REIT-Based Property Return Indices: *A New Way to Track and Trade Commercial Real Estate*

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REITs are a means of real estate investment that provide good liquidity and good transparency. While REIT equity values were pummeled during the recent downturn—in a manner understandably exaggerated by REIT leverage—REIT stocks have nevertheless maintained their liquidity and transparency. Whatever the stock market's weaknesses regarding *herd behavior* and excess volatility, the public securities exchanges are highly efficient mechanisms for information aggregation and price discovery. These beneficial characteristics allow us to infer price movements in underlying property markets on a daily basis from REIT returns without having to directly observe property transactions, which occur only with varying frequency and among dissimilar assets.

REITs pose some difficulties for investors and hedgers wishing to trade in commercial property markets, however. On the right-hand side of the balance sheet, almost all REITs are levered. On the left-hand side, almost all REIT asset holdings are diversified across individual commercial property market segments, especially across national and international regions. The result is some degree of obfuscation between the property level of the direct real estate market segments and the returns visible directly in REIT stocks or sectors. This article reports on a major effort, sponsored by NAREIT and undertaken at the MIT Center for Real Estate, to develop tradable REIT-based portfolios whose returns reflect unlevered, property-level returns within individual property market segments that are defined by property usage type sector and geographic region. These so-called pure-play portfolios can be useful both as information sources about property markets and potentially as tradable portfolios to enable liquid, transparent investment in property market segment-specific portfolios.[1]

BACKGROUND

The approach presented in this article of combining information on REIT asset holdings with REIT stock returns to derive information about the underlying property markets dates back, in part, to at least the mid-1990s with work by Giliberto [1993], Gyourko and Nelling [1996], and Geltner and Kluger [1995, 1998]. The last authors originally proposed two methodologies for constructing property return indices using REIT data. Geltner and Kluger [1995] offered a regression-based approach wherein REIT returns are delevered and regressed against property holding data in a pooled regression. Data limitations at the time of their analysis prevented the construction of a high-frequency index. With the benefits of new, larger datasets, we refined and extended their analysis. We show that it is possible to create good-quality, high-frequency indices of property prices using REIT data.

Geltner and Kluger [1998] offered a second approach—the *pure-play* methodology. This approach constructed long–short combination portfolios with "pure" exposures to target real estate segments using mathematical optimization. The pure-play approach also yielded promising results, but, again, a high-frequency index could not be well constructed due to limited data availability at the time. In this article, we will compare the pure-play methodology with the regression methodology, and show that under conventional assumptions the two methodologies yield mathematically identical results. In 2008, NAREIT and the MIT Center for Real Estate launched a project to revive and reexamine the pure-play index idea with the aim of developing commercially useful information and a trading product, taking advantage of the rich REIT industry data now available and the considerable growth and development of the REIT industry since the mid-1990s.

THE MECHANICS: HOW PURE-PLAY PORTFOLIOS WORK

As noted, from a mathematical perspective there are two essentially identical approaches to using REIT returns to construct segment-specific returns in the property asset market—the regression model and the long–short hedge portfolio. In the article, we will present the regression perspective, leaving to the appendix the discussion of the equivalence of the two approaches. In our analysis, we examined property-segment indices at the monthly and daily frequencies and compared them historically to the Moody's/REAL Commercial Property Price Indices (CPPI), the leading transaction price–based indices of U.S. commercial property price movements in the direct private asset markets.[2]

We employed a modified version of the Geltner–Kluger model in which we regressed the contemporaneous monthly REIT returns on a set of variables that represent proportional property-segment holdings for each REIT.[3] For a capital return index, the dependent variable is the REIT price return delevered using the weighted average cost of capital (WACC) accounting identity,[4]

$$roa_{i,t} = (\%\text{equity}_{i,t}) \cdot r_{i,t} + (1 - \%\text{equity}_{i,t}) \cdot \text{debtrate}_t \quad (1)$$

Rather than pooling observations as Geltner and Kluger [1995] did, due to the greater availability of REIT data now, we were able to perform a separate regression for each subperiod (monthly or daily) over the period January 1, 2001, to December 31, 2007.[5]

Therefore, the delevered return for REIT i is regressed on its asset-holding exposures to each property market segment,

$$\begin{aligned} roa_{i,t} = {} & b_{A,t}x_{A,i,t} + b_{O,t}x_{O,i,t} + b_{I,t}x_{I,i,t} + b_{R,t}x_{R,i,t} \\ & + b_{H,t}x_{H,i,t} + e_{i,t} \end{aligned} \quad (2)$$

where $roa_{i,t}$ is the REIT i delevered return over the period $t-1$ to t; x refers to the REIT i percentage of total assets held in each segment at $t-1$; b is the market-segment index return; and the A, I, O, R, and H subscripts refer to the apartment, industrial, office, retail, and hotel market segments, respectively, and[6]

$$x_{Ai,t} + x_{O,i,t} + x_{I,i,t} + x_{R,i,t} + x_{H,i,t} = 1 \quad (3)$$

Rewriting in matrix notation, we have the following (omitting the subscript t for clarity):

$$\boldsymbol{roa} = \boldsymbol{Xb} + \boldsymbol{u} \quad (4)$$

where $\boldsymbol{roa}$ is a vector of length N, with each element representing the period $t-1$ to t return to each of the $i = 1 \ldots N$ REITs. $\boldsymbol{X}$ is an $N \times K$ matrix containing the dollar percentages of assets held by each REIT in each of the $k = 1 \ldots K$ segments (in the model described by Equation (2), K is the fifth of five segments). By increasing the number and specificity of explanatory variables, we were able to construct indices of greater granularity as we will show later in the article.

In order to efficiently estimate the segment returns (the regression coefficients), we employed generalized least squares (GLS) weightings based on an assumption, consistent with Geltner–Kluger, that the variance of each REIT's idiosyncratic return, e_i, is inversely proportional to the total dollar value of its property holdings, and that the idiosyncratic returns are uncorrelated, normally distributed, and have mean zero.[7] Intuitively, this weighting reflects the assumption that larger REITs are likely to have less idiosyncratic return variance because they have less property-level idiosyncratic risk exposure as a result of holding larger, more diversified portfolios of properties. In other words, a type of heteroskedasticity exists in which smaller REITs have greater idiosyncratic variance.

We then estimated the indices using generalized least squares,

$$\hat{\beta} = (X^T \Omega^{-1} X)^{-1} X^T \Omega^{-1} roa \quad (5)$$

where Ω is an $N \times N$ diagonal matrix containing the idiosyncratic REIT return variances, with each diagonal element defined as[8]

$$u_{i,i}^2 = \frac{1}{\text{total}_i} \tag{6}$$

where

total_i = total dollar value of properties held by REIT i.

We define a segment portfolio $\boldsymbol{H}$ as follows:

$$\boldsymbol{H} = (X^T \Omega^{-1} X)^{-1} X^T \Omega^{-1} \tag{7}$$

The matrix $\boldsymbol{H}$ describes a set of weights, which define hedge portfolios that eliminate exposure to all but one market segment for each portfolio. That is, $\boldsymbol{H}$ is a $K \times N$ matrix where each row k represents a portfolio of weights of REITs having unit exposure (100% exposure) to segment k and zero exposure to every segment other than segment k. The segment portfolio weights, which represent both long and short positions, sum to one for the target segment and to zero for the nontarget segments. A segment portfolio, were it investable, would yield a pure return to the target segment while minimizing idiosyncratic REIT return variance.

The segment portfolios contained in $\boldsymbol{H}$ do not include the debt positions needed to offset the leverage held by the REITs, because that leverage has already been removed from the dependent variable, *roa*. Note also that the optimal relative weights of the REITs in the segment portfolio $\boldsymbol{H}$ are independent of leverage and the techniques used to deleverage the REIT returns. This implies that, were an investor to purchase the *segment portfolio*, it would be possible to synthetically add or subtract leverage by appropriately scaling the portfolio weights.

DATA

We studied publicly traded equity REITS during the period 2001–2007, using as our universe the REITs listed in the NAREIT/FTSE indices. Exhibit 1 shows the number of publicly traded equity REITs in each of the NAREIT/FTSE indices in each year during the study period. The decline in publicly traded equity REITS in 2006, 2007, and into 2008 was caused both by consolidation within the REIT industry and by a flurry of privatizations.

Using information supplied by NAREIT along with data pulled from public SEC 10-K filings, we calculated the explanatory variables needed for the models for each month. For example, Exhibit 2 shows the distributions of the exposures, *exp*, to the office sector for the first and last years in our study period.

Where the dollar value of assets in a REIT portfolio is unknown, proxies for property value, such as rental

EXHIBIT 1
Equity REIT Universe

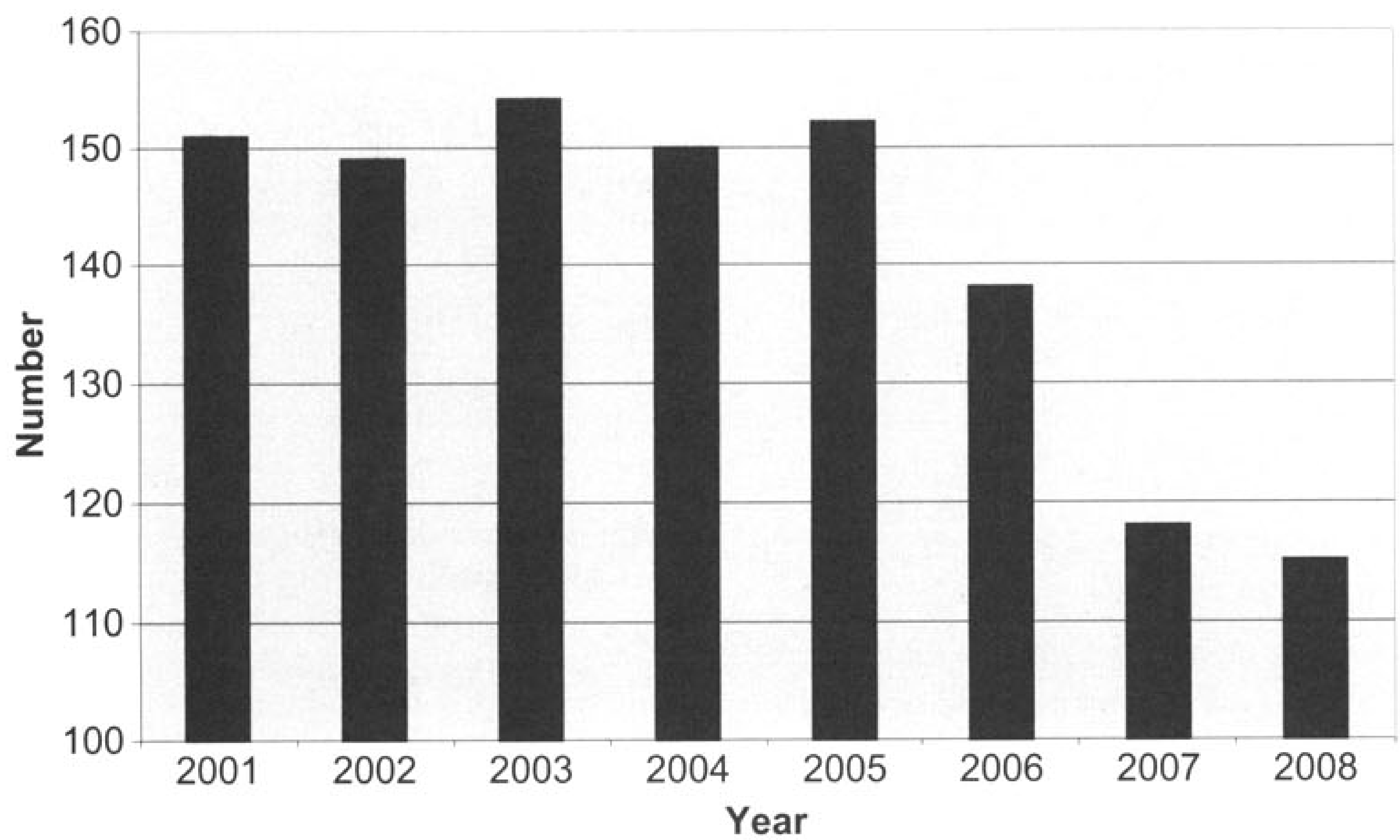
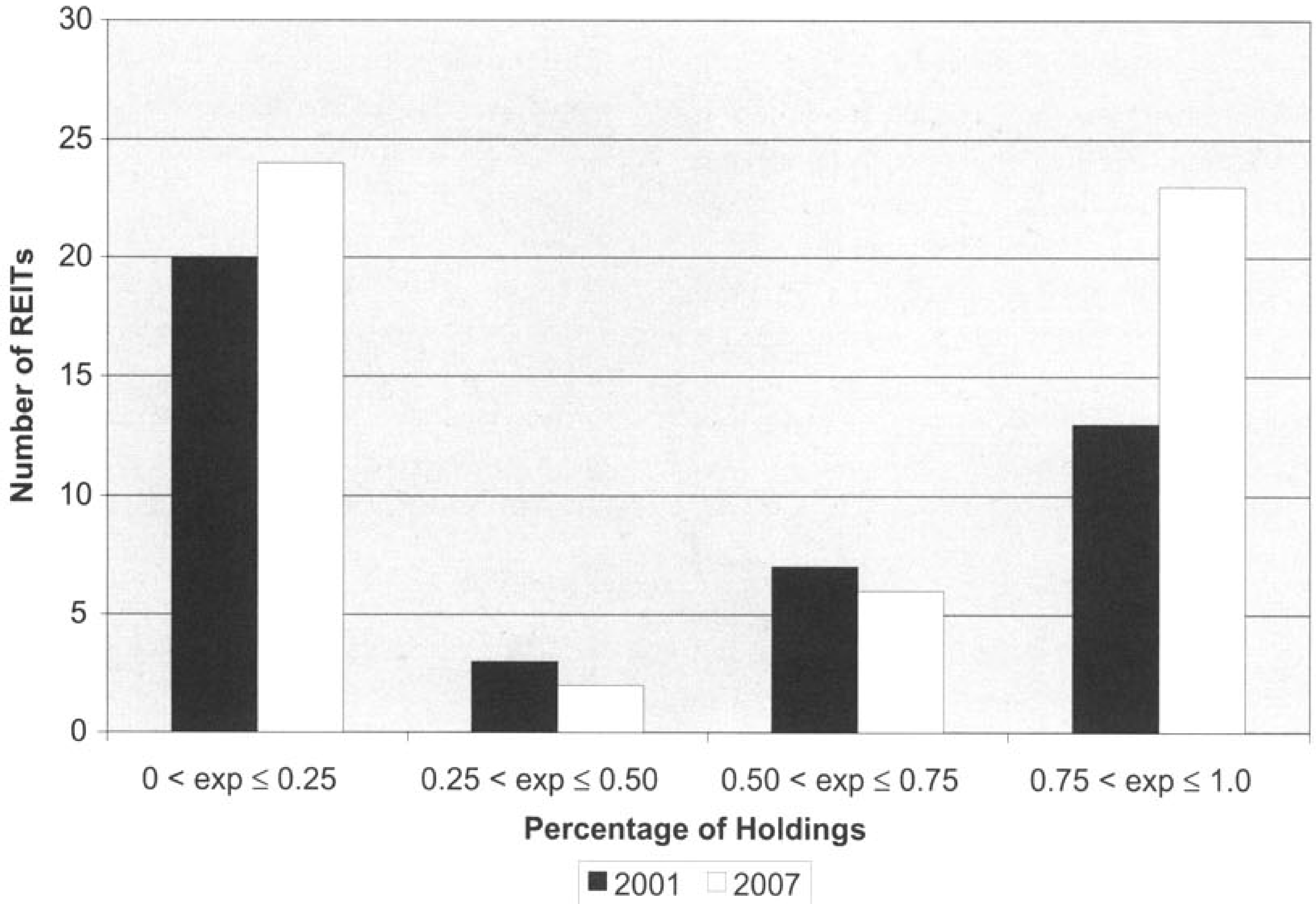


Exhibit 2

REIT Investment Levels in Office Sector



income or total square footage, were used to calculate the percentage holdings in the various market segments.[9] Few REITs diversify equally across industries. It is unusual to find a REIT with 25% of its holdings in apartment, 25% in industrial, 25% in retail, and so forth, but many REITs do have some small exposure to sectors outside their primary type. Of the sectors examined, hotel/lodging REITs tend to be the most highly focused.

Exhibit 2 is typical and shows that classifying REITs into property sector categories without accounting for smaller segment holdings ignores a good deal of valuable information. The regression model presented here is able to utilize all of the property holding information—even the smallest exposures. By contrast, the NAREIT/FTSE sector indices exclude from the retail sector index any REIT whose retail properties compose 60% of its portfolio, despite the fact that the majority of its property exposure is in the retail sector. (As noted, this convention applies to all of the NAREIT/FTSE indices.)

Using the same property holding data, we can similarly generate independent variables for a 20-segment model consisting of the five property sectors times four geographic regions. As we will discuss later in the results portion of the article, a few segments must be recombined in order to create stable regression estimates. For example, regional hotel segments are not well represented in the data in the early years of the study and are recombined.

Return data for the REITs were supplied by NAREIT. We utilized price-only returns (excluding dividends), so as to track property price movements.[10] Returns were reviewed for data errors, but none needed to be culled or truncated.

Using financial information from NAREIT and from annual 10-K forms, we generated values for the $\%equity_{i,t}$ and the $(1 - \%equity_{i,t})$ terms of Equation (1) for each REIT and time period. The %equity, also referred to as the equity ratio, is defined as total stockholder's equity, as reported on the REITs' 10-K forms, divided by the sum of total stockholder's equity and total liabilities. The equity ratio data is updated annually for each year in the study. We did not adjust for possible minority interest holdings, because during the study period minority interests were relatively insignificant on most balance sheets. In the future, minority interests may become more significant on a greater number of REIT balance sheets and would then warrant closer attention. Equity ratios remained fairly stable over the period with a mean and median of 36% in both 2001 and 2007, and with a cross-sectional range from 7% to 83% in 2001 and from 7% to 76% in 2007.

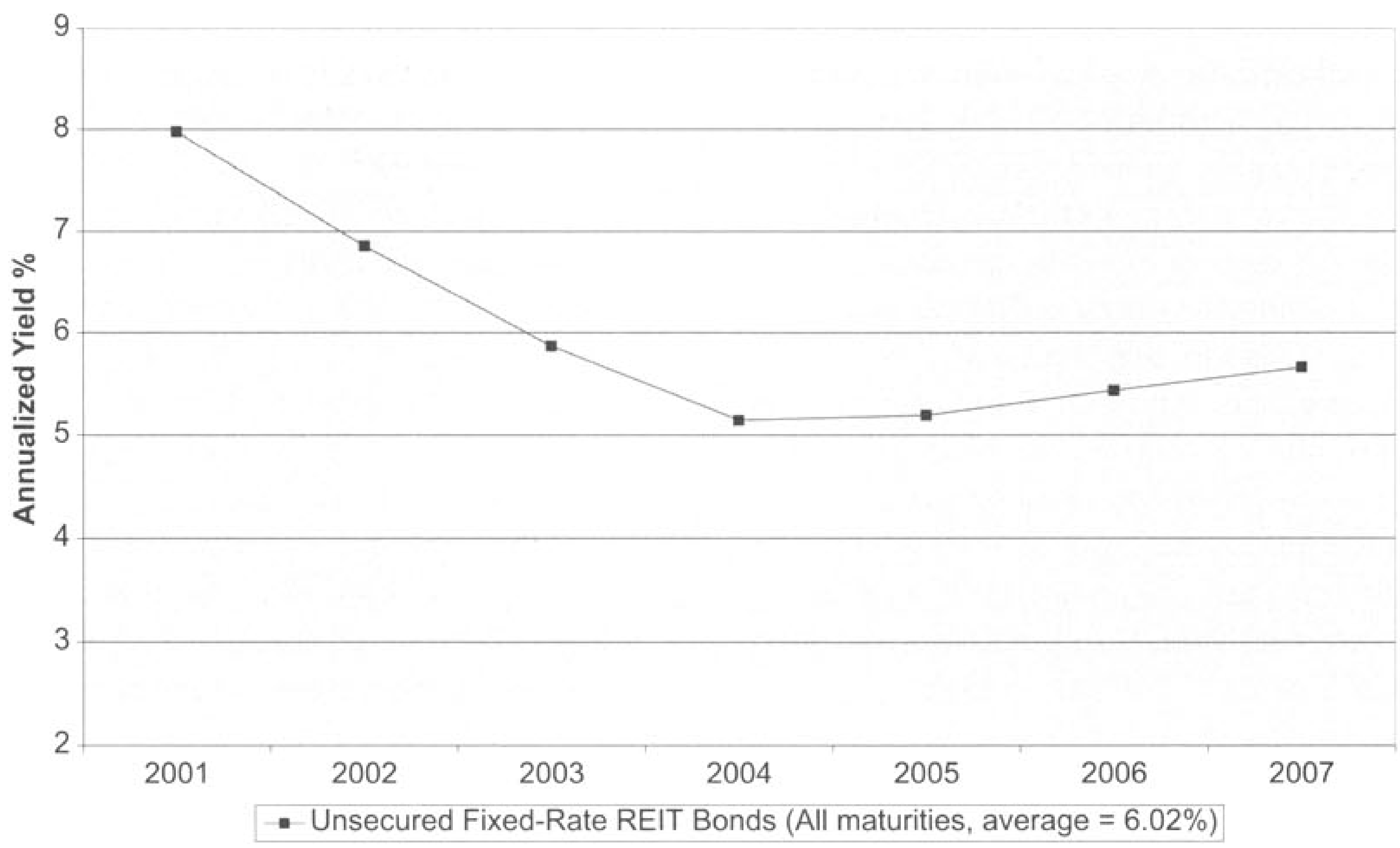
In reference to Equation (1), we needed an estimate for the cost of debt, *debtrate*, in order to complete the deleverage calculation. Pagliari, Scherer, and Monopoli [2005] proposed estimating the cost of debt as a function of interest expense, preferred dividends, value of preferred shares, and debt. In our study, we used market-wide average yields on unsecured REIT debt as a proxy for the cost of debt, with the same rate applied to every REIT for the year. Some REITs report their weighted average cost of debt in their annual 10-K filings. A comparison of the REIT-reported average costs of debt with the estimated values in Exhibit 3 indicates that our estimates are reasonable. For example, in 2007, Boston Properties reported a weighted average cost of debt of 5.60% and Mack-Cali Realty reported a value of 6.08%. The model uses a value of 5.66% in 2007 for all REITs. Although the deleveraging process would be more precise if REIT-specific values were obtained, we defer this refinement for future research. As mentioned in the preceding section, assumptions regarding the cost of debt can be varied without changing the composition of the segment portfolios defined by Equation (7).

RESULTS

We began by separately running the GLS regressions described by Equation (2) for each of the 84 months spanning the period 2001–2007. We accumulated the estimated segment returns defined by Equation (5) and plotted them against the corresponding quarterly or annual Moody's/REAL CPPI, which directly tracks private market transaction prices. As illustrative examples, Exhibits 4 and 5 plot the indices for the apartment and office sectors. The similarity between the REIT-based and private market–based price indices suggests that the REIT-based indices are indeed capturing the essence of the segment-specific returns to the underlying private property market, but with some interesting differences, as described next.

For each sector except apartment/residential, the REIT-based estimated delevered segment returns resemble the corresponding Moody's/REAL price changes. Of course, we would not expect the two types of indices to be identical because they are not tracking the exact same property markets and the stock market does not exactly evaluate property in the same way the private direct market does. Furthermore, the REIT-based indices may reflect effects of REIT-level management or a

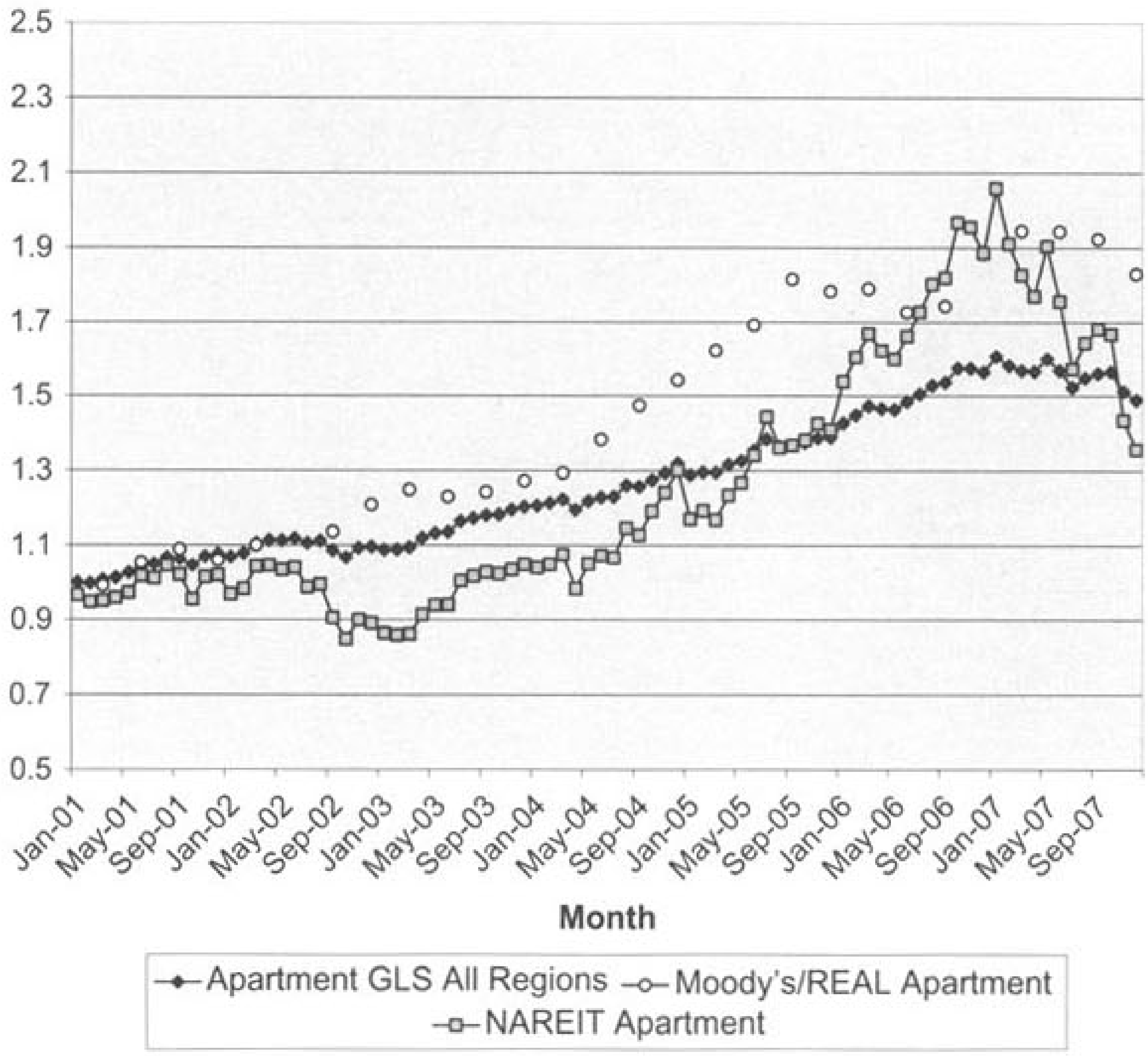
EXHIBIT 3
Historical REIT Debt Costs



Note: Rates on newly issued unsecured debts.

Exhibit 4

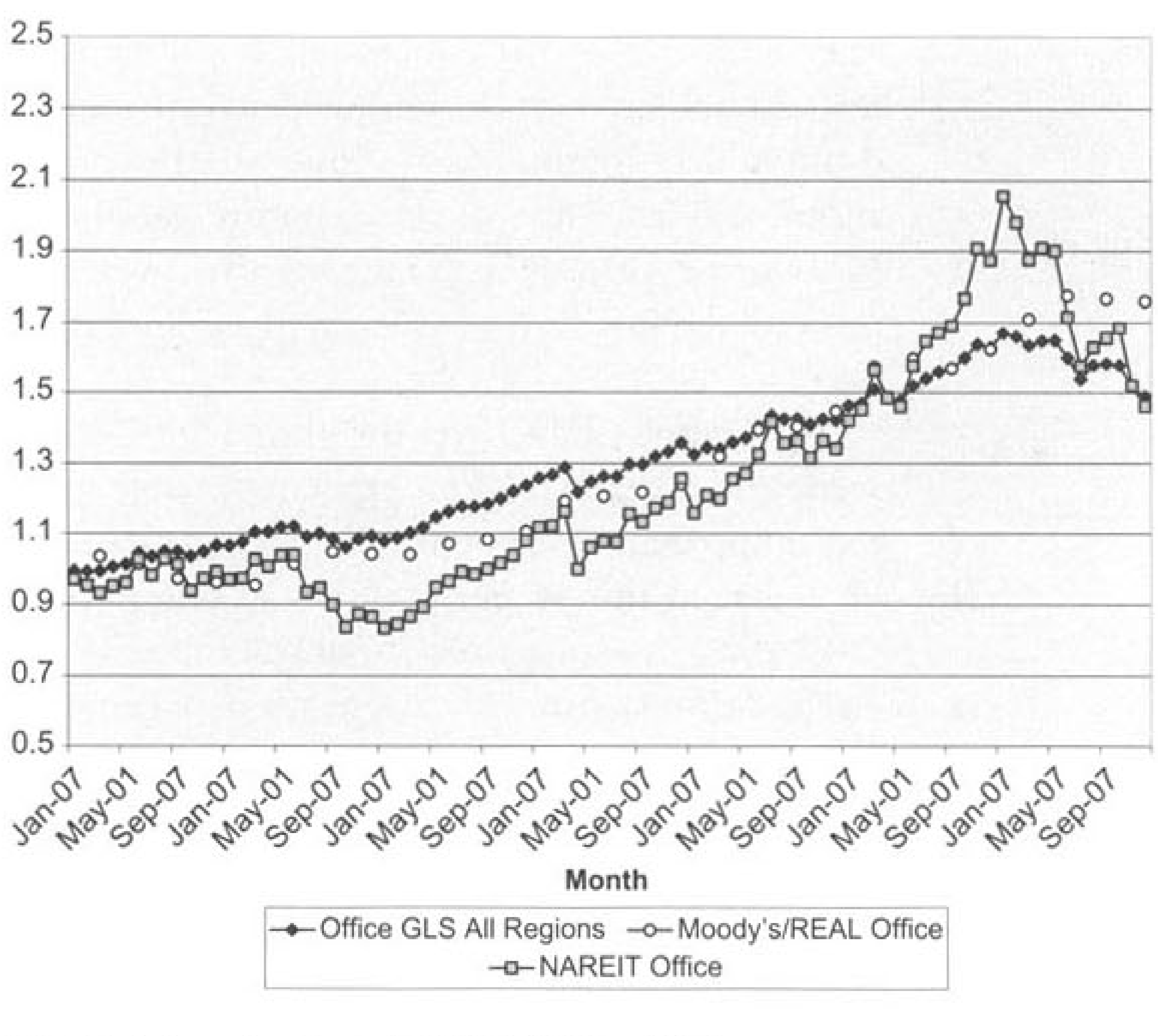
Apartment Sector, 2001–2007



Note: Industry-only delevered GLS REIT-based index.

Exhibit 5

Office Sector, 2001–2007



Note: Industry-only delevered GLS REIT-based index.

market-wide REIT discount or premium. Perhaps most interesting is the apparent ability of the REIT-based indices to lead the private market price movements. For example, the REIT-based office index shown in Exhibit 5 begins to decline in January 2007, whereas the Moody's/REAL suggests that prices in the private market did not begin to decline until after the following June.

The difference noticeable in Exhibit 4 between the REIT-based index and the private market–based index in the apartment sector is logically attributable to the difference in condo-conversion participation during this time period, with REITs being less active in this market than private investors. Exhibit 6 highlights the spike in private-market condo conversions that began in 2003 and 2004 and declined after 2005. During 2004 and 2005, condo-conversion demand drove up broadly the prices of apartment property transactions in the private market as landlords sold to converters. But apartment REITs were generally committed to remaining permanently in the apartment rental business and the stock market knew that. Hence, apartment REIT share prices were not bid up in anticipation of "flipping" apartments to condo converters. The REIT-based apartment index therefore continued to reflect more fundamental valuations of apartments as rental units, unlike many transactions in the direct private property market. In late 2005 and 2006, the condo boom came to an abrupt end, causing the price drop in the private market reflected in the Moody's/REAL index during that period, while the REIT-based valuations continued to rise steadily. The last surge in the private equity and CMBS-based boom in the private property market was reflected in the upsurge of the Moody's/REAL index from late 2006 through mid-2007, whereas the REIT-based apartment index began its downturn in January 2007, anticipating the subsequent private market correction.

Exhibit 7 compares the annualized volatilities of the REIT-based pure-play indices with the Moody's/REAL indices over the same period.[11] The pure-play volatilities are similar to, and in some cases lower than, the volatilities of the corresponding transaction-based private market indices.[12]

Exhibit 6
Apartment Purchases, 2001–2007

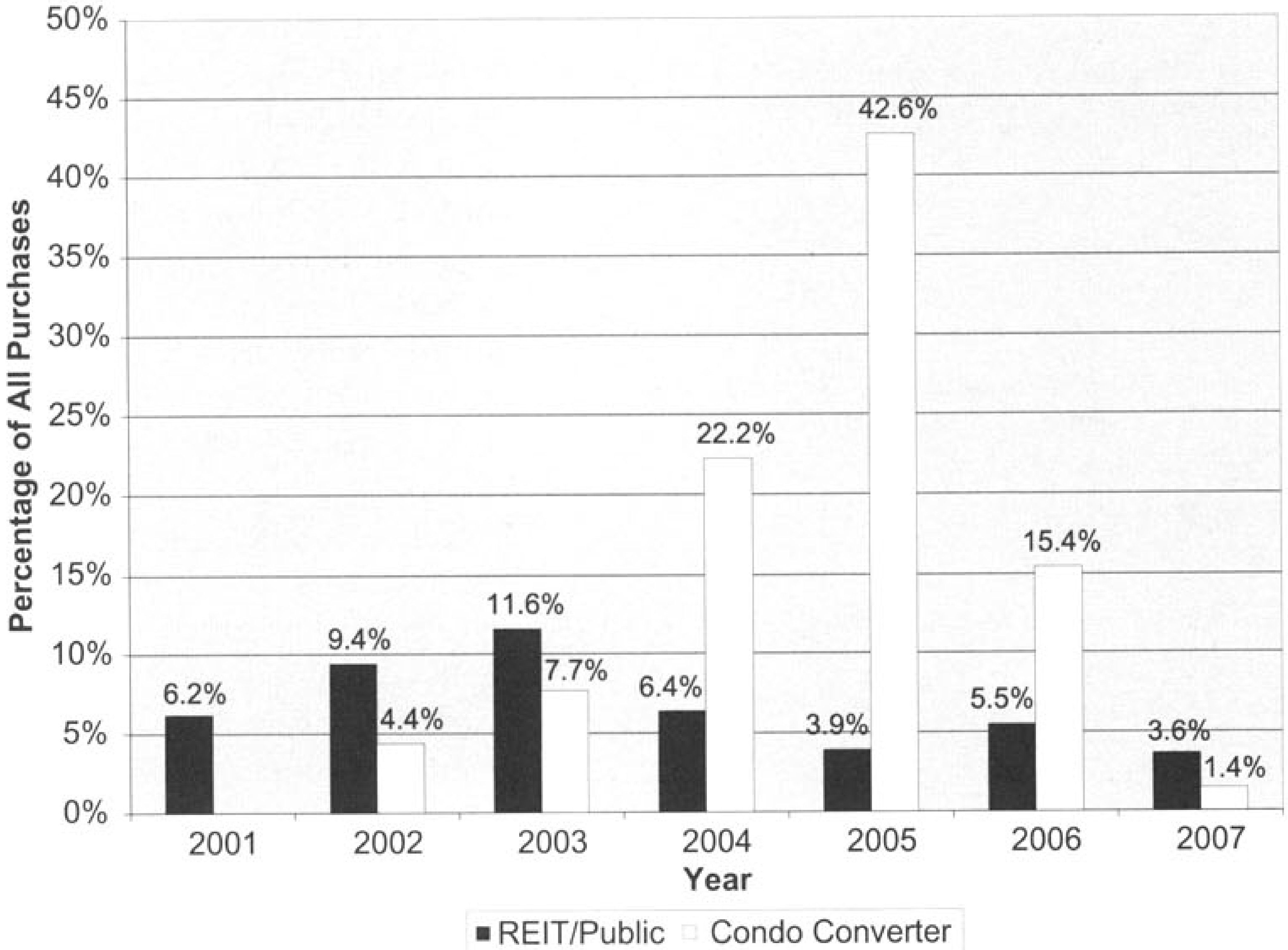


Exhibit 7
Volatility Comparison, 2001–2007

	Apartment	Office	Industrial	Retail	Hotel
REIT-based Monthly Delevered Annualized Volatility	4.80%	5.84%	6.46%	5.18%	10.15%
Moody's/REAL Quarterly Annualized Volatility	8.06%	6.27%	7.05%	5.11%	N/A

EXPERIMENTING WITH MODEL GRANULARITY

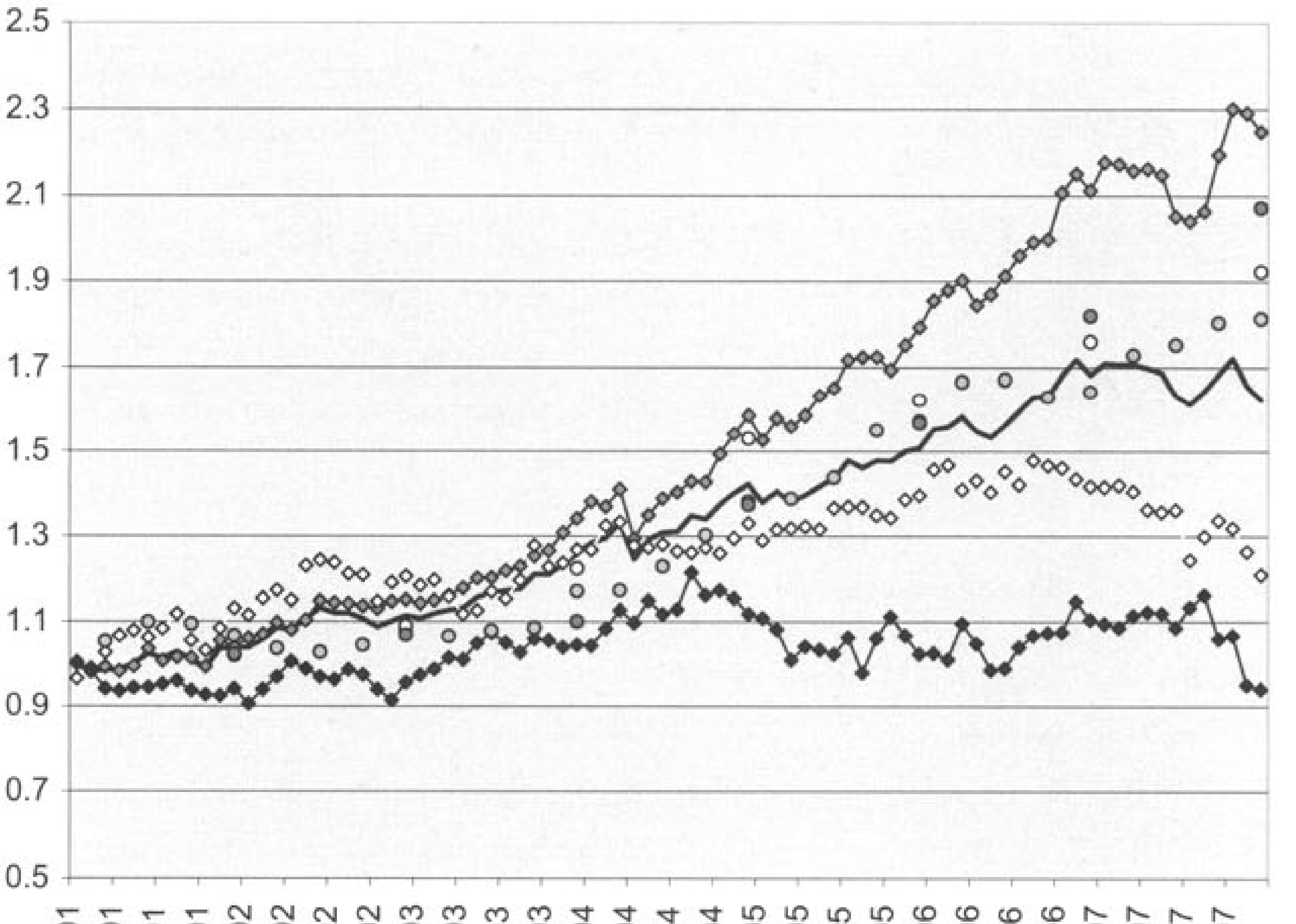
Across industry segments, the pure-play indices resemble delevered NAREIT indices while offering modest improvement in volatility.[13] A more significant contribution of the pure-play methodology lies in its ability to simultaneously provide granularity across industry segments and regions. Therefore, we explored the feasibility of combining property-usage-type sectors and geographic location information to further refine market segments.[14] To do this, we expanded the number of independent variables in the regressions from 5 to 20, reflecting five sectors times four regions. Of course, the inclusion of 20 explanatory variables can cause high standard errors in the estimated segment returns due to the multicollinearity of a few of the exposure variables.[15] In order to quantify and mitigate the severity of this multicollinearity, we calculated variance inflation factors (VIFs).[16]

For each month over the period 2001–2007, we regressed each market segment variable on all remaining market segment variables and calculated VIFs. We averaged the 84 period VIFs to compute an average VIF for each explanatory variable. Using the VIF analysis, in addition to simple correlations between variables, we analyzed how best to combine regions so as to retain as much granularity as possible. We combined the hotel market segments into a single, nearly orthogonal, independent variable, and we combined the industrial South and industrial West. The resulting VIFs in the 16-segment model are much lower for the combined segments and are low and mostly unchanged for the remaining segments (VIFs of 2.00 or lower). Only the industrial Midwest segment remains possibly problematical. It is important to remark that the VIFs for the regional hotel market segments drop significantly between 2001 and 2007. In fact, by 2006, the regional hotel VIFs are all 2.00 or lower as a result of increased REIT participation in the hotel market segment. In the future, it may be possible to disaggregate the hotel segments. In contrast, the VIFs for Southern industrials and Western industrials remain stable and elevated over the period. Given the limitations of the data, at this time we are unable to explore market segments, such as economic or metropolitan regions. Our early investigations suggest, however, that with additional data, further segmentation will be possible and valuable.

Exhibit 8 shows the graphs for the delevered industrial East, Midwest, and South/West model alongside the corresponding Moody's/REAL index (where available) and the national sector index previously reported. Exhibit 8 highlights the difference in regional performance within the industrial property sector over the period 2001–2007. The difference in cumulative return performance between Southern/Western industrials and Midwestern Industrials is over 130%. Other sectors show less regional differentiation. For example, in the retail sector, the West Coast outperformed the East Coast by 35% over the seven years in our study period.[17] In general, the Moody's/REAL indices do not reflect as much regional differentiation as the REIT-based indices over this period.

EXHIBIT 8

Industrial Sector, 16-Sector Model GLS REIT-Based Indices



DAILY FREQUENCY PROPERTY SECTOR INDICES

We generated the national sector indices on a daily basis beginning in 2004. We have not yet been able to update property portfolio holdings or balance sheet data on a daily basis for this study, but we have observed little change in overall proportional holdings over time, even on a quarterly basis. Daily returns for REITs are readily available. Exhibit 9 shows the estimated indices for the industrial sector on a daily basis, on a monthly basis, and as compared to the quarterly Moody's/REAL CPPI. Increasing the estimation frequency from monthly to daily does not introduce additional noise into the estimated indices. This is confirmed visually by the graphical comparison of the daily and monthly indices, as well as statistically, as shown in Exhibit 10, which provides a comparison of volatilities of the indices. This type of increasing frequency without increasing noise or lag is only possible with a stock market–based index because of the informational efficiency of daily stock market closing prices; relatively little random price level dispersion or "noise" exists in stock prices compared to individual private market transactions of individual properties.

THE ROLE OF PURE-PLAYS IN PORTFOLIO INVESTMENT STRATEGY

The pure-play portfolios, which are presented in this article, are of interest as information tools that can empirically track price movements and investment returns in property market segments; however, they potentially go beyond merely providing useful information to the marketplace. These indices present interesting possibilities for

EXHIBIT 9
Industrial Sector Daily and Monthly Indices, 2004–2007

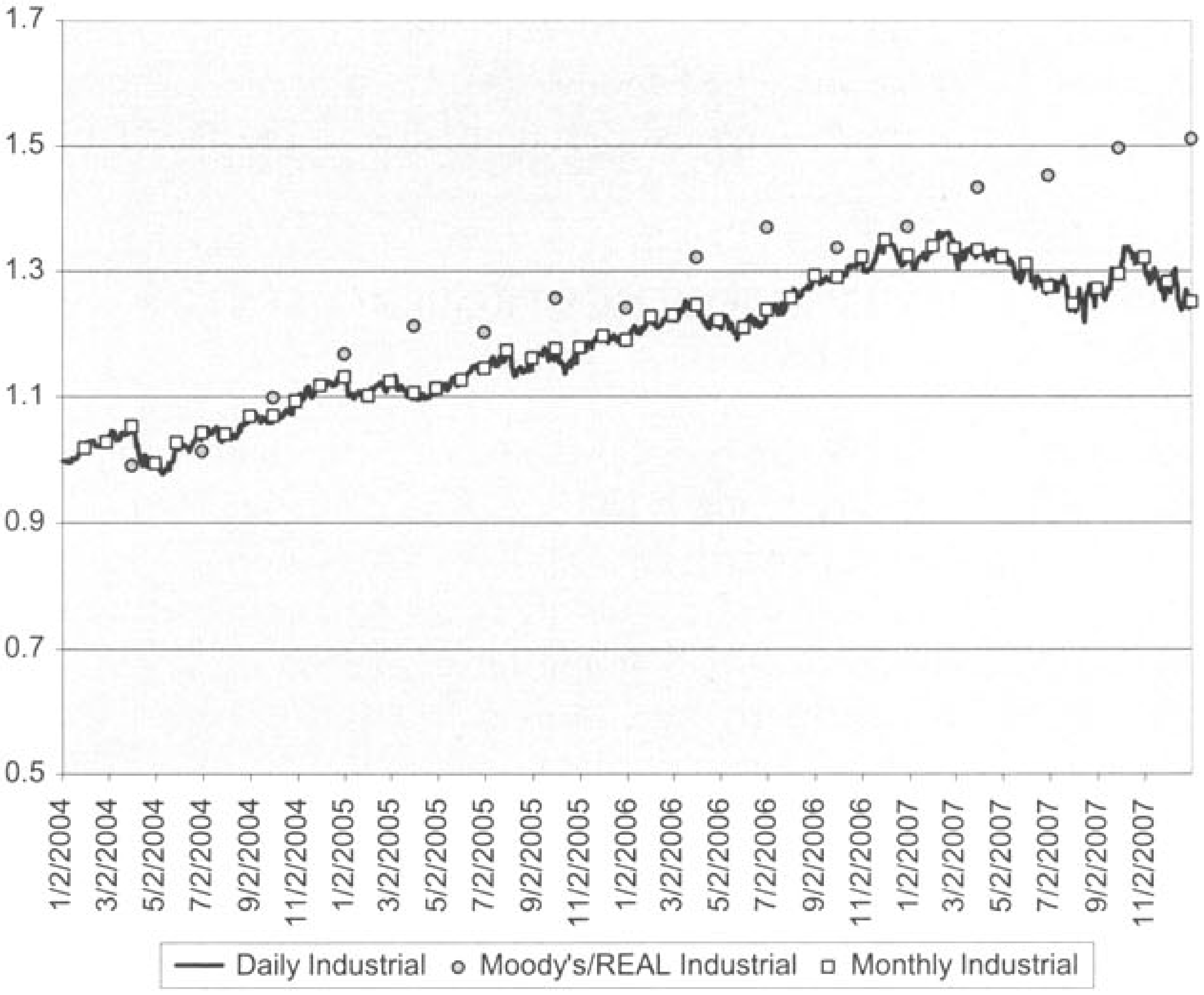


EXHIBIT 10
Volatility Comparison, 2004–2007

	Apartment	Office	Industrial	Retail	Hotel
Daily Model Annualized Volatility	4.70%	6.49%	6.25%	6.32%	7.34%
Monthly Model Annualized Volatility	4.36%	6.11%	6.18%	6.27%	7.27%
Moody's/REAL CPPI Quarterly Annualized Volatility	8.03%	6.15%	6.13%	5.70%	N/A

supporting derivatives and investment vehicles for synthetic or indirect investment in commercial property. Recently, the trading of derivatives based on private market indices of commercial property returns has significantly taken off in the U.K., where the notional value of swaps traded based on the (appraisal-based) IPD Index has grown to approximately one-half the cash trading volume in the physical properties tracked by the index.[18] Synthetic real estate investment vehicles offer certain features, such as low transactions and management costs, relatively less management burden, easy diversification across individual properties, and the ability to sell short, which enables hedging of real estate market risk exposures and the harvesting of portable alpha.

The pure-play indices presented in this article may support commercial property derivatives and synthetic or indirect property investment in several new ways. First, as we have discussed, the public market tends to lead the private market indices in time, so the pure-play indices contemporaneously reflect the relevant price discovery in each property market segment. Second, the pure-play indices can be produced at a high frequency without loss of accuracy. For example, daily updated indices can be easily produced using daily REIT share closing prices. Frequent updating can be useful in derivatives markets because it allows frequent marking to market of the values of the derivative contracts, which in turn minimizes required margin positions. Third, unlike private market–based indices for which it is not possible to actually buy and sell the underlying properties, the pure-play portfolios can, in principle, be directly constructed and traded via long and short positions taken in the publicly traded REITs that compose the portfolios. This facilitates pricing of derivatives (as it renders more meaningful the use of traditional arbitrage-based pricing formulae), and it also enables construction of exchange-traded funds (ETFs) or other such funded vehicles that track or implement the pure-play indices. This helps to address the "counter-party problem" that can make it difficult to establish a liquid derivatives market. In effect, the liquidity in the stock market can be used to provide the necessary counterparties to the derivative transactions.

CONCLUSIONS

Using REIT return data, property holdings data, and REIT financial information, it is possible to construct REIT-based pure-play indices (or portfolios) with unit exposure to a desired property market segment, zero exposure to all other property market segments, and minimum idiosyncratic risk. Additionally, with financial data about REIT debt and equity holdings along with information about the cost of REIT debt, it is possible to adjust for REIT leverage and to generate estimated market-segment returns for the underlying property market using the segment portfolio weights. These estimated market-segment returns, or indices, provide new and valuable information about the underlying property markets on a high-frequency, temporally leading basis. In this article, we have demonstrated by comparison to the Moody's/REAL indices that a 16-segment model provides good granularity with high-frequency potential.

An important contribution of the type of indices we have described in the article lies in their application to support derivatives trading and synthetic investment in the commercial property market. Higher-frequency indices enable lower margin requirements for derivative products such as swaps. Because REIT-based indices lead private market–based indices, they are a natural basis for derivative products. The tradable underlying market-segment portfolios enable arbitrage execution between the derivative and the underlying, thus facilitating pricing in the derivatives market and providing a profit opportunity for traders, which promotes liquidity in the derivatives market. Starting from the market-segment portfolio weights, sophisticated users can synthetically construct targeted or balanced portfolios and synthetically add or subtract leverage as desired.

APPENDIX

Demonstration of Equivalence of the Regression and Long–Short Pure-Play Portfolio Approaches

Consider how the regression-based approach to property segment-specific index identification using REIT returns represented by Equations (1) through (7) effectively implements the so-called pure-play portfolio approach described in Geltner and Kluger [1998]. Using Geltner–Kluger notation,

$$\tilde{r}_i = x_{A,i}(\tilde{r}_A + \tilde{e}_{A,i}) + x_{O,i}(\tilde{r}_O + \tilde{e}_{O,i}) + x_{I,i}(\tilde{r}_I + \tilde{e}_{I,i}) + \cdots + x_{K,i}(\tilde{r}_K + \tilde{e}_{K,i}) \quad \text{(A-1)}$$

where

r_i = observed return to REIT i
$\tilde{r}_k$ = pure-play return to segment k
$x_{k,i}$ = fraction of REIT i invested in segment k
$\tilde{e}_{k,i}$ = idiosyncratic return to REIT i property in segment k and again,

$$\sum_K x_{k,i} = 1$$

where K denotes the last of some number of segments. Note that Equation (A-1) looks very similar to Equation (2) except for the specification of the error terms (the idiosyncratic returns).

The Geltner–Kluger notation assumes that the idiosyncratic components are random, uncorrelated with each other, and have mean zero. Define a pure-play portfolio as a portfolio with unit exposure to the desired segment and zero exposure to all other segments,

$$\tilde{r}_p = \tilde{r}_A \sum_{i=1}^{N} w_i x_{A,i} + \tilde{r}_O \sum_{i=1}^{N} w_i x_{O,i} + \cdots + \tilde{r}_K \sum_{i=1}^{N} w_i x_{K,i} + \sum_{i=1}^{N} (w_i x_{A,i} e_{A,i} + \cdots + w_i x_{K,i} e_{K,i}) \quad \text{(A-2)}$$

where each w_i equals the percentage of the portfolio's holdings in REIT i and where the constraints for a pure-play portfolio for a single segment k can be written mathematically as

$$\sum_{i=1}^{N} \sum_{j \neq k} w_i x_{i,j} = 0 \quad \text{(A-3a)}$$

$$\sum_{i=1}^{N} w_i x_{i,k} = 1 \quad \text{(A-3b)}$$

Substituting the constraints (A-3) into Equation (A-2) yields a simplified equation for the return to the pure-play portfolio for segment k,

$$\tilde{r}_p = \tilde{r}_k + \sum_{i=1}^{N} (w_i x_{A,i} e_{A,i} + \cdots + w_i x_{K,i} e_{K,i}) \quad \text{(A-4)}$$

the variance of which is given by

$$\text{VAR}(\tilde{r}_p) = \text{VAR}(\tilde{r}_k) + \sum_{i=1}^{N} (w_i^2 x_{A,i}^2 \text{VAR}(e_{A,i}) + \cdots + w_i^2 x_{K,i}^2 \text{VAR}(e_{K,i})) \quad \text{(A-5)}$$

In Geltner and Kluger [1998], the authors assumed that the idiosyncratic segment variance is inversely proportional to a REIT's dollar holdings in that segment; recall that this assumption is similar to, but not identical to, the assumption used in the GLS model, Equation (6). Specifically,

$$\text{VAR}(e_{k,i}) = \frac{1}{x_{k,i} \cdot \text{total}_i} \quad \text{(A-6)}$$

If we substitute the values from Equation (A-6) into Equation (A-5), we can simplify the minimization problem somewhat more, as follows:

$$\text{VAR}(\tilde{r}_p) = \text{VAR}(\tilde{r}_k) + \sum_{i=1}^{N} \left(w_i^2 x_{A,i}^2 \frac{1}{x_{A,i} \cdot \text{total}_i} + \cdots + w_i^2 x_{k,i}^2 \frac{1}{x_{k,i} \cdot \text{total}_i} \right) \quad \text{(A-7)}$$

which reduces to

$$\mathrm{VAR}(\tilde{r}_p) = \mathrm{VAR}(\tilde{r}_k) + \sum_{i=1}^{N} \left(w_i^2 \cdot \frac{1}{\mathrm{total}_i} \right) \qquad \text{(A-8)}$$

As we differentiate Equation (A-8) with respect to w_i for the purposes of minimization, it becomes clear that the solution is a function of only the second term.

Because of our assumptions regarding idiosyncratic returns, the variance of the idiosyncratic returns in the pure-play model reduces to the same variance assumption used in the GLS regression models. Recall that the estimated GLS coefficient vector minimizes the sum of the squared errors of the regression. In other words, it minimizes the variance of the error terms (i.e., the idiosyncratic returns).[19] In the case of the GLS regression models, these variances are assumed values contained in Ω that were defined in Equation (6). Therefore, the GLS solution yielding H is identical to the solution to minimizing Equation (A-8) with respect to w_i. As a result, it is not necessary to develop both the regression and long–short hedge portfolio frameworks under the current set of assumptions, and the article proceeds using the regression framework.

ENDNOTES

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[1]We use the term "segment" to refer to a combination of property-usage-type sector and geographical region that defines some segment of the overall aggregate commercial property market. From the perspective of institutional investment, the entire commercial property market (all income-producing investable properties) may be viewed as composing the investment asset class. However, from the perspective of users of commercial space (the rental market), this aggregate of all property is actually a collection of numerous, effectively geographically bounded, specific-property-type markets, such as the Manhattan office market. Many investors in the real estate asset class like to target their investments based on some segmentation related to an understanding of the underlying rental markets. Although the REIT-based indices presented in this article are not granular to the metro-area level, they do provide substantial geographical and usage-type segmentation.

[2]The Moody's/REAL Commercial Property Price Index (CPPI) is based on data from Real Capital Analytics and methodology licensed by MIT to Real Estate Analytics LLC (REAL). The CPPI is produced and published monthly by Moody's Investors Service and is downloadable at no cost from Moody's at www.Moodys.com, REAL at http://www.realindices.com, or MIT/CRE at http://web.mit.edu/cre/research/credl/rca.html.

[3]The Geltner–Kluger [1995] working paper was presented at the 1996 AREUEA Annual Meeting and is available from the authors upon request.

[4]Of course, a total return index is also possible simply by substituting total returns for price returns. In the present model the same debt interest rate is used for each REIT in order to implement the WACC. This could be revised to incorporate unique debt rates at the REIT level. We also created the pure-play indices without delevering REIT returns, but the results are not presented in the interest of brevity.

[5]Although running a pooled regression can sometimes provide more explanatory power than running separate regressions for each time period, separate regressions have the advantage of avoiding backward revisions in estimated returns, and this can be useful in an index designed to support derivatives trading.

[6]In practice, many REITs have miscellaneous property exposures to segments not included in the model, such as land, garages, or international assets. Based on experimentation, we aggregated the miscellaneous property exposures into a single "Other" segment and excluded any REITs having an "Other" segment in excess of 30% of total property holdings. When "Other" was less than 30% of total holdings, the REIT was included in the regression, the "Other" exposure was ignored, and the remaining segment exposures were rescaled to sum to one. The error term correctly captures returns due to these miscellaneous exposures as long as the miscellaneous exposures are not substantially correlated with our included segments.

[7]These assumptions are not necessary to construct our model using regression analysis, but relaxing these assumptions requires additional econometric manipulations not explored within the scope of this article.

[8]We also explored an alternative assumption using $u_{i,t}^2 = \frac{1}{\sqrt{\mathrm{total}_i}}$ as our idiosyncratic variance assumption. The results are not presented in the article, but we found that in certain circumstances this formulation may be preferable; in most cases, however, results were insignificantly different.

[9]We checked the validity of this assumption by comparing changes in exposures using various methodologies on REITs for which multiple types of data were available.

[10]As noted previously, the methodology described here could just as easily be applied to total return data in order to yield total return property indices. From the perspective of derivatives trading, there is little need for a total return index, as almost all of the volatility in property returns is in the capital component.

[11]Annualized volatility = monthly volatility * sqrt(12) for the REIT-based index and quarterly volatility * sqrt(4) for the Moody's/REAL index.

[12]NCREIF indices may have even lower volatility, but they are based on appraisals rather than actual transaction prices. With an appraisal-based index, low volatility suggests a concern about lagging and smoothing in the appraisal and index construction process. However, in the case of a transaction-based or stock market–based index, artificial lagging and smoothing are not a concern, which means that low volatility is an indication of a good quality index that avoids excess noise or idiosyncratic variance.

[13]Please contact the authors for detailed comparisons between the five-segment industry pure-play indices and the NAREIT/FTSE indices.

[14]We used the NCREIF geographic definitions for West, Midwest, South, and East.

[15]Fundamentally, this is due to insufficient REIT holdings in the case of the hotel sector. In the industrial sector, the multicollinearity is caused not by a scarcity of holdings but rather by similar investment patterns across REITs.

[16]For more information on variance inflation factors, see, for example, Greene [2003, pp. 56–58].

[17]Please contact the authors for detail on all 16 property and region indices.

[18]In the U.S., trading on the NCREIF index has been slower to take off, but has been active since mid-2007 with over $2 billion notional value of OTC NPI swaps by late 2008. (This amount is miniscule compared to direct cash trading in underlying commercial property, which exceeded $300 billion in the U.S. during 2006, as tracked by Real Capital Analytics.)

[19]As long as we continue to assume the idiosyncratic returns are random, uncorrelated, and have mean zero.

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