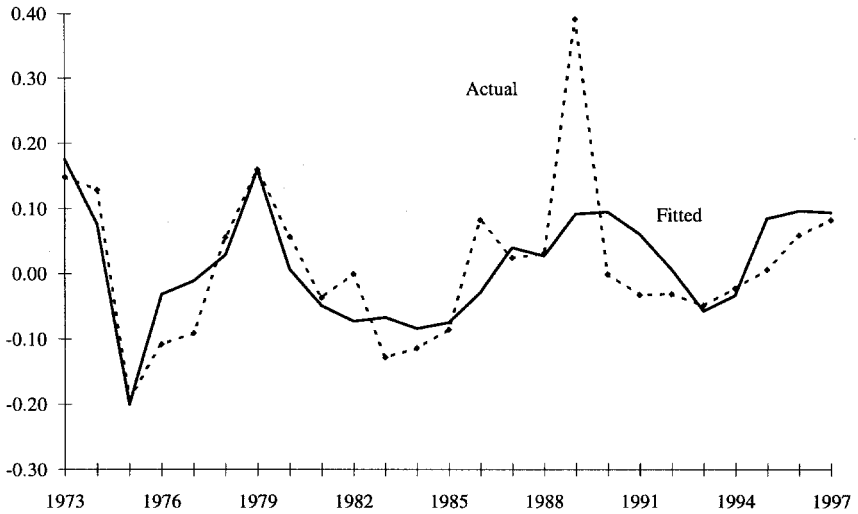

Fig. 1. Actual values of office rents and fitted values based on Equation 3.

construction in the previous four years contributed to this dramatic increase in rents.[8] If a dummy variable is included to allow for this change in rent the explanatory power of Equation 3 increases substantially. However, it is more appropriate to exclude the artificial contribution of the dummy variable when testing the stability of the model and assessing its suitability for forecasting.

Figure 2 shows the actual rent index for Dublin (1990 = 100) and the predicted index produced by the fitted values of the series modelled (changes in the logged values of actual rents). The actual index displays two distinctive trends. Real office rents appear to have followed a long-term downward trend over the period 1974–85. Since 1985 real rents have exhibited an upward long-term trend. These phases largely reflect the fortunes of the Irish economy throughout the period. In the second phase the rent cycle is more explosive with real rents exhibiting a consistently stronger growth trend and a noticeably weaker fall relative to the previous cycle. This reflects Ireland's unparalleled experience of economic growth since 1985 which has transformed the Irish economy from being one of the poorest in Europe to a level of income currently above the European Union average.[9]

Overall, the fitted index of real rents replicates the actual series well. However, Equation 3 tends to consistently overpredict real rents since 1991. This may be explained by the persistent high growth rates of real *GDP* (annual average rate of 6.8% in the period 1992 to 1997) which, in the context of Equation 3, suggests a more than proportionate growth in real rents. However, actual rents have not increased by as much, as Fig. 2 illustrates. This is because other factors affect rents. For example, supply side influences on rents are not fully captured by the series used in Equation 3. Another factor may be that firms use

[8] The volume of new space completed in 1988 was the lowest for twenty years, with the figures for 1986 and 1989 being the second and third lowest respectively.

[9] See Walsh (1996) and Duffy *et al.* (1997) for useful accounts of Ireland's recent economic transformation.

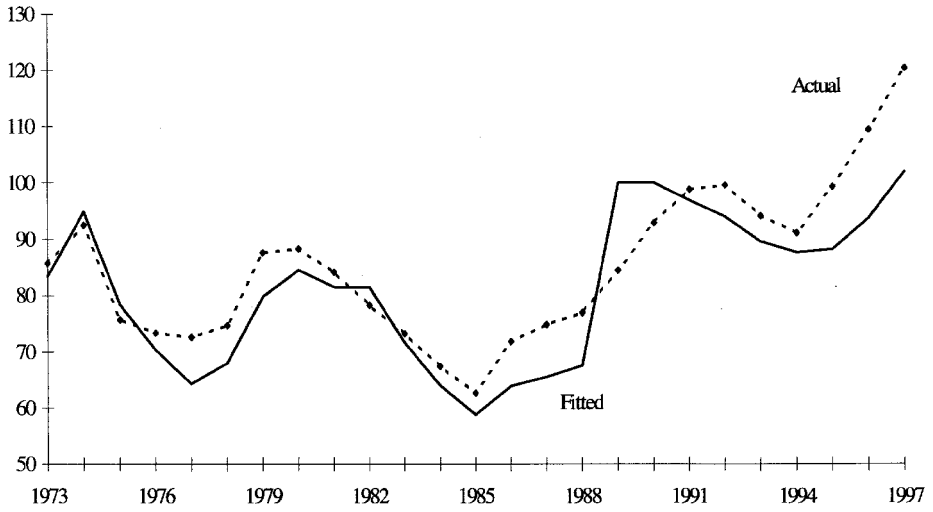

Fig. 2. The actual and predicted office rent index for Dublin.

their existing space more intensively in the face of stronger economic activity and higher levels of rents and consequently this dampens the demand for space.

Finally a number of diagnostic tests on Equation 3 were performed. The Breusch–Godfrey test (Breusch, 1978; Godfrey, 1978) for more general forms of serial correlation (up to fourth order) did not detect any signs of serially correlated errors (the value of the estimated χ^2 at 5% with four degrees of freedom is 2.13 compared to the critical value 9.49). White's test for heteroscedasticity (White, 1980) showed that the errors are homoscedastic (the value of the estimated χ^2 at 5% with five degrees of freedom is 5.34 compared to the critical value 11.07). The line of the cumulative sum of squared residuals test is within the 5% critical boundaries for the whole sample period. Therefore, there is no evidence of a structural break. A further stability test, the Chow breakpoint test was also applied, to find out whether there is a structural change in the relationship between $\Delta rent_t$, Δgdp_{t-1} and $ofnct_{t-3}$ between the periods 1973–1989 and 1990–1997. This test did not indicate a structural break in 1989 and thus the intercept and coefficients of Equation 3 are invariant over the two sub-periods. The computed value of the F-test does not exceed the F-critical value at the 5% level of significance (computed F-value = 2.90 and critical F-value = 3.13). One of the most used formal misspecification tests of the functional form together with the possible omission of an important variable is Ramsey's RESET test (Ramsey, 1969). Ramsey and Alexander (1984) showed that this test could provide evidence of misspecification even if other traditional tests (R-bar squared, t-statistic, DW d-statistic) take satisfactory values. The application of this test showed that the RESET test statistic is not significant indicating no functional misspecification in the regression (when two terms are included the value of the estimated F (2, 20) statistic at 5% is 0.04 compared to the critical value 3.49). Finally, an augmented Dicky–Fuller (ADF) test on the residuals (including an intercept and time trend) showed that the residuals are stationary. Based on these tests, it is concluded that Equation 3 is well specified and can be used for forecast purposes.

3.2. *Forecasts*

The forecasting adequacy of the estimated rent model is examined through the production of sample forecasts of real rents for 1996 and 1997. These are then compared with actual rents. In addition, forecasts were produced by two alternative statistical methodologies used for the production of short-term forecasts, the double exponential smoothing (DES) and the Holt–Winters (H–W) procedure. This allows a test to be constructed of alternative forecast methodologies. The double exponential smoothing and the Holt–Winters procedures are methodologies which use only past values of the series being forecast and are available on most statistical packages. Therefore, they can be accessed readily by analysts and used for effortless forecasts since they are not data intensive. In general these techniques smooth the original series and then extrapolations for forecasting can be made. The double exponential smoothing procedure calculates the smoothed series as a damping coefficient (α) times the actual series plus one minus the damping coefficient ($1 - \alpha$) times the lagged value of the smoothed series. The closer the value of α is to 1 the more heavily the current value of the actual series is weighted in generating the current value in the smoothed series. In the double smoothing procedure this process is repeated and the extrapolated (forecast) series has a constant growth rate, equal to the growth of the smoothed series at the end of the sample period. The Holt–Winter method explicitly incorporates a linear trend to prevent the current value of the smoothed series from deviating significantly from recent values of the actual series. A one period ahead forecast is then based on the most recent value of the smoothed series and the expected increase based on the long-run linear trend. A detailed treatment of these methodologies can be found in Bowerman and O'Connell (1979), Granger and Newbold (1986) and Pindyck and Rubinfeld (1991).

Table 1 presents the forecasts based on the two variants of exponential smoothing and Equation 3.[10] The lag structure of the terms in Equation 3 restricts forecasts to a period ahead only. This is due to the term gdp_{t-1}. For longer forecasts future values of *gdp* are required. Similarly the term $ofnc_{t-3}$ allows forecasts for three periods ahead based on the known values. Therefore, using the known values of *gdp* and *ofnc* up to 1995 and forecasting office rental values for 1996 and 1997 the value of *gdp* for 1996 is required. This is obtained from a double exponential smoothing which is applied to the series for the period 1971 to 1995. In computing the rent forecasts the lags and coefficients on *gdp* and *ofnc* are those estimated in Equation 3. The changes in the logged series of rents are initially predicted. From the predicted changes in logged rents the forecast series of the

Table 1. Forecasts of real office rents for 1996 and 1997

	Index of actual real rents (1990 = 100)	DES	H–W	Eqn 3	Error DES	Error H–W	Error eqn 3
1996	93.8	87.3	89.0	97.3	− 7.5%	− 5.3%	+ 3.6%
1997	102.0	86.5	89.8	105.1	− 17.9%	− 13.6%	+ 3.0%

[10] The estimated damping coefficient for DES is 0.75 and it takes a value close to 1 in the Holt–Winters procedure. This suggests that the real rent series is a random walk and the methodologies place significant weight on the most recent values of the series.

Table 2. *Ex ante* forecasts of office rents for 1998–2000 based on Equation 3

	Forecast of index of real rents (1990 = 100)	Forecast of change in real rents
1998	116.8	+ 14.5%
1999	120.8	+ 3.4%
2000	124.2	+ 2.8%

level of logged rents is obtained which is then converted into the actual series of real rents. The results show that Equation 3 produces the smallest forecast errors. Equation 3 tends to overpredict slightly whereas the two exponential smoothing techniques underpredict. It is also noticeable that when the smoothing procedures are used for two year ahead forecasts the errors increase significantly. This is not surprising since in these forecasts only information from past data trends are utilized and any structural influences are not taken into account. This is in accordance with the finding of McClure (1991) who concluded that econometric techniques are superior for forecasting purposes relative to conventional trend line analysis methods. On the basis of this evidence it is recommended that the use of these statistical methods in rent forecasting in the Dublin market for longer than one period can result in very large errors.

The forecasting performance of Equation 3 was also examined by comparing the values of the standard error of the full sample period regression estimation with the value of the root mean square error (RMSE) computed for the forecast period. The value of the former is 0.08 and the value of the latter is 0.03. Therefore, the value of the RMSE is about 0.30 times that of the regression standard error which is an indication of strong forecasting ability.

Based on all these results *ex ante* forecasts for 1998 to 2000 are made using only the framework of Equation 3. These forecasts, however, require projections of *gdp* for 1998 and 1999. For this purpose we utilize the most recent forecasts of real *GDP* growth produced by the Irish Central Bank (Central Bank of Ireland 1998). These forecasts suggest that *GDP* will increase in 1998 by 7.5% in real terms. Utilizing this information the index value of *gdp* for 1998 is obtained. Subsequently the double exponential smoothing procedure is used to obtain the forecast value of *gdp* for 1999. This forecast suggested that real *GDP* will increase further by 7.8% in 1999. For three year predictions the variable *ofnc* does not need to be predicted. The forecasts of the index of real rents for Dublin obtained from Equation 3 suggest that rents will increase in real terms over the next three years (Table 2). The largest increase is expected to be in 1998. Then the growth rate will considerably slow down. This slowdown cannot be explained by a similar fall in the growth rate of *GDP* since the forecasts were based on a growth rate of 7.8% for 1999. Therefore this is attributed to the current increases in the volume of office building construction which is expected to provide sufficient new space to meet office demand in the years 1999 and 2000. Following a period of a relatively low rate of new construction since 1991 (1992: 16 952 m^2; 1993: 26 255 m^2; 1994: 20 578 m^2; 1995: 24 743 m^2) the volume of new space has increased to 62 859 m^2 in 1996 and 74 473 m^2 in 1997. Despite the fact that a significant portion of this in the form of prelets, if such a rate were to

continue for the next two to three years there is a danger of oversupply in the market. Given the very favourable medium-term prospects in the Irish economy (Duffy *et al.*, 1997) combined with a significantly lower interest rate climate as a result of Irish membership of the European monetary union from January 1999 may in fact make this scenario a very distinct possibility.

4. Concluding remarks

This paper has extended existing quantitative research on European office markets by examining the process of rent determination in the Dublin office market over the period 1970–1997 using a regression methodology. The results demonstrate the importance of changes in real *GDP* lagged one period and changes in the stock of office space lagged three periods as key determinants of rental value changes in this market. These findings with respect to *GDP* confirm previous research on rent determination in European office markets. Furthermore, the satisfactory results obtained clearly demonstrate the validity of using a model correctly specified in terms of demand and supply interactions to explain rental change even in the context of a small market like Dublin. However, the problem of dramatic swings in rental values in certain years due to the small size of the market can cause problems for modelling as the 47.9% increase in real rents between 1988 and 1989 highlighted.

The model was also used for forecasting purposes. Its forecasting adequacy was assessed by producing in sample forecasts for 1996 and 1997 and comparing them with actual values for these years. As part of this process an evaluation of alternative forecast methodologies was carried out by comparing the forecasts derived from the estimated econometric specification with those derived from two commonly used statistical methodologies, double exponential smoothing and the Holt–Winters procedure. The results demonstrate the superiority of rent forecasts based on an econometric methodology, especially if more than single period forecasts are required. Also they demonstrate the suitability of a single equation demand-supply interaction model for rent forecasting. Having established the model's forecasting adequacy, forecasts up to three years ahead were produced. These suggest a significant slowdown in the growth of real rents in 1999 and 2000 reflecting the large volume of new space coming on to the letting market in both 1997 and 1998.

At a wider level the analysis in the current paper raises a number of issues for consideration in the context of future research on modelling office markets. First, those involved in the collection of direct property information need to improve their coverage of the supply side of the market as a key input into the development of better rent determination models. Secondly, the availability of European wide regional data of a consistent quality is required if models are to advance both in terms of analysing the impact of local market conditions on rents and in making valid comparisons between cities. Thirdly, more attention needs to be given to the development of appropriate comparative indicators of response to demand and supply side changes in the office market. For example through the construction of demand and supply elasticities. Finally, there is an urgent requirement for more studies to address the issues of rent forecasting and within this to assess the suitability of different forecasting methodologies within as wide a range of market structures and circumstances as possible.

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