Estimating Occupied Office Space: Comparing Alternative Forecast Methodologies

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Abstract **This study compares alternative methodologies that can be used to forecast growth in a market's occupied office space. Trend line analysis methods are compared to econometric methods. Using 1978 through 1987 data from the Boston market, these models have been used to predict the known performance of the market in 1988 and 1989 permitting comparison of these models in terms of their overall performance and their ability to predict the recent downturn in that market. The results suggest that real estate practitioners and planners should employ econometric techniques in their efforts to forecast the incremental changes in occupied office space.**

Introduction

Concern about overbuilt office markets is widespread. The popular press describes the surplus space and its impact upon credit markets [9]. Professional publications warn developers, investors, and planners of the high vacancy rates in office markets nationwide [10, 14]. Scholarly publications attempt to explain what went wrong and to calibrate the extent of the harm [6, 15].

The cyclical nature of the real estate industry in general and the office sector in particular has been the subject of considerable research. Some research holds that investors do not overreact to cyclical changes in the economy and that the shocks these changes create within the investment community are not felt beyond the normal construction period [8]. This suggests that the scale of the overinvestment in office space can be easily exaggerated and that the damage from such excess development may be more readily absorbed than is commonly supposed. Others show that vacancy rates in office markets are edging upward over time and that reduced income streams are likely [17]. This suggests that a major problem does confront the office industry and that the future is not at all certain. Whatever the case, it is unmistakably true that excess space exists within most office markets today. Further, it is probably true that fewer buildings would have been added to the stock if, a few years ago, developers had more accurately estimated the reduced capacity of these markets to absorb the buildings upon completion.

Builders and developers need to accurately estimate the future amount of occupied space within a market in order to make good decisions on whether or not to build additional space within that market. Office markets involve especially large investments of time, effort, and money. These markets are very competitive; leasing agents constantly

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seek to attract tenants to available space. In soft markets this can mean offering concessions to tenants of other buildings in order to entice them to move. Consequently, rent levels constantly fluctuate, even for space that appears to be securely leased. If developers mistakenly overestimate the future increases in the amount of occupied space, they may construct buildings that are unneeded, and they will be subject to bitter competition for tenants.

Review of Existing Models

Two basic types of models are employed to generate estimates of future amounts of occupied space in office markets. These are (1) accounting or trend line models favored by practitioners and (2) econometric forecast models favored by economists. Trend line models are easy to use and require little data. Econometric forecast models are more demanding in terms of the need to apply economic theory, the necessary command of statistical methods, and the data required.

Conventional Trend Analysis

Conventional trend analysis has been used to analyze the behavior of office markets in many cities [1, 7]. The Boston Redevelopment Authority (BRA) closely monitors occupancy levels in the office market of downtown Boston as well as the flow of new space into the market. The BRA has expressed an interest in regulating the flow of new space so as to keep vacancy levels within the range that it deems to be desirable for the Boston market—8% to 12% [2].

The BRA's method is a simple accounting technique. The agency knows the total stock of space in the market from the tax assessor's inventory of buildings. It knows the number of buildings that have been approved for construction along with the size of these buildings and the expected date on which these buildings will be completed and ready for occupancy. This permits very accurate projections of the total supply of office space within the market. In order to keep the vacancy rate within the desired range, the city must either approve or delay progress on proposed new buildings such that the added space will not contribute too much to the total supply, raising the vacancy rate above acceptable levels. This assumes some knowledge of the amount of space that will be occupied in the future.

The BRA obtains occupancy data on a quarterly basis from a variety of private real estate brokerage firms. These data are combined to determine the total amount of occupied space on a quarterly basis. To predict the future occupancy levels, the BRA simply employs a moving average technique. The future occupancy level is estimated to be the present level plus an incremental increase that assumes continued growth similar to historical trends.

The obvious problem with such a moving average technique is the assumption that the future will reflect the past. A downturn in the economy is not predicted in the moving average until well after the downturn has occurred. The moving average can be updated as frequently as quarterly, but even this frequency may be too slow to accurately adjust growth estimates to new conditions.

Trend line models such as these have been harshly criticized [12]. The methodology is viewed as inadequate in that it assumes that the future will somehow mirror the past independent of changing economic conditions. Rather than using a model that can statistically forecast the amount of occupied office space, the traditional methodology merely extrapolates past trends, and this is seen as unsatisfactory for purposes of forecasting.

Econometric Models

The literature on office markets provides several models linking the rate of growth of occupied office space to such market conditions as vacancy rate, rent level, and the rate growth of employment among firms needing office space. These models provide an alternative approach to forecasting the amount of occupied space in a local office market. Wheaton [16], Rosen [12] and Hekman [8] all offer theoretical models along with empirical tests of these models. The empirical tests of these models demonstrate that they can be used to generate conditional forecasts of future increases in occupied office space within a local market, given estimates of future economic conditions. Conditional forecasts assume that the user has knowledge of the values of the independent variables that are used to generate the forecast. In practice, these factors cannot be known with certainty, but reliable estimates for these factors are generally available from sources within the industry [4, 5, 11, 13, 14].

The specifications of these models differ somewhat. All of the research agrees upon the need to include an explanatory variable that describes the cost of office construction and a variable that measures the cost of construction financing. The relationship between the growth in occupied office space and the cost of construction is expected to be negative. Wheaton's research did not find a significant relationship between the amount of office space added to the stock and construction costs. Hekman found a significant relationship but of the wrong sign. The relationship between space consumed and interest rates is also expected to be negative. However, neither Wheaton nor Hekman found significant relationships in their models. Rosen did not test either of these two variables empirically.

Hekman and Rosen argue that a model explaining the periodic increases in occupied office space in a market should include a variable describing the presence or absence of tax incentives. They argue that the era after the Economic Recovery Tax Act of 1981 represents a time period during which increased incentives were available to office investment which should result in greater space being added to the market. Only Hekman tested this theory, and he did not find a statistically significant relationship.

All three authors agree that the level of employment in the business sectors that normally require office space is of crucial importance to a model explaining a market's occupied office space. They differ on how to measure the influence of employment and on how it should be entered into the model. Rosen uses a standard stock adjustment model. This model assumes that the influence of employment—measured as the total number of employees in the finance, insurance, and real estate sectors—is limited to the total amount of space consumed in the longrun and that it does not affect the incremental increase in space consumed in the shortterm. The empirical tests performed by Rosen support this assertion. Hekman and Wheaton opt for a different approach.

They indicate that the growth in employment among firms needing office space does influence the incremental increase in office space within a market. They measure this growth in employment in slightly different ways. Hekman uses the current rate of growth in employment; Wheaton uses a lagged version of the employment growth rate. However, both found the expected positive and statistically significant relationship.

Wheaton suggests that the scale of the market itself influences the incremental amount of new office space added to the market. He reasons that a larger market should have a larger amount of space being built at any point in time simply to account for higher quantities of demolition and replacement. He confirms that larger markets grow by larger amounts as he finds a positive, significant relationship between the amount of occupied space added to the stock and the total size of the existing stock of space.

The effects of vacancy rates and rent levels pose the greatest problems in terms of the specification of an office space model. Rosen argues that measures of both vacancy and rent should be included in the model. Recognizing that this would create a problem due to the strong correlation between these two variables, Rosen substitutes an estimate of expected rent rather than the rent itself. This estimated rent is a function of general price levels and a function of the spread between the actual vacancy rate and an optimal vacancy rate that represents an expected amount of empty space given natural turnover within the market. The final Rosen model takes the form:

$$CHNGOSF_t = f(ESTRENT_t, VAC_t, COST_t, INT_t, TAX_t), \quad (1)$$

where:

$CHNGOSF_t$ = Increase in the occupied office space at time t
$ESTRENT_t$ = Estimated rent at time t
VAC_t = Vacancy rate at time t
$COST_t$ = Construction cost at time t
INT_t = Interest rates at time t
TAX_t = A dummy variable with 0 if before 1982 and 1 on or after 1982.

This model was tested only in a simplified form. The results indicate that vacancy has the expected negative relationship with the growth in occupied office space.

Hekman uses a similar approach. He estimates the rents for an individual office market as a function of the vacancy rate, the gross national product, total employment in the market, and the unemployment rate. The rents estimated in this step are then used in a second step to estimate the change in occupied office space. The specification of this second step does not include any measure of vacancy as it has been used in the estimation of the rent variable. The final Hekman model is:

$$CHNGOSF_t = f(ESTRENT_t, GEMP_t, COST_t, INT_t), \quad (2)$$

where:

$GEMP_t$ = Rate of growth in office employment at time t.

Hekman finds a positive relationship between rents and the growth of occupied office space. He suggests that this unexpected result is due to a correlation that exists between rents and construction costs. Hekman also tested a variable controlling for the presence of tax incentives over time. As he failed to find a significant coefficient for this variable, he omitted the variable from his final model.

Wheaton uses vacancy rates in his model as a proxy for the influence of rent. As such, he does not place a rent term in the model. Unlike the other models, Wheaton experimented with this vacancy term by lagging it at various levels. He finds that the model performs best if the vacancy term is lagged 2.5 years. This lag corresponds to the normal delay between the decision to develop office space and the completion of the space. The final Wheaton model is:

$$CHNGOSF_t = f(VAC_{t\text{-lag}}, GEMP_{t\text{-lag}}, COST_t, INT_t, TSF_t), \quad (3)$$

where:

TSF_t = Total square feet in the market at time t.

Wheaton finds the expected negative relationship with this lagged version of the vacancy variable.

While significant differences exist between these models, they do have much in common. Most importantly, they provide the needed theoretical foundation for forecasting incremental changes in the stock of office space in a market as a function of various economic factors rather than performing the customary trend analysis.

Analysis

Boston has been a particularly vibrant office market in the recent past. It has grown by over 10 million square feet in the last decade. The vacancy rates have fluctuated widely from a very low level, below 2% in 1980, to the current level which is over 11%. The growth in the amount of occupied office space has also fluctuated widely. In 1978 through 1980, the increase in occupied space was less than 150,000 square feet per year. The five-year period of 1984 through 1988 witnessed yearly increases in occupied office space in excess of one million square feet per year. The five-year average was over 1.4 million square feet per year.

However, the boom seems to be subsiding. The peak year was 1987 with 1.9 million additional square feet absorbed. This fell to 1.06 million square feet in 1988. In 1989, only 850,000 square feet were absorbed.

Given this rapid growth, and just as rapid downturn, the Boston office market provides an excellent opportunity to compare alternative methods for the estimation of growth in occupied office space.

The analysis employed here is a post hoc test of forecasting techniques permitting comparative evaluation of alternate methodologies. The analysis employs the Hekman, Rosen and Wheaton models using Boston data for 1978 through 1987. These data have been used to estimate models that explain the incremental change in occupied square feet. By using just the data through 1987, the models have been generated using only information available at the time of the BRA's original projection. These models are then used to make conditional forecasts for the 1988 and 1989 increases in occupied office space by employing estimates of the 1988 and 1989 levels of the independent variables.

In addition, a modified version of the Wheaton model has been used in the analysis. This modified version employs two-year lagged versions of all independent variables to estimate the model's parameters. With this lagged structure, data from 1978 to 1985 is

used to build the model, and data from 1986 and 1987 is used to forecast the 1988 and 1989 increases in occupied space. This unconditional forecast has the advantage of providing forecasts without requiring separate estimates of the various independent variables.

The forecasts from these four models are compared to the actual increases in the office market in 1988 and 1989 to determine which of the methodologies best predicts the behavior of the market.

Trend Line Track Record

Using only data up to the peak year of 1987, the downturn in the Boston market could not have been predicted using a moving average trend analysis system to predict later years. In 1987, the BRA anticipated that 1989 would see an increase of 1.4 to 1.8 million square feet [3]. These projections assume constant growth. Some projections assumed growth by a constant amount of square feet based upon an average number of square feet absorbed during the prior years. Other projections assumed growth by a constant percentage growth rate, again, based upon the average found in the immediately preceding years. Thus, this method overestimated the true growth in occupied space for 1988 and 1989 because of the assumption of continued growth. As the actual increase in occupied space was only about 850,000 square feet in 1989, the resulting errors in the projections ranged from 74% to 112%.

Exhibit 1
Estimation of Expected Office Rents

Dependent Variable: Effective Annual Rent per Square Foot

Independent Variables:	Rent Model: Rosen	Hekman
Vacancy	−0.27	0.64
	(−1.01)	(5.49)
GNP Deflator	0.42	
	(7.59)	
GNP		0.01
		(2.77)
Total Employment		−0.01
		(−0.33)
Unemployment		0.84
		(2.26)
Constant	−12.28	0.88
R-squared	0.87	0.99

Notes: *t*-statistics are reported in parentheses.
Source: Derived by the author.

Exhibit 2
Estimation of Growth in Occupied Office Space Using Alternative Specifications

Estimates of Increases in Boston Class A Occupied Office Space
Dependent Variable: Increase in Occupied Square Feet

Independent Variables:	Model: Rosen Conditional	Hekman Conditional	Wheaton Conditional	Wheaton Unconditional
Construction Cost	116.32	79.69	111.00	65.22
	(1.52)	(1.12)	(2.92)	(1.44)
Interest Rates (3-year T-bill)	−46.73	−47.71	−9.34	
	(−0.86)	(−0.75)	(−0.21)	
Estimated Rent	−99.98	−34.08		
	(−0.84)	(−0.39)		
Vacancy	−92.32		177.54	121.55
	(−1.43)		(3.99)	(1.43)
Growth in Employment		4697.76	−2791.60	−2742.82
		(0.92)	(−1.06)	(0.48)
Total Square Feet			−0.10	−0.03
			(−0.92)	(−0.17)
Constant	−1704.65	−6747.56	−787.64	615.35
R-squared	0.83	0.81	0.98	0.87

Notes: All variables are current (not lagged) in the Rosen and Hekman models. In the Wheaton conditional model, the vacancy and growth in employment variables have been lagged two years. In the Wheaton unconditional model, all variables have been lagged two years.
Source: Derived by the author.

The Performance of Econometric Models

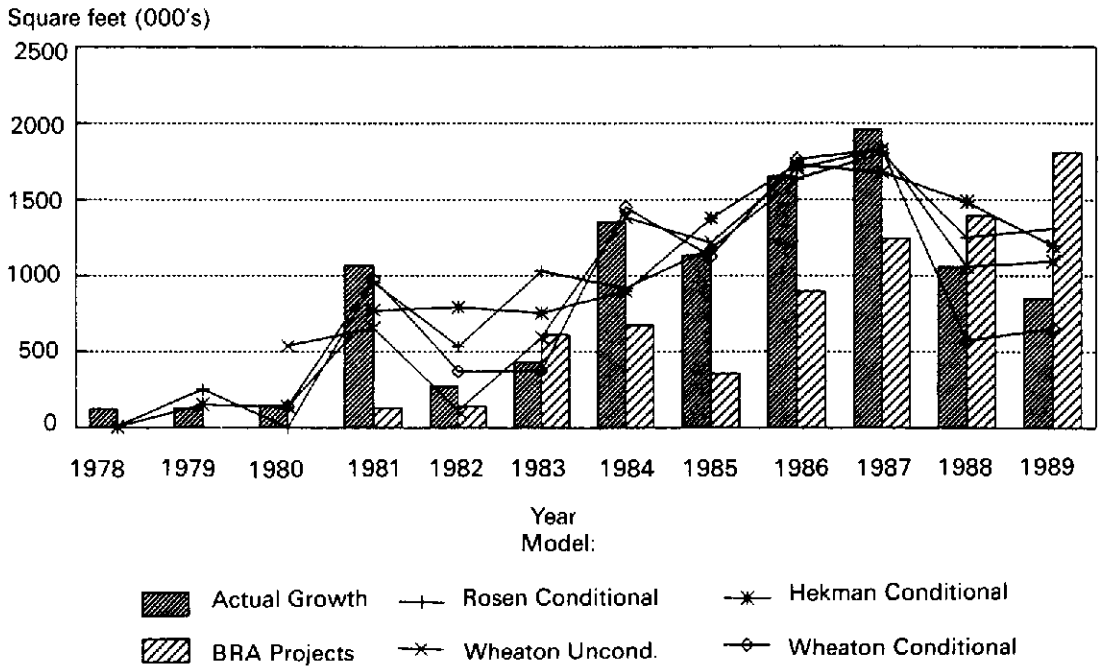
The data used to build the econometric models provide conflicting information on the overall health of the office market. Some data suggest that the office market boom would continue. The amount of occupied square feet increased at a rapid rate while the vacancy rate dropped. However, other information available in 1987 suggested that the boom might subside. Interest rates started up in 1987, real effective rents flattened out, and the latest round of federal income tax reform removed some of the benefits available to real estate.

Well-specified models need to be able to examine these conflicting indicators and properly forecast the resulting growth in occupied office space. The four models have been applied to these Boston data and the results are summarized in Exhibits 1 and 2.

All four of the models examined here appear to track the trend relatively well. (See Exhibit 3.) All four models traced the peaks of 1981 and 1987, and all four predicted a downturn after 1987. The Wheaton models did the best job of forecasting the downturns of 1982–1983 and 1988–1989. The Rosen and Hekman models did indicate that a downturn would occur in 1988 and 1989, but the scale of the decline was underestimated.

The models provide conflicting information in terms of the parameters estimated. As with Hekman's original work, the variable for the presence of tax incentives did not

Exhibit 3
Alternative Office Space Models
Boston Class A Office Market



Source: Derived by the author.

prove to be helpful and was omitted from the models estimated here. Only the original Wheaton conditional forecast model has an R-squared statistic in excess of 0.95; the others fell within the range of 0.81 to 0.87 which is low for time-series models. Relatively few of the variables tested proved to generate coefficients of the correct sign and passing normal tests of significance. The coefficient for vacancy rate was negative in the Rosen model but was not significant. In the Wheaton conditional model, the variable was significant but had the wrong sign. The employment growth variables were not significant with the Hekman or the Wheaton models.

Exhibit 4 lists the forecasts generated from these models. In each case, the quality of the forecast is assessed by measuring its deviation from the actual market behavior. All of the models, despite their unimpressive performance on theoretical grounds, generated better forecasts than could be achieved with the moving average, trend line approach. For the 1988 forecasts, the econometric models performed slightly better with forecast errors ranging from less than 1% to about 40% while the trend line models had errors ranging from 32% to 69%. With the large drop in the growth in office space in 1989, the difference between the two approaches becomes apparent. The trend line models had errors from 74% to 112% while the econometric models ranged from 23% to 54%.

The differences between the econometric models probably have more to do with the quality of the data available than with their specification. The available data for Boston cover only a few years providing a very small data set from which to estimate the

Exhibit 4
Forecasts of Growth in Occupied Office Space Using Alternative Models

Actual and Estimated 1988 and 1989 Increases in Boston Class A Occupied Office Space
Dependent Variable: Increase in Occupied Square Feet

		Year 1988	Year 1989
Actual Increase (000's of Square Feet)		1,062	850
Model			
Rosen Conditional:	Forecast	1,252	1,313
	Error	18%	54%
Hekman Conditional:	Forecast	1,487	1,200
	Error	40%	41%
Wheaton Conditional:	Forecast	657	655
	Error	−38%	−23%
Wheaton Unconditional:	Forecast	1,061	1,097
	Error	1%	29%
BRA Projections			
Assumption:			
Constant	Projection	1,800	1,800
Avg. Growth	Error	69%	112%
Constant 5.5%	Projection	1,400	1,478
Growth Rate	Error	32%	74%
Constant 6%	Projection	1,583	1,678
Growth Rate	Error	49%	97%

Source: Derived by the author.

models. By making these comparisons, it must also be remembered that the conditional econometric models' error rates are probably understated. The conditional models were used to make forecasts with the known 1988 and 1989 data for the independent variables. If used in practice, this would imply perfect knowledge of the 1988 and 1989 data in 1987 when the forecasts would have been made. In all probability, a practitioner would have to make forecasts based upon imperfect predictions of the economic conditions that will hold during the forecast time period, increasing the likely difference between the actual growth in occupied space and the forecast.

Conclusions

The comparison of alternative forecast models provides some mixed evidence on the desirability of using econometric models rather than trend analysis models. Although the degree of improvement varies with the econometric model employed, the econometric forecasts are likely to be more accurate than the projections generated using trend analysis. This improved performance is due to the econometric models' greater responsiveness to changes in economic conditions, especially where the changes are found in leading indicators such as rent levels and vacancy rates. These econometric

models do not relay on past trends, rather they are based upon empirically derived relationships between the amount of occupied space and selected economic factors. This provides greater predictability in times of dramatic shifts in economic conditions. The comparison also indicates that the office space models can be applied to small data sets covering only a single, local market. While these econometric models require more raw data and more data manipulation than their trend analysis counterparts, the amount of extra work is not prohibitive, and the forecasts are likely to be more accurate. At the very least, practitioners in real estate development should monitor alternative forecasts generated using a variety of forecast techniques, including econometric models, fitted to data from the market being considered for further investment.

References

[1] R. Amatruda. The Boston Office Market, First Quarter 1990 and Quarterly Projections, 1990–1994. Boston: The Boston Redevelopment Authority, 1990.

[2] ———, J. Avault, A. Ganz, R. Henderson, M. Johnson and G. Perkins. *Outlook for Boston and the Bay State: Economy at Crossroads.* Boston: The Boston Redevelopment Authority, 1990.

[3] R. Amatruda and K. McClure. *Boston Class A Office Vacancy Rates: 1989 First Quarter Estimated and 1987–1991 Projected.* Boston: The Boston Redevelopment Authority, 1987.

[4] Coldwell Banker. *Downtown Boston Office Market Report.* 1989.

[5] Cushman & Wakefield. *Focus on Boston Trends, 3rd Quarter.* 1989.

[6] D. Dowall. Planners and Office Overbuilding. *Journal of the American Planning Association* 52:2 (Spring 1986), 131 32.

[7] D. Ellis and G. K. Brown. Nominal and Real Vacancy Rates in Office Market Analysis. *Real Estate Review* 19:3 (Fall 1989), 67 71.

[8] J. S. Hekman. Rental Price Adjustment and Investment in the Office Market. *AREUEA Journal* 13:1 (Spring 1985), 32 47.

[9] R. D. Hylton. Real Estate Woes Seen Worsening: Commercial Values Expected to Plunge in Next 2 to 3 Years. *New York Times*, November 19, 1990.

[10] W. B. Martin. Finding and Financing a Turnaround Office Building. *Real Estate Finance* 20:2 (Summer 1990), 41–45.

[11] Meridith & Grew. *Greater Boston Market Report, 3rd Quarter.* 1989.

[12] K. Rosen. Toward a Model of the Office Building Sector. *AREUEA Journal* 12:3 (Fall 1984), 261–69.

[13] Spaulding & Slye. *The Spaulding & Slye Report, 2nd Quarter.* 1989.

[14] Urban Land Institute. Development Trends 1991. *Urban Land* 50:3 (March 1990), 16 19.

[15] R. Voith and T. Crane. National Vacancy Rates and the Persistence of Shocks in U.S. Office Markets. *AREUEA Journal* 16:4 (Winter 1988), 437 58.

[16] W. C. Wheaton. The Cyclic Behavior of the National Office Market. *AREUEA Journal* 15:4 (Winter 1987), 281 99.

[17] ——— and R. G. Torto. Vacancy Rates and the Future of Office Rents. *AREUEA Journal* 16:4 (Winter 1988), 430–36.