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Efficiency, Scale Economies, and the Risk/Return Performance of Real Estate Investment Trusts

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Abstract

Estimates from a directional output distance function are used to construct a risk/return frontier that defines the best-practice management technology for Real Estate Investment Trusts (REITs). We model REIT performance as a production process in which each REIT produces a desirable output (return) and an undesirable output (risk) using inputs of managerial effort and financial capital. The results suggest that ignoring the effects of risk yields a management technology that is significantly different from one that incorporates risk. In addition, market valuation is inversely related to inefficiency and directly related to leverage.

Key Words: best-practice technology, REIT risk/return, directional distance function

1. Introduction

The ability of a firm's managers to marshal inputs in the production of risk adjusted returns on behalf of equity investors is one of the most important aspects of asset pricing. The operative word is "produced." Consistent with the theoretical model developed by Grossman and Stiglitz (1980), we argue that superior investment company return performance occurs as a consequence of superior asset selection and/or timing of transactions using inputs of financial capital and management effort.

The increase in the number of publicly traded Real Estate Investment Trusts (REITs) over the last decade suggests that the REIT became a relatively more efficient real estate ownership form than in the past. Unlike closed-end investment companies that manage portfolios of financial assets and incur relatively low transaction costs, REIT managers deploy physical assets and make investment decisions that are not easily reversed in the short-run. In this respect, the production process among REITs may be more similar to manufacturing firms than many other closed-end investment companies.

The most efficiently managed firms in an industry employ the best-practice technology and occupy an observed production frontier. The production process can be modeled as a multiple output technology in which all outputs are desirable, or it can be a process in which desirable outputs are accompanied by the simultaneous production of undesirable outputs. The undesirable outputs can be pollution, contingent legal liability, nonperforming bank loans that accompany the production of performing loans, or risk associated with managing a portfolio of assets.

The desirable/undesirable output taxonomy of return/risk is consistent with both production theory and the standard finance textbook exposition which utilizes positively sloped indifference curves to illustrate the tradeoff between risk and return. (Tobin, 1958). We combine elements of a Markowitz (1952, 1959) efficient frontier with the directional output distance function, which is a generalization of Farrell (1957) efficiency. Borrowing from finance and production theory, we assume that REITs produce a desirable output (return) and an undesirable output (risk) by employing inputs of financial capital and management effort. A piecewise linear frontier of risk/return is constructed which defines the best-practice REIT management technology from all observed combinations of risk and return given REIT inputs. The directional output distance function measures REIT inefficiency and is estimated as the solution to a linear programming problem.

Linear programming (LP) estimates of efficiency have several advantages. Unlike stochastic estimates, LP estimates of efficiency are derived from a best-practice technology rather than an average technology. Furthermore, the LP method does not require specification of an ad hoc error structure or restrictive functional form. However, a disadvantage of the LP approach is that all deviation of output from the production frontier is attributed to inefficiency rather than managerial luck or other types of random error.

Our model measures the potential decrease in risk and increase in return that could be achieved by a REIT if it were to occupy the efficient frontier. Efficient REITs produce on the frontier and have the highest possible return for a given risk, or alternatively, the lowest possible risk for a given return relative to other REITs given inputs. Inefficient REITs can expand return and reduce risk through better managerial oversight of REIT inputs, financial restructuring, or restructuring of real estate assets consistent with REITs that occupy the frontier. Sengupta (2000), Basso and Funari (2001), and Murthi et al. (1997) examine the efficiency of mutual funds using nonparametric data envelopment analysis (DEA). They model risk as an input in the production of mutual fund returns and measure the expansion of returns holding risk constant. In contrast, our approach takes risk as an undesirable output and measures the simultaneous expansion of REIT return and contraction of REIT risk, given REIT inputs.

In the next section we give a brief review of the literature on REIT efficiency and risk/return. In Section 3 we show how the directional output distance function is used to measure output technical efficiency when return and risk are produced using selected inputs. In Section 4 we present the specification for the LP problems used to estimate the directional output distance function. In Section 5 we describe the data and present the empirical results. The final section summarizes the paper and concludes.

2. REIT efficiency and risk/return

A large and growing body of research examines REIT efficiency. Anderson et al. (2000) review the REIT efficiency literature. Bers and Springer (1997) and Yang (2001) find evidence of scale economies for REITs. Using data envelopment analysis (DEA) Anderson et al. (2002) examine the technical and scale efficiency of REITs for the period 1992–1996 and find that most REITs operate in the range of increasing returns to scale. They also find that internal management is positively related to efficiency while leverage is negatively related. They find that REIT diversification across property type enhances scale efficiency and that diversification reduces input technical efficiency. However, none of these studies control for the effects of risk.

Variables identified as having a potential influence on REIT performance include advisor type, property segment, and REIT financial policy. Howe and Shilling (1990) conclude that REIT performance differs across advisor groups. Capozza and Seguin (1999) find dis-economies of scope in that REIT diversification across property type reduces value and increases administrative expenses. They argue that the positive relation between property diversification and general administrative expense suggests greater managerial effort is expended on more diversified trusts. Most REIT risk/return studies model risk using the Capital Asset Pricing Model (CAPM). The standard CAPM identifies two types of risk associated with an investment in REIT k. Systematic risk for REIT k reflects the co-movement of returns with the market portfolio and equals the product of the REIT's beta (β_k) and the volatility of the market portfolio (σ_m). Unsystematic risk (σ_{ek}^2) is specific to each REIT. Since unsystematic risk can be diversified away, investors are only compensated for systematic risk. When systematic risk and unsystematic risk are independent, the total risk of REIT k can be written as the sum of systematic and unsystematic risk:

$$\text{Total Risk} = \text{Systematic Risk} + \text{Unsystematic Risk}$$

$$\sigma_k^2 = \beta_k^2 \sigma_m^2 + \sigma_{ek}^2$$

Roll's (1977) theoretical critique of the CAPM and market portfolio is well known but it may have special significance for real estate since the S&P500, the most common proxy for the market portfolio, has typically excluded REITs. Malkiel and Xu (2001) deepen the Roll critique by demonstrating that if a group of investors fail to hold the market portfolio for exogenous reasons, the remaining investors will also be unable to hold the market portfolio. The empirical shortcoming of beta risk has also been well documented. Corgel and Djoganopoulas (2000) estimate betas for a sample of sixty equity REITs and report many negative betas as well as an average R-square of 0.03. Individual betas among six investment advisory firms differed by as much as 25%. Shalit and Yitzhaki (2002) link the poor empirical performance of beta to non-normality in return distributions and inadequate specification of investor utility functions.

Given the poor performance of the CAPM, some researchers suggest variance or total risk as an alternative to systematic risk. Enders (1995) maintains that if the investor utility function is quadratic and/or the excess returns from holding the asset are normally distributed, an increase in the variance of returns is equivalent to an increase in "risk." Engle et al. (1987) demonstrate that the relation between the variance and the maturity premium in the debt market depends on the utility functions of the agents and the supply conditions of assets.

Researchers find evidence of both a positive and negative tradeoff between return and total risk. French et al. (1987) find a positive tradeoff between return and variance as did Campbell and Hentschel (1992). Devaney (2001) finds a positive tradeoff between returns and own conditional variances for REIT indices. Baillie and DeGennaro (1990) conclude that the tradeoff parameter is insignificant for many of the portfolios in their study. Glosten et al. (1993) find support for a negative tradeoff between return and volatility for some stocks.

Ultimately, the appropriate measure of REIT risk is an empirical question. Rather than impose assumptions regarding investor utility functions and return distributions, REIT inefficiency will be modeled using both total risk (σ_k^2) and systematic risk ($\beta_k^2\sigma_m^2$). As a benchmark for comparison we also estimate REIT efficiency ignoring risk.

3. Method

We employ the directional output distance function to model the production technology of REITs that jointly produce the undesirable output of risk and the desirable output of return. When firms produce a single output, Farrell's measure of output technical efficiency equals the ratio of actual output to maximum potential output. If multiple outputs are produced, the output distance function serves as the measure of Farrell output efficiency and its reciprocal gives the maximum proportional expansion in all outputs given inputs. Sengupta (2000), Murthi et al. (1997), and Basso and Funari (2001) take risk as an input and estimate the Farrell measure of output technical efficiency. When return and risk are jointly produced, the reciprocal of the traditional output distance function gives the maximum proportional expansion of both outputs for a given level of input. A more appealing measure of output technical efficiency would give credit to firms that reduce risk and simultaneously increase return. The directional output distance function is the output version of Luenberger's (1992) benefit function and scales a REIT's return and risk to the output set which depends on inputs. Linear programming methods are used to recover the directional output distance function and measure the extent of inefficiency.

We denote desirable outputs by $y \in R_+^M$, undesirable outputs by $b \in R_+^J$, and inputs by $x \in R_+^N$. Individual REITs are indexed by k = 1, ..., K. An observation for REIT k is represented by (y_k, b_k, x_k). For ease of exposition we drop the REIT subscript temporarily. The production possibility set, $P(x)$, gives the set of outputs, (y, b), that can be produced from input x.

To model the production process we make two assumptions regarding output disposability. First, we assume that desirable and undesirable outputs are weakly disposable and second, that desirable outputs are also strongly disposable. Weak disposability means that

$$\text{if}(y, b) \in P(x) \text{ and } 0 \leq \theta \leq 1 \text{ then } (\theta y, \theta b) \in P(x). \tag{1}$$

Weak disposability implies that a proportional contraction of both outputs is feasible, given inputs. Strong disposability of desirable outputs means that

$$\text{if}\,(y,b) \in P(x) \text{ and } y' \leq y, \text{ then } (y',b) \in P(x). \tag{2}$$

Strong disposability implies that one can freely throw away desirable outputs, but is not a maintained condition for undesirable outputs. In general, for REITs operating efficiently with a given level of input, it is not possible to reduce the undesirable output (risk) without a simultaneous reduction in the desirable output (return).

Finally, we assume that desirable outputs are null-joint with undesirable outputs. This condition implies that it is not possible to produce any positive quantity of desirable output without also producing some undesirable output. That is,

$$\text{if}\,(y,b) \in P(x) \text{ and } b = 0 \text{ then } y = 0. \tag{3}$$

In the context of risk/return, null-jointness implies there is no excess return for zero risk.

In Figure 1 we illustrate the construction of the production possibilities set given conditions (1)–(3). Suppose there are four REITs each employing the same inputs, with observations (and (b, y) coordinates) represented by points A = (3, 5), B = (18, 15), C = (9, 4), and D = (21, 12). We specify a piece-wise linear output set, $P(x)$, which takes the form:

$$P(x) = \left\{ (y,b) : \sum_{k=1}^{K} z_k x_k \leq x, \sum_{k=1}^{K} z_k y_k \geq y, \sum_{k=1}^{K} z_k b_k = b, \; z_k \geq 0, \; k = 1, \ldots, K \right\} \tag{4}$$

The intensity variables, z_k, serve to form linear combinations of all the REIT observations on inputs and outputs. Constraining each z_k to be nonnegative allows for constant returns to scale. The technology described in (4) means that for a given REIT, no less input can be used to produce no more desirable output (return) and an equal amount of undesirable output (risk) than a linear combination of all REIT inputs and outputs. The inequalities associated with the input and desirable output constraints allow for strong disposability. Weak-disposability is modeled by the equality associated with the undesirable output constraints. For the four REITS, the output set $P(x)$ is bounded by 0ABDF0. The vertical line DF is due to strong disposability of the desirable output. The negatively sloped line, BD, occurs because the undesirable output satisfies only weak disposability. The desirable output, y, is null-joint with b, since if $b = 0$, the only y with $(y, b) \in P(x)$ is $y = 0$. REITs A, B, and D produce on the boundary of $P(x)$ and are technically efficient. REIT C is inside the set $P(x)$ and is inefficient.

To measure inefficiency we use the directional output distance function which was developed by Chambers et al. (1996, 1998) as an output oriented version of the benefit function introduced by Luenberger (1992). This function is defined on $P(x)$ as:

$$\vec{D}_o\left(x, y, b; \; g_y, g_b\right) = \max\left\{\beta : (y,b) + \left(\beta g_y, \beta g_b\right) \in P(x)\right\} \tag{5}$$

The directional output distance function scales the output vector, (y, b) in the direction (g_y, g_b) to a point on the boundary of $P(x)$. The directional output distance function takes

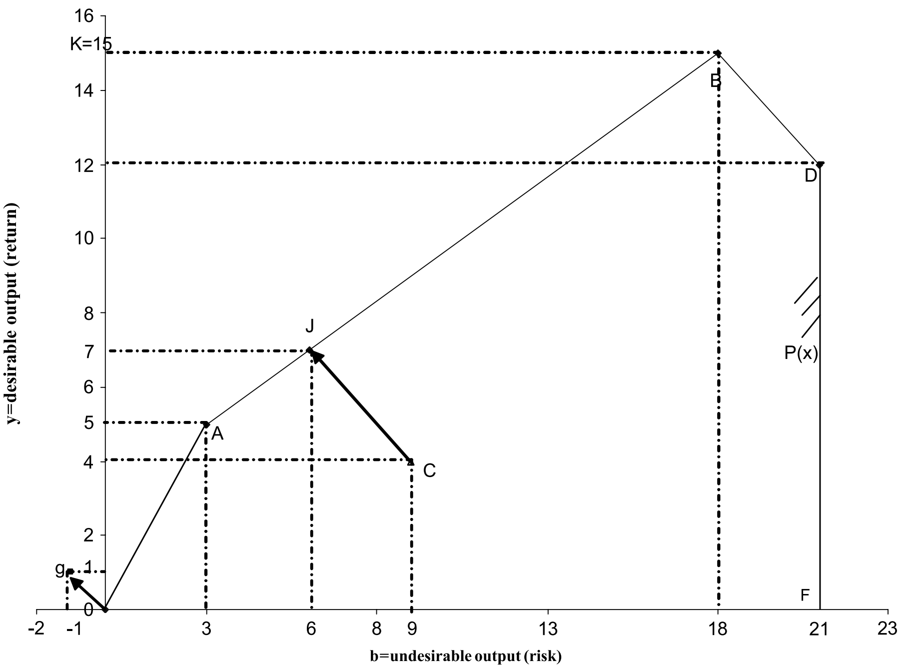

Figure 1. The output set, $P(x)$, and the directional output distance function.

a minimum value of zero for REITs that are output technically efficient; that is, for REITs operating on the frontier of $P(x)$. If $\vec{D}_o(x, y, b;\ g_y, g_b)0$, the REIT produces inside the $P(x)$ frontier and is technically inefficient. The direction chosen determines the output vector on the boundary of $P(x)$ to which the REIT is evaluated.

To illuminate, consider the directions (g_y = 1, g_b = −1). In Figure 1, the directional vector is represented by point g with coordinates (−1, 1). For this directional vector, $\vec{D}_o(x, y, b;\ 1, -1)$ gives the maximum unit expansion in return and the simultaneous unit contraction in risk. For REIT C, $\vec{D}_o(x, y, b;\ 1, -1) = \frac{CJ}{0g} = \frac{\sqrt{18}}{\sqrt{2}} = 3$, where point J has coordinates (6,7). That is, if REIT C were to efficiently utilize the best-practice technology, in this case a linear combination of the outputs of REIT A and REIT B, it could expand the desirable output (return) by 3% and contract the undesirable output (risk) by 3%. Depending upon the problem at hand, researchers can choose other directional vectors, to evaluate firm efficiency. For instance, when the directional vector (g_y = 1, g_b = 0) is chosen, the directional output distance function measures the unit expansion in return, holding risk constant. Alternatively, when the directional vector (g_y = 0, g_b = −1) is chosen, the directional output distance function measures the contraction in risk, holding return constant. It is possible that a REIT might be efficient in one direction, but not in another. For instance, while REIT D cannot expand return, it can contract risk. Therefore, REIT D is efficient in the (g_y = 1, g_b = 0) direction, but is inefficient in the (g_y = 0, g_b = −1) direction.

Now, consider the bias in the inefficiency estimate for REIT C if we ignore the undesirable output in constructing $P(x)$. Since all four REITS use the same inputs to produce output y, the output set is $P(x) = \{0K\}$. Since the undesirable output is ignored, it would appear that REITs A, C, and D are all inefficient. Given a directional vector $g_y = 1$, the unit increase in the desirable output for REIT C is $\vec{D}_o(y, 0, x;\ 1, 0) = 11\%$. For this naïve technology, only REIT B would be deemed output efficient.

In the next section we present the LP problems that are used to estimate the directional output distance function for the technology that accounts for both desirable and undesirable outputs as well as the naïve technology. In addition, we review the method that is used to determine whether a REIT operates in the range of increasing, constant, or decreasing returns to scale.

4. Empirical model specification

Given the constant returns to scale output set, $P(x)$, defined by (4), and a directional vector, $g_y = 1$ and $g_b = -1$, the directional output distance function for firm k' is estimated as the solution to the LP problem

$$\vec{D}_o\left(x^{k'}, y^{k'}, b^{k'};\ 1,\ -1\right) = \max_{z,\beta}\left\{\beta : \sum_{k=1}^{K} z_k x_k \leq x^{k'}, \sum_{k=1}^{K} z_k y_k \geq y^{k'} + \beta \cdot 1, \right.$$
$$\left. \sum_{k=1}^{K} z_k b_k = b^{k'} - \beta \cdot 1,\ z_k \geq 0,\ k = 1, ..., K \right\}. \tag{6}$$

We also want to determine the range of scale economies for each REIT. A variable returns to scale (VRS) technology allows for increasing returns to scale (IRS), decreasing returns to scale (DRS) or constant returns to scale (CRS), and is modeled by adding the constraint, $\sum_{k=1}^{K} z_k = 1$ to (6).[1] Because the addition of the VRS constraint to (6) makes the output set no larger, estimated inefficiency will be no larger than it is under CRS. A non-increasing return to scale (NIRS) technology is modeled by adding the constraint to $\sum_{k=1}^{K} z_k \leq 1$ to (6). We estimate $\vec{D}_o(x, y, b;\ 1, -1)$ under CRS, VRS, and NIRS to determine the range of scale economies the REIT operates in. A REIT's range of scale economies is indicated by:

$$\begin{aligned}
&\text{if } \vec{D}_o(x,y,b;\ 1,-1)^{VRS} = \vec{D}_o(x,y,b;\ 1,-1)^{CRS}, \text{ then CRS,}\\
&\text{if } \vec{D}_o(x,y,b;\ 1,-1)^{VRS} \leq \vec{D}_o(x,y,b;\ 1,-1)^{CRS}\\
&\qquad = \vec{D}_o(x,y,b;\ 1,-1)^{NIRS} \text{ then IRS, and finally,}\\
&\text{if } \vec{D}_o(x,y,b;\ 1,-1)^{VRS} = \vec{D}_o(x,y,b;\ 1,-1)^{NIRS} \leq \vec{D}_o(x,y,b;\ 1,-1)^{CRS} \text{ then DRS.}
\end{aligned} \tag{7}$$

We also estimate each REIT's inefficiency for the naïve technology that ignores risk when defining the output set, $P(x)$, by dropping the constraint $\sum_{k=1}^{K} z_k b_k = b$. Here, we solve the problem

$$\vec{D}_o\left(x^{k'}, y^{k'}, 0;\ 1, 0\right) = \max \beta : \sum_{k=1}^{K} z_k x_k \leq x^{k'}, \sum_{k=1}^{K} z_k y_k \geq y^{k'} + \beta \cdot 1,$$
$$z_k \geq 0,\ k = 1, \ldots, K, \tag{8}$$

under CRS, VRS, and NIRS. Comparing the solutions to (6) and (8) demonstrates the degree of bias involved in estimating inefficiency and scale returns when risk is ignored. We estimate REIT efficiency using two different specifications of risk. In model 1 we assume risk equals the total variance of the REIT's return, σ_k^2. In model 2 we assume that risk equals systematic risk, $\beta_k^2 \sigma_M^2$. Finally, for comparison, we estimate the naïve model which ignores risk in constructing the reference technology. We refer to the naïve model as model 3.

5. Data and empirical results

All REIT return data, property segment, and advisor type are provided by the National Association of Real Estate Investment Trusts (NAREIT). Balance sheet and income statement data are taken from annual reports on Disclosure. Risk and return are produced with inputs of financial capital and management effort. We measure the desirable output, return = y, as the average monthly return earned in 1999. The undesirable output, risk = b, equals either the total variance (Model 1) or the beta risk (Model 2) associated with the REIT. We calculate risk using the monthly return series for the period January 1995 to August 2000. We use total assets in 1999 as proxy for financial capital. Following Capozza and Seguin (1999), 1999 general/administrative/selling expense is used as a proxy for managerial effort. In an attempt to include both long-surviving REITs as well as REITs that became available in the 1990s, we examine the so-called new REIT era 1995–2000.[2]

Table 1 presents descriptive statistics for risk, return, total assets, and general/administrative/selling expense for the seventy-seven REITs. Table 1 also reports the market/book value of equity ratio at the end of the return period, the leverage ratio defined as the book value of liabilities/book value of assets for 1999, the number of REITs by property segment and advisor type. For the seventy-seven REITs sampled, the mean monthly return (from 1995:01 to 2000:08) is 1.05% with a range between −1.83% and 2.42%. The mean monthly return for 1999 is −4.59% with a range between −7.17% and 13.14%. Given that some of our returns are negative and our DEA method only allows for positive outputs, we subtract the most negative return from all seventy-seven REIT returns. The total variance of returns, σ_k^2, averages 38% with a range between 13.8% and 270%. Systematic risk, $\beta_k^2 \sigma_M^2$, averages 7.7% with a range between zero and 97%. The mean book-value of assets is 2.22 billion dollars and the mean value of selling/

general/administrative expense is 12.6 million dollars. The mean leverage ratio is 54% and the market/book value of equity is 1.39 with a range between 0.55 and 16.26. Of the seventy-seven REITS sampled, fifty-seven are in the retail, industrial/office, or residential property segments and the remainder is diversified, lodging/resorts, specialty, health care, and self storage. Seventy-one REITs are self-advised, while only six REITs are externally advised.

The estimates of inefficiency under variable returns to scale (VRS) and constant returns to scale (CRS) are presented in Table 2. As expected, the VRS technology gives a lower estimated value of the directional output distance function (less inefficiency) than the estimate under CRS. In Model 1, where risk equals the variance of REIT return, σ^2_{REIT}, the estimate of inefficiency is approximately 4.49 under CRS but only 2.15 under VRS. Given our choice of directional vector, $g = (1, -1)$ the interpretation of the inefficiency estimate is that if the REIT were to employ best practice management techniques, it could increase return by 4.49% and reduce risk by 4.49%. For the VRS technology, a reduction in REIT inefficiency would allow the REIT to gain 2.15% in return while simultaneously reducing the variance of return by 2.15%. When σ^2_{REIT} is used as the measure of REIT risk and VRS is assumed, fifteen REITs display best-practice techniques and define the return-risk frontier. Only ten REITs exhibit best-practice management under CRS. The higher number of best-practice REITs under VRS is due to the additional VRS constraint imposed on (6), which has the effect of making $P(x)$ no larger. In Model 2 based on systematic risk, $\beta^2_{REIT}\sigma^2_M$, estimated mean inefficiency is 4.73 under CRS and 2.98 under VRS. Eighteen REITs occupy the frontier

Table 1. Descriptive statistics for REIT inputs and outputs and REIT property segment.

Variable	*Mean*	*Std. dev.*	*Min*	*Max*
y = monthly return (Jan.–Dec. 1999)	−4.59%	2.62%	−7.17%	13.14%
b = risk(σ^2_{REIT}) (Jan. 1995–Dec. 1999)	38.23%	34.85%	13.79%	270.16%
b = risk($\beta^2_{REIT}\sigma^2_M$) (Jan. 1995–Dec. 1999)	7.71%	14.65%	0.00%	97.26%
x_1 = book value of assets, 1999 (000s)	2218834	1894294	215004	11715689
x_2 = Sell/Gen./Admin. Expenses, 1999 (000s)	12651.1	10022.11	1342	54714
Leverage = book value of debt/book value of assets, 1999	0.549	0.154	0.125	0.844
Market value of equity/book value of equity	1.391	1.810	0.550	16.256
FFO = Funds from operations/Assets	25.00	15.13	1	106
MFO = % of equity owned by mutual funds	13.77	6.89	3	32
Property Segment:	# of REITS			
Retail	19			
Industrial/office	19			
Diversified	5			
Lodging/resorts	5			
Specialty	4			
Health Care	3			
Self-Storage	3			
Advisor:				
Self-advised	71			
Externally advised	6			

Table 2. REIT Inefficiency = $\vec{D}_o(x, return, risk; 1, -1)$.

		Mean	*Std. Dev*	*Min.*	*Max*	*Frontier*
Risk = σ^2_{REIT}	VRS	2.15	2.40	0	16.16	15
Risk = σ^2_{REIT}	CRS	4.49	7.52	0	62.64	10
Risk = $\beta^2_{REIT}\sigma^2_{Market}$	VRS	2.98	3.60	0	14.15	18
Risk = $\beta^2_{REIT}\sigma^2_{Market}$	CRS	4.73	8.51	0	64.58	13
No risk	VRS	9.32	4.31	0	19.06	8
No risk	CRS	30.74	30.05	0	150.00	2

under VRS and thirteen under CRS. In Model 3, which ignores risk, the mean inefficiency is 30.74 under CRS and 9.32 under VRS. Eight REITs produce on the VRS frontier and two REITS produce on the CRS frontier. Of course, risk does matter, and the estimates of inefficiency for Model 3 are included only to illustrate the potential bias from ignoring risk when examining investment company inefficiency or scale economies.

Table 3 reports the estimates of inefficiency by property segment for all three models. We note that all seventy-seven REITs are used to define the frontier of risk and return, $P(x)$. For Model 1, where risk equals σ^2_{REIT}, the REITs in the Residential segment are the least inefficient followed by REITs in the Industrial/Office, Self-storage, Specialty, Diversified, and Retail property segments. The most inefficient REITs operate in the Lodging and Health Care property segments. For Model 2 where risk is taken to equal systematic risk, $\beta^2_{REIT}\sigma^2_M$, REITs in the Specialty, Residential and Industrial/Office property segments are the least inefficient, while REITs in the Diversified and Health Care segments are the most inefficient. When risk is ignored in constructing the best-practice frontier (Model 3), the estimates of inefficiency are higher for every property segment for both the VRS and CRS technologies.

Are the estimates of REIT inefficiency different for the three models? Let the null hypothesis be that the estimates of inefficiency for the CRS technology are pair-wise equal across the three models. Table 4 reports the results of an ANOVA F-test and a battery of non-parametric tests of the null hypothesis. Based on these tests, we reject the

Table 3. REIT inefficiency by market segment.

	Risk = σ^2_{REIT}		*Risk* = σ^2_{REIT}		*No risk*	
Segment	*VRS*	*CRS*	*VRS*	*CRS*	*VRS*	*CRS*
Retail	2.865	4.247	3.596	4.569	10.444	23.129
Industrial/Office	1.429	3.134	2.371	3.562	8.005	34.283
Residential	0.618	1.729	2.055	2.385	8.873	34.269
Diversified	2.428	18.404	4.158	20.770	10.761	61.519
Lodging/Resorts	3.547	4.921	4.711	5.206	5.673	20.958
Specialty	2.416	2.686	0.801	0.820	8.693	9.983
Health-care	9.050	11.214	6.009	6.370	16.072	21.287
Self-storage	1.819	3.978	3.796	3.983	11.126	35.525

Table 4. Do assumptions about risk change measured inefficiency? Results of statistical tests.

	Model 1 vs. Model 2	*Model 1 vs. Model 3*	*Model 2 vs. Model 3*
Anova F (Prob > F)	1.28 (0.028)	15.95 (0.01)	12.46 (0.01)
Wilcoxon (Prob > X^2)	1.01 (0.31)	8.34 (0.01)	8.12 (0.01)
Median (Prob > X^2)	4.39 (0.01)	78.57 (0.01)	72.96 (0.01)
Kruskal-Wallis (Prob > X^2)	1.03 (.31)	65.56 (0.01)	66.02 (0.01)
Van der Waerden (Prob > X^2)	0.48 (.49)	61.73 (0.01)	60.22 (0.01)

null hypothesis that the two technologies which include risk are the same as the one that ignores risk. In addition, the Median test indicates that the estimates of inefficiency using systematic risk are significantly higher than for total risk. These tests suggest that risk is a critical element in REIT management and that efficiency studies that fail to account for risk can yield results substantially different from those that incorporate risk into the analysis.

Table 5 reports the number of REITs operating in the range of IRS, CRS, and DRS. For Models 1 and 2, fifty-nine and forty-seven REITs operate in the range of IRS and could benefit from expansion. For Models 1 and 2, five and fourteen REITS operate in the range of DRS and could benefit from a contraction in size. These estimates are consistent with those of Anderson et al. (2002), Yang (2001), and Bers and Springer (1997), all of whom find evidence of REIT scale economies but do not control for risk.

Table 5. REIT scale economies by market segment and advisor type.

		$\vec{D}_o(x, return, \sigma^2_{REIT}; 1, -1)$			$\vec{D}_o(x, return, \beta^2\sigma^2_{Market}; 1, -1)$		
		# of REITS in the range of:			*# of REITS in the range of:*		
	# of REITS	*IRS*	*CRS*	*DRS*	*IRS*	*CRS*	*DRS*
All REITS Segment	77	59	10	8	47	16	14
Retail	19	18	0	1	11	5	3
Industrial/Office	19	13	2	4	11	4	4
Residential	19	12	6	1	14	3	2
Diversified	5	5	0	0	4	1	0
Lodging/Resorts	5	4	1	0	3	1	1
Specialty	4	2	1	1	1	1	2
Healthcare	3	3	0	0	1	0	2
Self-Storage	3	2	0	1	2	1	0
Advisor:							
Self-Advised	71	56	8	7	43	14	14
External Advised	6	3	2	1	4	2	0

IRS = increasing returns to scale
CRS = constant returns to scale
DRS = decreasing returns to scale

Investors could benefit if the large proportion of REITs operating in the range of IRS would expand in size. These REITs might achieve greater scale efficiency by merger with other REITs. After the rapid expansion in the number and market capitalization of REITs during the 1990's, the last two years of the decade saw a decline in both the number of REITs and their total market capitalization. This trend, along with the large proportion of REITs operating in the range of IRS suggests that the REIT sector might be ripe for a period of consolidation.

Our results might have significant implications for a broader segment of the corporate economy since IRS ruling 2001–29 allows companies with substantial real estate holdings to spin-off these properties tax-efficiently into REITs. Historically, the IRS determined that because of their structure, REITs could not engage in an active trade or business which is a prerequisite for a tax-free spin-off. The IRS now agrees that REITs can be engaged in an active trade or business, opening the door for REIT spin-offs among corporations with large real estate holdings. However, our findings suggest that the benefit of a REIT spin-off to the shareholders of real estate intensive corporations depends both on the size of the spin-off and the property segment of corporate real estate assets.

Anderson et al. (2002) examine the effects of REIT characteristics such as the debt ratio, property diversification, and internal versus external management on operating efficiency. If the efficiency model is to be of operational value to investors then it should be useful in predicting changes in REIT valuations. Similar to Wheelock and Wilson (1995), who utilize bank efficiency as an independent variable in explaining bank failure, we regress the log of the market/book ratio of equity, ln(MARK/BOOK), against inefficiency and other variables appearing in the literature as having a potential influence on REIT valuations.[3]

Explanatory variables also include the leverage ratio, measured as the book value of total liabilities divided by the book value of total assets for 1999, and the net margin on funds from operations (FFO) for 1999. A set of dummy variables take a value of one if the REIT belongs to the particular property segment and zero otherwise. The property segment dummy variables include RETAIL, IO (industrial/office), RESIDENTIAL, and OTHER. Because of the small number of REITs in the Diversified, Lodging, Specialty, and Healthcare segments, these property segments are combined to form the OTHER category. The impact of advisor type is measured by the dummy variable ADVISOR, which takes a value of one if the REIT is self-advised or zero if it is externally advised. The constant term captures the effects of externally advised and Self-storage REITs. Finally, MFO% is the percentage of the REIT equity owned by mutual funds as reported by Morningstar. Kalberg et al. (2000) find that in contrast to other mutual fund studies, REIT mutual fund managers add value by active portfolio management. They find that REIT fund managers "appear to have produced an incremental annual return of about 2% over passive strategies." Accordingly, we anticipate that REIT valuations will be related to percent of REIT equity owned by mutual funds (MFO%).

The results of the regression for each of the models are reported in Table 6. We obtain $R^2 = 0.39$ for Model 1, $R^2 = 0.45$ for Model 2 and $R^2 = 0.35$ for Model 3. In Models 1

Table 6. Regression Estimates-Dependent variable = ln(Market/Book equity) (Standard errors)

Variable\Estimate	*Model 1*	*Model 2*	*Model 3*
Constant	−1.140* (0.456)	−1.118* (0.527)	−1.2094* (0.5931)
$\vec{D}_o(x, return, \sigma^2_{REIT}; 1, -1)^{CRS}$	−0.022* (0.010)	–	–
$\vec{D}_o(x, return, \beta^2\sigma^2_{Market}; 1, -1)^{CRS}$	–	−0.027* (0.008)	–
$\vec{D}_o(x, return, 0; 1, 0)^{CRS}$	–	–	−0.0033 (0.0025)
Leverage	3.345* (0.601)	3.302* (0.566)	3.3226* (0.6364)
FFO	0.007 (0.005)	0.009# (0.0046)	0.008 (0.005)
Retail	−0.574 (0.369)	−0.537 (0.349)	−0.6015 (0.3806)
Industrial/Office	−0.339 (0.361)	−0.310 (0.341)	−0.3376 (0.3724)
Residential	−0.287 (0.381)	−0.239 (0.360)	−0.2227 (0.3941)
Other	−0.288 (0.381)	−0.248 (0.357)	−0.4475 (0.3940)
Advisor	−0.360 (0.299)	−0.372 (0.281)	−0.2622 (0.3051)
MFO%	0.005 (0.011)	0.002 (0.010)	0.004 (0.011)
Adjusted R^2	0.39	0.45	0.35
$F - value\left(criticalF_{9,69,\alpha=0.05} = 2.16\right)$	5.43	6.80	4.74

*Indicates coefficient is significant at $\alpha = 5\%$.
#Indicates coefficient is significant at $\alpha = 10\%$.

and 2 the coefficient on inefficiency is negative and significant, indicating that more efficient REITs have a higher market to book ratio of equity. When risk is ignored in constructing the reference technology (Model 3) the coefficient on inefficiency is insignificant and smaller in absolute value than it is for either of the models which include risk. The coefficient on Leverage is positive in all three models and is significant in Models 1 and 2. The insignificant coefficients on the dummy variables for REIT segment or advisor indicate that market valuation is not affected by the market segment of the REIT or whether the REIT is externally or internally advised. The percent of equity owned by mutual funds has a positive, but insignificant effect on the market to book value of equity capital. The net margin on funds from operations has a positive and significant effect on the market to book value of equity only for Model 2, where risk is measured as beta risk. Although the finance literature indicates a positive correlation between systematic risk and leverage which may influence the results from Model 2, the regression equations in Table 6 do lend support to the assertion that REIT efficiency measures which incorporate risk statistically impact REIT valuations.

Finally, does REIT inefficiency influence future returns? (See Table 7) Our estimates of risk are derived from the 68 months beginning January 1995 and ending in August 2000. In a subsequent sixteen month hold-out sample, September 2000 to December 2001, the mean return for the seventy-seven REITs is −0.3% with a range of −33% to 14%. Does the mean return of REITs that occupy the constant returns to scale (CRS) frontier outperform or under-perform the REITs that are inefficient? To address this question we again use the ANOVA F-test and the non-parametric tests to test for differences in the rankings of returns for efficient and inefficient REITs. While the mean return for the hold-out sample period is negative and the non-parametric tests are

Table 7. REIT Inefficiency and post-period REIT returns.

	$Risk = \sigma^2_{REIT}$	$Risk = \beta^2_{REIT}\,\sigma^2_{REIT}$
Mean Percent Return for Efficient REITs	−0.17%	0.07%
Mean Percent Return for Inefficient REITs	−0.35%	−0.43%
Analysis of Variance, F (Prob > F)	36.55 (0.01)	376.15 (0.01)
Wilcoxon Scores, X^2 (Prob > X^2)	0.97 (0.33)	0.26 (0.80)
Median Scores, X^2 (Prob > X^2)	0.12 (0.73)	0.004 (0.95)
Van der Waerden Scores, X^2 (Prob > X^2)	0.79 (0.37)	0.26 (0.61)

insignificant, the ANOVA provides partial support for the assertion that inefficiency measures can be used to predict future REIT returns.

Figure 2 graphs REIT inefficiency (accounting for risk) of the seventy-seven REITs against their market capitalization. First we rank the REITs from the most efficient REITs that operate on the frontier of $P(x)$, to the least efficient REITs that are located the greatest distance from the frontier. Next we plot inefficiency against the percent of market capitalization accounted for by REITs which are at least as efficient. When risk is measured as the variance of REIT return, σ^2_{REIT}, 8% of total market capitalization for the 77 REITS is in REITs with no inefficiency and 50% of total market capitalization is in REITs which could increase return and simultaneously reduce risk by no more than 3.6%. When risk is measured as systematic risk, $\beta^2_{REIT}\sigma^2_M$, 12% of total market capitalization is in REITs with no inefficiency and 50% of total market capitalization is in REITs which could increase return and simultaneously reduce risk by no more than 3% if inefficiency were reduced. Only 10% of total market capitalization is in REITs which could reduce risk and increase return by more than 8% by realizing greater efficiency.

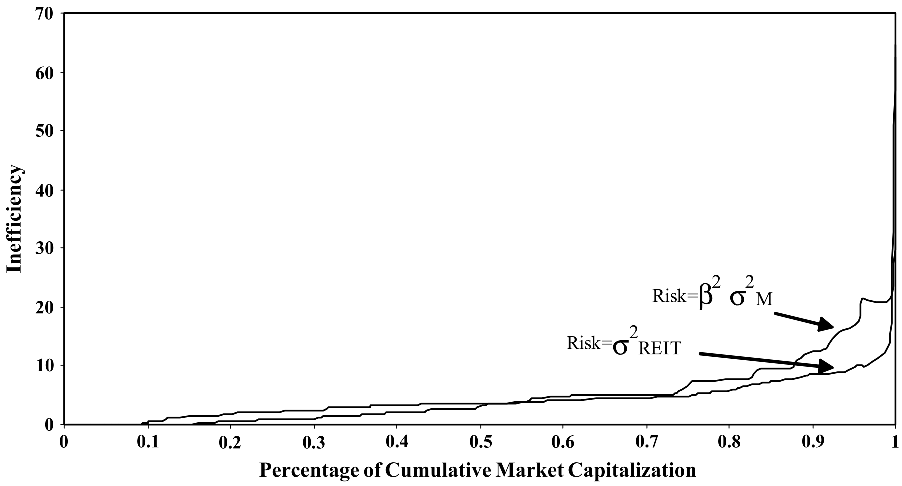

Figure 2. REIT inefficiency and cumulative market capitalization.

6. Summary and conclusions

We combine elements from the finance and production literature to model the best-practice management technology for Real Estate Investment Trusts (REITs). We obtain the best-practice frontier of REIT return and risk as a piecewise linear combination of all observed REIT return and risk combinations. The directional output distance function is used to measure each REIT's deviation from the frontier and serves as a measure of inefficiency. We measure REIT inefficiency as the maximum expansion in monthly return and simultaneous contraction in risk that is feasible given the observed best-practice frontier of all REIT return and risk combinations. The results indicate that a REIT management technology which ignores risk results in a significantly different best-practice technology than one that controls for risk.

For the two models that control for risk our estimates indicate that the Residential and Retail segments are the least inefficient while the Lodging/Resorts and Health Care property segments are the most inefficient. We also find that when risk is incorporated into efficiency estimates most REITs operate in the range of increasing returns to scale and could benefit from expansion. This finding is consistent with those of Anderson et al. (2002) and Yang (2001) who also find evidence of scale economies, but ignore REIT risk.

Using a regression model we find that REIT inefficiency is inversely related to the market/book equity ratio in the models which account for risk. The leverage ratio has a positive and significant impact on REIT valuation. However, advisor type and market segment have no impact on the market to book equity ratio. Based on a hold-out sample, efficient REITs have higher subsequent returns (or smaller losses), but the result is only significant for an ANOVA F-test and is insignificant for the other nonparametric tests. In our sample, 50% of the market capitalization of equity is invested in REITs that could increase return and reduce risk by no more than 3.6%.

Although our method has the potential for widespread application in the investment company sector, one important proviso applies. Because of changes in the structure of the REIT industry we examine a relatively short period, consequently, the short-run best-practice technology might differ from estimates based on a long-horizon holding period.

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Notes

1. The variable returns to scale output possibility set is: $P(x) = \{(y, b) : \sum_{k=1}^{K} z_k x_k \leq x, \sum_{k=1}^{K} z_k y_k \geq \delta y, \sum_{k=1}^{K} z_k b_k = \delta b, \delta \geq 1, z_k \geq 0, k = 1, \ldots, K\}$, which is different from the constant returns to scale $P(x)$ by the multiplication of y and b by the variable δ. Solving the directional output distance function for this set

would involve a non-linear programming problem. We follow convention and set $\delta = 1$ so that we may solve a linear programming problem. See Färe and Grosskopf (2004).

2. Many of the equity REITs followed by NAREIT are not actively traded for the complete 1995–2000 period. This is especially true for smaller REITs. Therefore, the sample is constructed by selecting the largest 100 market capitalization REITs as of the end of the return period (August 2000). REITs without a return history for each of the 68 monthly periods are dropped (i.e., the monthly return field could be zero, but not blank). REITs without data on total assets, total liabilities, selling, marketing and general administrative expenses and book value of equity appearing on 10Ks for 1995–2000 as reported by Disclosure are also dropped. The final sample included 77 equity REITs with complete data for the period examined. A major criticism of much investment company research is survival bias. Survival bias is described as a tendency for many investment company performance studies to exclude failed investment companies that merge or go out of business as well as new entrants without a lengthy return history. During the 1990s REIT market capitalization increased by a factor of 21 while the 1999 end of year market capitalization is approximately three times larger than in 1994. Clearly, REIT risk/return studies which exclude those REITs that became available in the latter half of the 1990s might be subject to survival bias. Our choice of period attempts to minimize the influence of survival bias.
3. The regression models are estimated using the log of market/book value of equity. Hirsch and Seaks (1993) use a Box-Cox transformation and find that the log of Tobin's q and related market value/accounting value type ratios provide a better fit than non-log forms. Konar and Cohen (2001) find identical results from both logged and non-logged versions in their model. Capozza and Seguin (1999) suggest using the ratio of equity to net asset value of each REIT. They calculate net asset value as the estimated market value of properties plus other assets minus liabilities. To perform this calculation one needs information on each REIT's capitalization rate. We obtained an estimate of net asset value for 44 out of the 77 REITs in our sample for 1979 from Green Street Advisors (2003) and performed the regressions given in Table 6 using the natural log of equity to net asset value as the dependent variable. In each case the coefficient for the inefficiency variable was insignificant. These regression results are available from the authors upon request.

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