
Great Britain

Abstract. This article adopts an unrestricted vector autoregressive framework methodology to examine the cyclical activity of office property development in Great Britain. The empirical analysis provides supporting evidence for the significant influence of office rents on the rate of new office construction. Service sector output has a small impact on office development, whereas the results do not establish a relationship with employment and interest rates. The significance of rents is attributed to the tenure characteristics of the market and the important role of developers and property investors in initiating office projects in Great Britain. A period of up to three years appears to be the optimum period between the time that rental signals are generated and the time that buildings are put in place, as a response to those signals.

Introduction

Identifying the forces and mechanisms that influence the dynamics of the office development cycle is a major and topical research area that is inextricably linked to the volatility of office building construction and the well-publicized periods of overbuilding. Moreover, it is important to a better understanding of the key influences on office development in different geographical contexts and over time. Statistical work in the United States has identified a number of economic and other variables that are important in explaining the flow of new office construction. These include gross national product, employment, vacancy rate (or the gap between the actual and natural vacancy rates) and total office stock (Rosen, 1984; Hekman, 1985; and Wheaton, 1987). Kling and McCue (1987) found that the U.S. office construction cycle is influenced primarily by nominal interest rates and output. Money supply and prices were also responsible for the variation in office construction. Further research has investigated the role of market size and market growth in office development (Hekman, 1985; and Pollakowski, Wachter and Lynford, 1992).

Systematic statistical work on the office cycle in the British context has only recently been undertaken. Tsolacos, Keogh and McGough (1998) have found that the major influences in the cyclical pattern of office development in Great Britain are office rents and capital values. Moreover, employment in banking-finance-insurance and real interest rates also appears to exert an influence. Other research has examined the

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cyclical regularities of different variables and office development after filtering all raw data series to extract their cyclical component (Barras and Ferguson, 1987; and McGough and Tsolacos, 1995; 1997). McGough and Tsolacos found that gross domestic product, output of business and finance industries and employment in banking-finance-insurance are procyclical with the office development cycle. However, the strongest procyclicality was exhibited by office rents and capital values. Wheaton, Torto and Evans (1997) and Hendershott, Lizieri and Matysiak (1997) have examined the office development cycle in London. Both papers use a standard ordinary least squares procedure to estimate the proposed equations for office development. Wheaton et al.'s paper specifies the level of current construction on the contemporaneous values of rents, vacancy rates and replacement costs. This article, however, assumes instantaneous adjustments in the development market, which is at variance with the 'time to build period' assumed in the study of Kling and McCue (1987). Hendershott et al.'s paper relates office completions to the gap between the actual and the estimated equilibrium rent (this relationship was extensively discussed in the context of economic and property market cycles in Born and Phyrri (1994)). This specification did not fully capture the cycle of office construction and was thus rectified with the incorporation of a dummy variable in 1989.

The aim here is to investigate further the economic relationship between office construction and the variables that theoretical reasoning and existing empirical findings identify as major influences on office development. A vector autoregressive framework (VAR) is deployed for the examination of the office building cycle at the national level. As such, the present study has methodological linkages with the work of Kling and McCue (1987) who adopted this methodology in their study of office construction in the U.S. These authors argued that the presence of development lags, which characterize the office cycle, makes the use of the VAR framework an appropriate study tool for property cycles. VAR models are in favor with researchers due to the flexibility they provide. They combine elements from regression analysis, where the determinant variables and the particular specification of the model are dictated by the underlying theory, and time series analysis, where current and future movements of a variable are explained by studying its past trends and shocks. This methodology assists in the task of investigating both the nature of the influences that determine movements in office building construction over time, and the dynamic response of new office development to shocks in its determinant variables.

Next, the main features of the VAR methodology and the data used are discussed, followed by the empirical results and the conclusion.

Methodology and Data

The VAR modeling system can be seen as an extension of the basic multivariate autoregressive (AR) model. An AR model is one where the dependent variable is modeled against lagged values of itself in an attempt to forecast future values. A VAR is a group of variables that are used to model each other via the use of their own lags. The basic VAR form is:

$$Y_t = B_0 + B_1 Y_{t-1} + B_2 Y_{t-2} + \dots + B_n Y_{t-n} + e_t \quad (1)$$

where Y is a vector of all variables used in the equations, B_0 is the $n \times 1$ vector of intercept terms, B_s are the $n \times n$ matrices of coefficients that relate lagged values of the variables to their current values, n is the desired lag length and e_t is the vector of errors that are uncorrelated with their own lagged values and with Y_{t-1} through Y_{t-n} .

In this study, the vector Y of variables includes a measure of office construction and its determining forces, which are assumed to be output in the service sector, employment in banking-finance-insurance, office rents and short-term interest rates. Movements in service sector output are expected to have a direct influence on the demand for office space and new construction. The influence of the output increase will, of course, depend on its strength and the amount of suitable vacant office space in the market since the latter can partially satisfy new office demand. Employment in banking-finance-insurance captures the effect on the office market of the fast growth rate that these service sector industries experienced in the last two decades. Therefore, new office construction may partly reflect the expansion and office space needs of the banking-finance-insurance industries. The magnitude of this variable's influence is dependent on changes in the 'space occupied per employee' ratio. The inclusion of office rental values is dictated by the information that rental movements convey about demand and supply of space in the office market, the need for new development and the profitability of development. Given the low owner-occupation rate in the office market, developers and lenders, especially long-term lenders and equity investors, are major players in the initiation of office projects. Development will, however, take place only when these projects are financially viable. The inclusion of office rents in the VAR model is expected to capture the profitability of new office developments. Interest rate changes are indicators of monetary policy and future economic activity and are thus incorporated in the VAR model to capture the effects of anticipated economic trends on office development (Kling and McCue, 1987; and McCue and Kling, 1991). Within the VAR framework described by Equation (1), each of the above variables is explained by lags of their own values together with lags of all other variables.

Authors have also included in their models of office building development the vacancy rate (Rosen, 1984; Wheaton, 1987; and Wheaton et al. 1997). It would have been useful to test the explanatory ability of this variable in the British market within the statistical methodology of this article but a national office vacancy series is not available in Great Britain (Kling and McCue (1987) identified a similar problem in the U.S.). However, the vacancy rate (and also the difference between the natural and actual vacancy rates) is not an exogenous variable in the office market and therefore it can be argued that it is an indirect proxy for the demand forces that are already included in the model.

Office building construction (*OBC*) is measured by the contractors' new office work for the private sector. The data for this series refers to the value of new office building output, which represents new additions to the office stock. It should be noted that this

series does not refer to the volume of the finished building in a given period; it reflects the construction expenditure in a particular period on all buildings under construction. For the purpose of this study, the office building output series is converted in real terms to represent volume of building construction using the GDP implicit price deflator. Data for office building construction is compiled by the Department of the Environment and can be obtained from *Housing and Construction Statistics* an HMSO publication. Service sector output (SSO), interest rates, measured by the Treasury Bill rate (TBR), and data for employment in banking-finance-insurance (EBFI) are obtained from *Datastream International*. The data for these series are compiled by the Office for National Statistics. Service sector output data are available in real terms. Interest rates are in nominal terms but they are converted in real terms by subtracting the year on rate of inflation at each quarter from the quarterly nominal interest rates). Finally, the office rental series (ORS) is an index of office rents produced CB-Hillier Parker international property consultants. These rental values relate to properties in good locations throughout the country let of full repairing and insuring lease or service charge to cover similar provisions. The rent represents the best headline rent achievable for a new or recently refurbished building (to standard equivalent to new space) of the highest specification. From 1992, the CB-Hillier Parker rent index is compiled by properties in 731 locations throughout the country. The survey also includes properties in out of town office parks. In this study, the rent series is adjusted for inflation using the GDP price deflator. The study period is confined by the availability of data for office building output. This series begins in 1980 and is quarterly; thus, the study period is 1980:1 to 1996:4.

The first step in the analysis is to apply Granger causality tests to examine whether the chosen determinant variables influence office development in Great Britain. In the next stage, the preferred VAR model is specified to fit the office building output data series. Subsequently, a historical analysis is undertaken aiming to identify the forces that were responsible for the deviation of the actual values of *OBC* from the forecasted trends. The dynamic behavior of the VAR model is then illustrated in two ways: (1) through a variance decomposition analysis that identifies the contribution of each of the variables to the variance in the error of multi-period forecasts of office construction produced by the preferred VAR; and (2) the calculation of impulse responses that trace the response of *OBC* over a number of time periods to one-off shocks in endogenous variables.

Results

The first step in the empirical analysis is to investigate the causal relationship between *OBC* and the determinant variables using Granger causality tests (Granger, 1969). The results are shown in Exhibit 1 with four lags. Regressions for this test were also run with longer lags to ensure that the results were not sensitive to different lag lengths.

Exhibit 1 reveals some interesting information about the causal relations examined. The null hypotheses that '*ORS* does not cause *OBC*' and '*SSO* does not cause *OBC*' are rejected at the 5% level of significance (the observed *F*-value is greater than the

Exhibit 1
Granger Causality Results

Null Hypothesis	F-Statistic
H_0 : <i>ORS</i> does not cause <i>OBC</i>	11.54
H_0 : <i>OBC</i> does not cause <i>ORS</i>	0.75
H_0 : <i>SSO</i> does not cause <i>OBC</i>	3.86
H_0 : <i>OBC</i> does not cause <i>SSO</i>	2.01
H_0 : <i>EBFI</i> does not cause <i>OBC</i>	1.55
H_0 : <i>OBC</i> does not cause <i>EBFI</i>	1.42
H_0 : <i>TBR</i> does not cause <i>OBC</i>	0.21
H_0 : <i>OBC</i> does not cause <i>TBR</i>	0.41

Note: The number of lags is 4. The critical value $F(4,56) = 2.46$; the sample period is 1980:2–1996:4.

OBC = Volume of office building construction.

ORS = Real office rents.

SSO = Volume of service sector output.

EBFI = Employment in banking-finance and insurance.

TBR = Real Treasury Bill rate.

critical F -value), but the hypotheses that '*EBFI* does not cause *OBC*' and '*TBR* does not cause *OBC*' are not rejected. These findings do not change when six or eight lags are used in the estimates. Further tests showed, however, that *EBFI* and *TBR* do not appear to have a causal relation with either of the two other variables in the VAR system (*ORS* or *SSO*). Based on these results, it is inferred that *EBFI* and *TBR* do not carry information directly or indirectly about the movements of the other variables. Therefore, their consideration for the VAR model will not make a significant contribution to the explanation of trends in *OBC*, *ORS* and *SSO*. Consequently, these variables were dropped from the formulation of the VAR model, which incorporated only office building construction (*OBC*), office rents (*ORS*) and service sector output (*SSO*), all treated as endogenous variables.

An unrestricted VAR was used for the estimation. Variables are thus considered as endogenous and the flexibility of the VAR is not restricted by assumptions of exogeneity. The implication of the assumption that all variables are endogenous is that there are no direct effects of any one variable on others. Any effects are indirect through feedback from the endogenous variables themselves. McCue and Kling (1991) highlight some weaknesses in using an unrestricted VAR model (particularly the issue of over-parameterization). However, given the results of the Granger causality tests and the resultant reduction in the number of variables, this seems less of a problem. Thus, the unrestricted VAR is used in preference to a Bayesian VAR with prior restrictions. The Akaike Information Criterion was used to specify the optimum length of lags.¹ This appeared to be six periods (quarters). The estimated VAR is, therefore given by Equation (2):

$$Y_t = B_0 + B_1Y_{t-1} + B_2Y_{t-2} + \dots + B_6Y_{t-6} + e_t, \quad (2)$$

where $Y = (OBC, ORS, SSO)$ is the vector of variables, B_0 is now the 6×1 vector of intercept terms, B_s are the 3×6 matrices of coefficients that relate lagged values of these variables to their current values and e_t is the 6×1 vector of serially uncorrelated error terms.

Equation (2) was estimated over the sample period and the model was then used to perform a decomposition of historical values of OBC . The historical data are decomposed into a forecast trend and into the accumulated effects of the residuals, that is the effect of the current and past accumulated changes in the variables (known as innovations or shocks). The accumulated effects of the residuals represent the effect of influences (current and past changes in the variables in the VAR system) that cause office building output to shift from its forecast trend growth. This is the cyclical component of OBC . Exhibits 2 and 3 illustrate this decomposition.

Exhibit 2 shows the actual values of OBC . There is a clear cyclical element to the data with the boom of the late 1980s being followed by a very steep downturn. There appears to be no clear trend over and above this cyclical phenomenon. Exhibit 3 shows the make up of the difference between trended projections for OBC and its actual values; that is, the influence of the variables on the cyclical component of OBC .

Exhibit 2
Office Building Construction in Great Britain

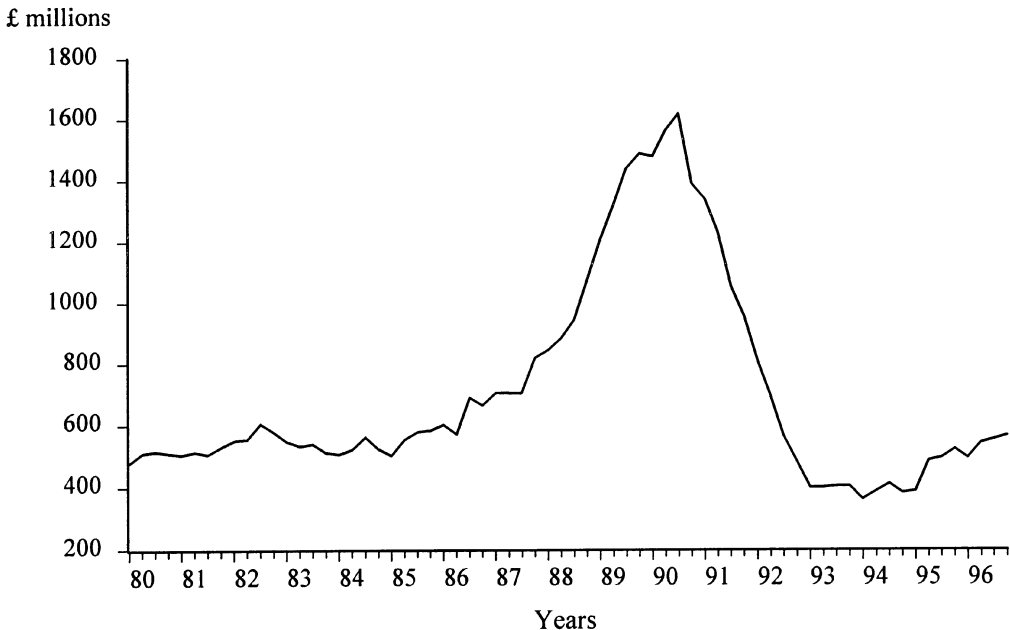
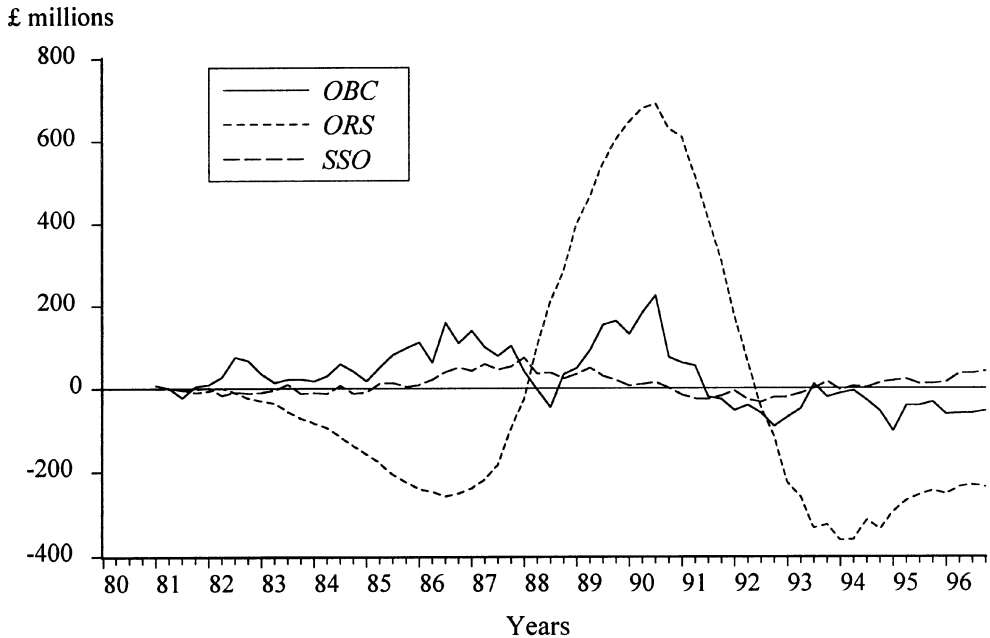


Exhibit 3
Decomposition of the Cyclical Component of Office Building Construction



The importance of rents is clear as a major driving force. Prior to the boom of the late 1980s, poor office rental growth was a dampening influence on building construction. This was partly offset by the influences of service sector output growth and past building output. During the boom period in the U.K. in the last 1980s, rents encouraged building construction to rise well above its trended position and during the slump they were the driving force behind the fall in the volume of office building output.

Exhibit 4 further illustrates the dynamic behavior of Equation (2) and provides the results of the variance decomposition calculations for *OBC*. It breaks down the variance of the forecast error of *OBC* for different time horizons into components that can be attributed to each of the three variables. The second column is the error in the forecasts of *OBC* produced by Equation (2) for sixteen quarters. The forecast error becomes larger in subsequent periods because it incorporates the effects of uncertainty in the previous periods. The last three columns give the percentage of the variance of the forecast error due to innovations originating in *OBC*, *ORS* and *SSO*. If the model is used to make predictions of *OBC* for six quarters, the forecast error is 93.14. About 54% of this forecast error is attributable to innovations in *OBC* itself, whereas shocks to or innovations in rents are responsible for 45% of the error. With regard to the effects of *SSO* innovations, it can be observed in Exhibit 4 that the percentage of the forecast error, which is attributed to shocks in *SSO* is very small throughout the four-

Exhibit 4
Variance Decomposition of the Office Building Construction

Period (quarters)	Forecasting Error	<i>OBC</i>	<i>ORS</i>	<i>SSO</i>
1	35.03	100.0	0.0	0.0
2	44.93	99.4	0.6	0.1
3	53.45	93.6	2.2	4.2
4	66.41	78.4	18.2	3.4
5	77.02	68.2	29.1	2.6
6	93.14	53.5	44.6	1.9
7	111.40	40.0	58.3	1.7
8	131.06	30.9	67.5	1.5
9	153.11	23.9	74.8	1.4
10	173.65	19.9	79.3	1.4
11	194.71	15.9	82.7	1.4
12	213.38	13.8	84.7	1.6
13	229.87	12.5	85.9	1.7
14	243.64	11.7	86.4	1.9
15	254.48	11.5	86.4	2.1
16	262.69	11.6	86.1	2.3

year time horizon. In fact, only 2% of this error is attributable to innovations in *SSO*. The results also indicate that after six quarters over 50% of the *OBC* forecast error comes from innovations in rents.

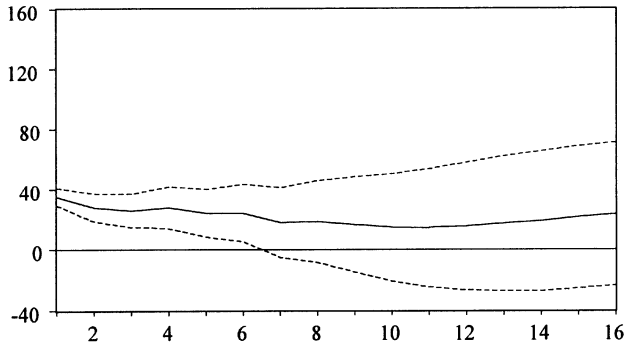
Additional information about the dynamics of the office cycle in Great Britain based on Equation (2) can be derived by studying the response of *OBC* to shocks in each of the endogenous variables. Impulse responses need, therefore, to be calculated for *OBC* when forced innovations occur to *OBC*, *ORS* and *SSO*. This innovation takes the form of an increase of the error term by one standard deviation for one quarter

Exhibit 5
Residual Correlation Matrix of the VAR System

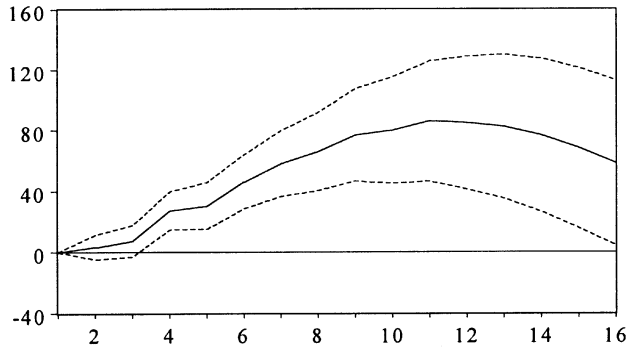
	<i>OBC</i>	<i>ORS</i>	<i>SSO</i>
<i>OBC</i>	1.00	0.19	-0.04
<i>ORS</i>	0.19	1.00	-0.07
<i>SSO</i>	-0.04	-0.07	1.00

Exhibit 6
Analysis of Impulse Responses for Office Building Construction

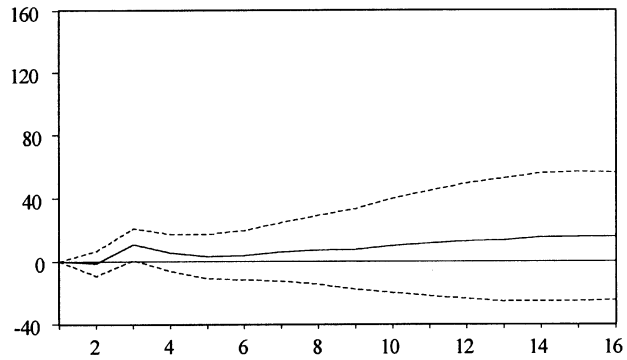
Panel A: Response of *OBC* to *OBC*



Panel B: Response of *OBC* to *ORS*



Panel C: Response of *OBC* to *SSO*



only in each of the three equations (*OBC*, *ORS* and *SSO*) in the VAR system. The calculation of the impulse responses, however, requires that the errors of the three equations are not highly correlated. If the error of one equation is strongly correlated with the error(s) of the other equation(s), then they have common components that cannot be identified by any of the three variables. Exhibit 5 shows that the errors of the three equations are not correlated and thus a shock to any one of the errors will not have a common component with the others. Therefore, shocks to specific variables in the impulse response calculations can be identified.

Exhibit 6 presents the graphs of the impulse responses for *OBC* when innovations occur to *OBC*, *ORS* and *SSO*. These are of the order of one standard deviation shock to the relevant variable. The boundaries on the graphs are two standard errors, and indicate how particularly significant *OBC*, *ORS* and *SSO* are in influencing *OBC* over time. The impulse responses are shown for a period of sixteen quarters (four years). Innovations to *OBC* itself result initially in a positive effect but then this effect seems to decline and become rather stable. Innovations originating in *SSO* have a positive effect on *OBC* (Panel C) but this effect tends to be small. Following the results of the variance decomposition analysis, it is expected that *ORS* would have a significant impact on *OBC* (Panel A). The impulse response graph for *OBC* shows that when a shock to the error of the rent equation is introduced it creates the expected positive effect on *OBC* (Panel B). In the first year, this effect is small but it continually increases reaching the highest point after eleven to twelve quarters before it declines. This finding suggests that the period between the time that rental signals are produced and evaluated, decisions made, projects started and buildings put in place in the British office market is approximately three years. Since all variables in the estimated VAR model are treated as endogenous, the effect of rental shocks in latter periods is also the result of feedback effects through the other variables. The implication is that the effect of a positive shock to rents, probably indicating a surge in demand for office space, may be maintained or even exaggerated in the subsequent periods. This is because of the feedback to rents from the market, caused by a lack of change in office building output due to the inelastic supply of office space, particularly in the first year.

Finally, given the importance of employment and interest rates in existing studies on office development, the variables *EBFI* and *TBR* were included in the VAR specification. The results did not indicate any influences,² supporting the findings of the Granger causality tests.

Conclusion

The objective has been to further the existing, rather limited empirical treatment, of office building development in Great Britain. The study followed a VAR methodology to examine the office cycle proxied by the volume of office building construction. Within this framework, it was assumed that trends in office rental values, service sector output, employment in banking-finance-insurance and the real Treasury Bill rate will capture the movements of office construction in Great Britain through time. Granger causality tests and VAR estimates established, however, that employment and the

interest rate are variables that do not exert any notable direct influence on office development in Great Britain. This different result from obtained by some U.S. studies in which employment variables have received strong empirical support. However, with regard to interest rates Kling and McCue (1987) argued that interest rates affect office construction through their effect on output. The office cycle was thus modeled with a VAR that included office building output, the CB-Hillier Parker office rent index and output in the service sector.

The study of the dynamics of the VAR model of office development was based on a decomposition of historical deviations of the actual office construction values from a predicted trend. Also analyzed was a variance decomposition of errors produced by the model when office construction was forecast four years ahead and an analysis of the response of office construction to shocks in any of the three variables. These investigations revealed that the major influence on office construction in Great Britain appears to be office rents. The office market is a market where rented accommodation is the dominant form of tenancy. This means that new developments are largely initiated by developers and/or investors when rents and total returns on the completed projects indicate a profitable development. Therefore, office construction in Great Britain is driven by office rents since they carry information about demand and supply conditions in the market and indicate the degree of profitability of new developments. These findings are in accordance with those obtained by Giussani and Tsolacos (1994) who studied industrial construction in Great Britain and showed that from 1982 to the early 1990s industrial rents became a major determinant of new industrial construction. This was attributable to a shift in the 1980s from owner-occupation towards rented accommodation. The study of the responses of office building output to a shock in office rents suggests that the supply is inelastic in the first year but then office construction responds positively and this reaction reaches a maximum point after a period of nearly three years.

Many authors have noted the relevance of real estate cycles in the strategies of real estate market participants. Roulac (1996) suggests that effective investing in real estate depends to a large degree on understanding real estate market cycles, an issue that is expected to be of increasing importance to institutional investors in future years. Born and Phyrri (1994) have argued that property market research can improve if real estate analysts take into account variables describing economic and property cycles. Within the framework of the property cycle model presented by Born and Phyrri, the results of the present study highlight the significance of market rents. According to this study, the rent cycle provides information to decisions about investing and developing and can be used to predict the cyclical behavior of office development and explain its severity. International property investors should note that relatively strict planning controls and lack of development land in Great Britain could hinder an effective response of the development industry to office demand pressures. Rents and capital values may remain high for subsequent periods and generate an excessive optimism, the result of imperfect market information or even the human nature that the good will continue (Roulac, 1996). Excessive optimism can lead to misforecasts and situations of oversupply (Ball 1994). Since office rents are the most significant determinant force to cause the large swings in the supply of new office space, market

analysts should consider both the advantages and potential pitfalls associated with rapidly increasing rents, as the experience of the overbuilding in several office markets in Great Britain showed in the late 1980s and early 1990s.

Endnotes

¹ The Akaike Information Criterion (Akaike, 1977) provides guidance as to how many lags to include in an equation. It is based on the sum of squared residuals and penalizes the addition of regressors (which reduces the number of degrees of freedom). In principle, the analyst could select the number of terms that minimizes the value of this criterion.

² These findings were similar to the results of the Granger tests and for brevity, they are not reported since they do not add anything. However, these results are available from the authors on request.

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