The Risk and Return Characteristics of Real Estate Investment Trusts

by

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Abstract

In this dissertation, I empirically investigated the risk and return characteristics of Real Estate Investment Trusts (REITs). In particular, I am interested in three issues: the historical performance of REITs, the REIT return generating process, and the efficiency of the REIT market. The answers to these three questions are critical to our understanding of the risk and return characteristics of REITs and thus of the $8.7 trillion real estate market.

REIT performance is measured against the security market line as defined by the Capital Asset Pricing Model (CAPM). The test results indicate that the performance of REIT portfolios was consistent with the security market line for the 1970-1989 period. However, REIT performance varied over time in the last two decades. Therefore, it is difficult, if not impossible, to predict the future performance of REITs based upon their historical performance. Moreover, the performance of the survivor REIT sample was superior to that of the REIT population sample. The use of Standard and Poor's 500 Composite Index as a performance benchmark also led to an overstatement of REIT performance.

Furthermore, a REIT return generating model is developed based upon the assumptions that a REIT's value is the sum of the values of its assets and is independent of its capital structure. The results of the statistical tests are consistent with the hypothesis that the returns on REIT stocks are weighted averages of the returns on REIT assets and debts. Considerable evidence also suggests that the returns on REIT stocks are generated by the returns on commercial real estate properties and by the returns on long-term Treasury bonds for the 1971 to 1989 period. Ex post simulations also indicate that it is possible to replicate the risk and return characteristics of commercial real estate properties using equity REIT stocks and Treasury securities.

Finally, the random walk hypothesis is tested against four specific alternative (irrational) price behaviors: the January effect, the small firm effect, market overreaction, and fads. The findings suggest that the random walk hypothesis is inconsistent with the ex post behavior of REIT prices for the January 1970–December 1989 period. Inefficiency arises in the REIT market mainly because of the January effect and the "underreaction" from the investors of small REITs to new information. Short-term market overreaction does not appear to be a significant source of inefficiency in the REIT market. There is some evidence of long-term mean-reversion in REIT returns; but it is not clear whether this is caused by the deviation of the market prices from fundamental REIT values or the fluctuations in the REIT history.

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Chapter 1

Introduction

Real Estate Investment Trusts (REITs) are tax-exempt conduits that pool capital from individual investors to invest in real estate properties and mortgages. Because of the resources and knowledge required, very few investors are able to participate directly in the ownership or financing of commercial real estate properties. Investment in commercial real estate properties through REIT ownership does not require the large and illiquid financial commitment typical of other real estate investment alternatives. Also, the ownership of most REITs can be easily transferred with very low transaction costs because the shares of most REIT stocks are publicly traded. Therefore, REITs provide a mechanism to pool resources and thus to enable investors, especially small investors, to gain the economic and other advantages of commercial real estate investment.

The REIT industry has not been well received by the investment community. In the unexpected financial crisis of the mid 1970s, many investors were badly hurt. The shadow of that crisis has lingered over the REIT industry ever since, and even now REIT stocks are generally regarded by the investment community as inferior investments. The industry is generally ignored by Wall Street. The REIT market is also perceived as relatively inefficient. As a result, the REIT industry has not lived up to its potential role as a liquid real estate investment vehicle. For instance, the total assets of the REIT industry represented about only 1% of the $3.77 trillion commercial real estate assets in the United States in 1988 [64, 36].

The dramatic events associated with the industry have stimulated many studies on REIT performance [80, 12, 46, 84, 73, 32]. However, the results from these studies are still inconclusive. Furthermore, they suffer from three major methodological flaws: their use of short sample periods in such a volatile industry, their use of survivor samples for an industry that is known for frequent entry and exit, and their use of the unrepresentative Standard and Poor's Index as a performance benchmark.

The return-generating process for REITs has also been the focus of many empirical studies. Although researchers [84, 14, 32] found that REIT returns are influenced by more than one factor, they failed to explain what these factors were and why the returns on REITs should be sensitive to them. The interest in this return-generating process arises partly from the debate over whether REITs should be considered to be direct investments in real estate. Researchers and practitioners are interested in using the information derived from securitized real estate to help understand the risk and return characteristics of the $8.7 trillion real estate market, especially the $3.77 trillion market in commercial real estate [36]. The research results on this topic, however, are still few and preliminary. They provide little direction about how to utilize the information embedded in REIT returns to improve our understanding of the risk and return characteristics of unsecuritized real estate properties.

Studies on the efficiency of the REIT market are also relatively sparse compared to the vast literature on the efficiency of the stock market. Of the limited number of studies, findings are also inconclusive [49, 29, 86, 5]. There are also two problems associated with previous studies. First, these studies depend almost exclusively on the autocorrelation coefficients to make inferences about the efficiency of the REIT market. Because the significance test on the autocorrelation coefficients is weak in its ability to detect some long-term transitory components in the price process [82], we may fail to reject the random walk hypothesis even when it is false (Type I error). Second, there is no explanation for the appearance of anomalous evidence in the REIT market other than the possible January effect [16]. Thus, more study on the efficiency of the REIT market is needed.

1.1 Objectives

This dissertation addresses three major issues: the historical performance of REITs, the REIT return-generating process, and the efficiency of the REIT market.

1.1.1 REIT Performance

REITs can play a more significant role in improving the liquidity of the real estate market and in channeling capital intc the real estate sector. Due to its unpleasant experience in the past, the REIT industry has been suffering from a poor reputation among the larger investment community. The inconclusive findings on REIT performance from previous studies have not really helped to improve the image of the industry.

In this study, I am primarily interested in three specific issues about the performance of REITs. The first issue is whether REITs performed differently from the stock market portfolio on a risk-adjusted basis over the past two decades. My intent is to investigate how well investors would have done, relative to a representative stock market portfolio, if they had invested in some REIT portfolios throughout the last two decades. This investigation is based on ex ante strategies. Although few investors would invest in an asset class or industry continuously for two decades, the answer to this question will certainly clarify the question of whether REITs are inferior stocks.

The second issue is whether REIT performance varies over time. Although studies of different sample periods often come to different conclusions on REIT performance, no study has been conducted on the issue of whether REIT performance is stable over time. The issue is important in a practical sense because its answer will determine how reliable the historical performance is in predicting the future performance of REITs.

Finally, I will investigate whether the outcomes of REIT performance studies are sensitive to the choice of performance benchmarks and REIT samples. Some researchers, like Sagalyn [73], have questioned the possible bias associated with using a survivor sample; however, no study has addressed the dual issues of survivor bias and of the effect that the choice of performance benchmarks has on the outcomes of performance studies.

1.1.2 The Return-Generating Process of Real Estate Investment Trusts

There are two benefits to be gained from studying the REIT return-generating process. Not only will it help improve our understanding of the risk and return characteristics of REITs; it also provides a basis to replicate the risk and return characteristics of the $3.77 trillion market in commercial real estate properties [36].

In this study, I will address two issues regarding the return-generating process of REITs. The first is the development of a model of the REIT return-generating process based upon the principle of value additivity. Myers [61] and Schall [74], among many others, showed that the value of a firm should be the sum of the values of its assets in a perfectly competitive capital market. According to Modigliani and Miller [59], capital structure should also be irrelevant in this market. In other words, the value of a firm should be simply the sum of its assets minus its liabilities. This principle of value additivity provides a convenient framework for developing a return-generating process for REITs: if the market for REITs is perfectly competitive, the returns on the REIT stocks should be the weighted average of the returns on the assets and debts of these REITs.

The second issue under investigation is whether investors can use REIT stocks and fixed income securities to replicate the risk and return characteristics of unsecuritized real estate. If the returns on REIT stocks are indeed generated by the returns on REIT assets and debts, we should be able to replicate the risk and return characteristics of real estate properties by using equity REIT stocks, debts, and other REIT assets.

1.1.3 The Random Walk Hypothesis

The random walk hypothesis states that the changes in security prices are independent of one another and thus are unpredictable from historical information alone. Although it is simple, the random walk hypothesis is a foundation for many pricing theories and paradigms in modern financial economics [56].

Two questions regarding the efficiency of the REIT market are investigated. First, do REIT prices follow a random walk? The efficiency of the REIT market is an important issue because it reveals whether REIT prices are "fair." If REIT prices follow a random walk, or if the market for REIT stocks is at least weak-form efficient, REIT prices would reflect the fundamental values of the underlying assets of REITs [24, 10].

The previous tests on the efficiency of the REIT market have been weak and incapable of detecting some long-term irrational price behaviors [82]. A more comprehensive study on the issue is much needed. In addition to the conventional test, which examines the significance of the autocorrelation coefficients of REIT returns, I employ a more powerful variance-ratio test on the random walk hypothesis. I also cross-examine the effects of variable expected return and different holding periods.

The second issue concerning the efficiency of the REIT market is what causes the breakdown of the market if the market for REITs is indeed inefficient. Four alternatives to the random walk hypothesis are tested in this paper, namely, the January effect hypothesis, the small firm effect hypothesis, the market overreaction hypothesis, and the fad hypothesis. The testing of these alternative hypotheses will not only help answer the questions about whether REIT prices follow a random walk, but will also offer a plausible explanation about the sources of market inefficiency if the random walk hypothesis is indeed rejected.

1.2 Summary of Findings

The results of this study indicate that the performance of REIT portfolios was consistent with the security market line for the 1970-1989 period. In other words, REITs are not "inferior" investment vehicles. However, REIT performance varied over time in the last two decades. Therefore, it is difficult, if not impossible, to predict the future performance of REITs based upon their historical performance. Moreover, the performance of the survivor REIT samples was better than that of the overall REIT population. Therefore, the use of survivor-only samples will overestimate the performance of the REIT industry. Finally, the use of the S&P Index as a performance benchmark also tends to overstate REIT performance. Therefore, the choice of the performance benchmark will affect the outcomes of any performance studies.

Furthermore, the results of this study are consistent with the hypothesis that the returns on REIT stocks are weighted averages of the returns on REIT assets and debts. Considerable evidence also indicates that the returns on REIT stocks are generated by the returns on real estate properties and long-term Treasury bonds. The returns on the three-month Treasury bills appear to be insignificant in the REIT return-generating process. Our ex post simulations suggest that it is indeed possible to use REIT stocks and Treasury securities to replicate the risk and return characteristics of real estate properties.

Finally, the test results generated in this chapter do not support the random walk hypothesis for REIT prices. The random walk hypothesis is rejected for the January 1970–December 1989 period. Short-term market overreaction does not appear to be a significant source of inefficiency in the REIT market. Inefficiency arises in the REIT market mainly because of the January effect and the "underreaction" of investors in small REITs. Thus, it is implausible that the REIT market is "excessively volatile", as suggested by many real estate professionals [79, 53, 73, 75]. I also found long-term mean-reversion in REIT returns. However, it is not clear whether this is caused by the long–term deviation of the market prices from fundamental REIT values or by the historical fluctuations in the REIT industry.

1.3 Outline of the Dissertation

This dissertation addresses each of the three issues in independent and self-contained chapters. Chapter Two discusses the historical performance of REITs. It is followed by chapters on the REIT return-generating process and the random walk hypothesis of REIT returns.

Chapter 2

The Historical Performance of Real Estate Investment Trusts

Abstract

This empirical study investigates the performance of Real Estate Investment Trusts (REITs). Although many have studied REIT performance since then, their findings on the long-term performance of REITs are inconclusive. Furthermore, there are three methodological flaws associated with these studies: their use of short sample periods, survivor samples, and unrepresentative performance benchmark. The objectives of this study are: (1) to evaluate the long-term performance of REITs; (2) to examine the stability of REIT performance over time; and (3) to investigate the sensitivity of a performance measure, the Jensen Index of Performance, to the choice of performance benchmarks and the REIT sample. The test results indicate that the performance of the REIT portfolios was consistent with the security market line for the 1970-1989 period. However, REIT performance varied over time in the last two decades. Survivor REITs also performed better than the overall REIT population. Finally, this study found that t he use of the unrepresentative S&P Index tends to overstate REIT performance.

Real Estate Investment Trusts (REITs) are tax-exempt conduits that pool capital from investors in order to invest in real estate properties and mortgages. Originated as business trusts in Massachusetts in the nineteenth century, REITs are characterized by their investments almost exclusively in real estate assets, their distribution of virtually all income as dividends to shareholders free of any tax at the corporate level, their management by knowledgeable professionals, and their ownership through transferable shares [63].

REITs are important investment vehicles in direct real estate ownership or lending. Because such a high level of both resources and knowledge is required, very few investors are able to participate directly in the ownership or financing of commercial real estate properties. Investment in real estate through REIT ownership, however, does not require the large and long-term financial commitment typical of other real estate investment alternatives. The ownership of most REITs can also be easily transferred with very low transaction costs, since shares of most REIT stocks are publicly traded. Therefore, REITs provide a mechanism to pool resources to enable investors, especially small investors, to gain economic and other benefits of commercial real estate investments. In today's illiquid real estate market, REITs have attracted more and more attention as liquid real estate investment vehicles even from institutional investors such as pension funds.

The poor reputation of REITs, a leftover from the industry crisis in the mid 1970s, deters many investors from participating in the REIT market. Since the late 1970s, many researchers have studied REIT performance and have contributed a great deal to our understanding of this important real estate investment vehicle. Unlike the consistent findings on the apparently superior performance of unsecuritized real estate [90, 28, 11, 26, 37, 53, 57, 58, 70, 88], research findings on REIT performance, especially equity REIT performance, have been mixed relative to the stock market portfolio. For instance, while some researchers such as Smith and Shulman [80], Titman and Warga [84], and Goebel and Kim [31] suggested that the performance of REIT stocks was worse than or comparable to the market portfolio, others such as Burns and Epley [12], Kuhle [45], and Sagalyn [73] found that REITs, especially equity REITs, outperformed the stock market portfolio. The debate over REIT performance remains.

The inconclusive findings are not a surprise due to the short sample periods used in the previous studies. These short sample periods are not representative of the overall history of REITs. Given the booms and busts of the REIT industry over the past two decades, similar performance studies on different periods of time might lead to different results.

There are also two additional problems associated with these studies. First, most researchers used only survivor REITs in their studies. Survivor REITs are by no mean identifiable ex ante. Therefore, the performance of a group of survivor REITs is by no means representative of the performance of the larger REIT population.

Furthermore, the Standard and Poor's 500 Composite (S&P) Index has been used as the performance benchmark for almost all the previous performance studies. The S&P Index represents only the blue chip stocks, not the universe of all stocks. Since historical evidence suggests that large stocks underperform compared to small stocks, the use of the S&P Index might overstate the performance of REIT stocks, most of which are "small."

This study addresses three specific issues. The first issue is whether REITs performed differently from the stock market portfolio on a risk-adjusted basis over the past two decades. My intent is to answer a hypothetical question: How well would an investor have done relative to a representative stock market portfolio if he had invested in some REIT portfolios based on ex ante strategies throughout the last two decades? Although few investors would invest in an asset class or industry continuously for two decades, the answer to this question will certainly clarify the question of whether REITs are inferior stocks. The performance of the REIT population will be compared with that of a more representative stock market portfolio over a period that is more representative of the REIT history. In the frameworks of the capital asset pricing model of Sharpe-Lintner [76, 48] and an efficient market, we should expect that the performance of REIT stocks would be similar to the market portfolio on a market-risk adjusted basis in the long run.

The second issue is whether REIT performance varies over time. Although studies of different sample periods often come to different conclusions on REIT performance, no study has been conducted on the issue of whether REIT performance is stable over time. The issue is important in a practical sense because its answer will determine how reliable the historical performance is in predicting the future performance of REITs.

Finally, I will investigate whether the outcomes of REIT performance studies are sensitive to the choice of performance benchmarks and REIT samples. Some researchers, like Sagalyn [73], have questioned the possible bias associated with using a survivor sample; however, no study has addressed the dual issues of survivor bias and of the effect that the choice of performance benchmarks has on the outcomes of performance studies.

The results of this study indicate that the performance of REIT portfolios was consistent with the security market line for the 1970-1989 period. In other words, REITs are not "inferior" investment vehicles. However, REIT performance varied over time in the last two decades. Therefore, it is difficult, if not impossible, to predict the future performance of REITs based upon their historical performance. Moreover, the performance of survivor REIT samples was better than that of the overall REIT population. Therefore, the use of survivor-only samples will give a biased estimate of REIT industry performance. Finally, the use of the S&P Index as a performance benchmark also tends to overstate REIT performance. Therefore, the choice of the performance benchmark will affect the outcomes of any performance studies.

The following sections will discuss the details leading to these conclusions. The first section, which reviews the literature, is followed by discussions on methodology and hypotheses, data, and summary of findings. A brief overview concludes this chapter.

2.1 A Review of the Literature on REIT Performance

The industry crisis in the mid 1970s has left REITs with a bad reputation among investors. Since then, many researchers have attempted to evaluate the historical performance of REITs. The findings from these studies have certainly helped investors better understand the risk and return characteristics of REITs, but they are by no means conclusive. Furthermore, they generally suffer from three methodological flaws: their use of too-short sample periods, survivor samples, and an unrepresentative performance benchmark. For these reasons, more study is needed. In this section, I briefly review the recent history of REITs, the literature on REIT performance, and the problems associated with these studies.

2.1.1 History of the REIT Industry

Few other industries have experienced the same kind of booms and busts as REITs. The passage in 1960 of the Real Estate Investment Trust Act of 1960 granted the tax-exempt status to REITs . After a slow start, REITs took off in the late 1960s and the early 1970s. During the 1968-1973 period, for instance, total REIT assets rose by almost 2,000% [33, pp. 18–22]. This growth was largely fueled by the increased demand for construction and development (C&D) financing and the inability of the existing financial institutions to meet this demand. Moreover, the boom was mostly financed by funds borrowed through short-term commercial paper and bank notes.

Because of the large spreads between the rates charged for C&D loans and short-term interest rates, most REITs made very handsome returns in this period.

This rapid growth came to a halt in 1973. As interest rates started to rise in 1972, the previously large spreads between the rates for C&D loans and short-term interest rates began to disappear, and eventually became negative after the 1973 oil crisis. Many REITs were operating at a net loss. Overbuilding and high vacancy rates in the real estate market also forced many developers to default on their loans. During the period from January 1973 to January 1975, the Share Price Index of the National Association of Real Estate Investment Trusts (NAREIT) dropped by about 56.3% [64, pp. 44–48]. If this was not bad enough, the conservative procedures for loan-loss provisions and for valuing defaulted loans, established by the American Institute of Certified Public Accountants in June 1975, dealt the REIT industry another blow. Since REITs had previously no loan-loss reserves, the markdown in REIT book values for loans eliminated shareholder equity completely in many REITs.

The sudden bust of the REIT industry took many investors by surprise. Inevitably, many were seriously hurt. Since then, the REIT industry has staged a slow and painful comeback. The REIT industry experienced significant structure changes during the late 1970s and the early 1980s. Leverage was reduced from 64% in 1972 to 48% in 1984; short-term debts also declined from 44% of total assets in 1972 to 11% in 1984. The investment in construction and development loans also decreased from 53.4% of the total assets in 1972 to 8.1% in 1984 [63, p. 13].

REITs also benefited a great deal from the Tax Reform Act (TRA) of 1986. The TRA eliminated the tax advantage for many tax-driven investments, such as real estate limited partnerships, by lengthening depreciation schedules and replacing accelerated cost recovery by straight-line depreciation schedules. Non-cash losses from passive investments are no longer allowed as shelters for earned income. Since REITs are income securities and have never been used to shelter income, the elimination of tax shelters only enhanced the comparative advantages of REITs relative to other real estate investment vehicles.

However, the favorable changes in REIT structure and REIT external environment have not enabled the REIT industry to recover completely from its crisis in the mid 1970s. The recovery of the REIT industry has been slow since the mid 1970s. In nominal terms, industry's total assets rose from $19.90 billion in 1974 [63, p. 13] to $40.56 billion in 1988 [64, p. 48]. However, in real 1974 dollars, the total assets in 1988 were worth only $15.22 billion, about 76.5% of the value in 1974. Moreover, the NAREIT Share Price Index in 1988 was 95.93% in nominal terms and 36.00% in real terms of that at the beginning of 1972 [64, pp. 44–46].

The REIT industry also remains an insignificant player in the real estate market. For instance, total REIT assets account for only 1.08% of the total of $3.77 trillion in U.S. investment real estate assets in the late 1980s [36, p. 31]. Given the unpleasant history of the REIT industry, it is possible that the poor reputation might have slowed the recovery of the REIT industry.

Table 2.1: Summary of Findings on REIT Performance

Author	Data	Performance Measure	Finding
Smith and Shulman (1976)	Quarterly returns on 16 survivor REITs, 1963-1974.	Jensen Index, means, R^2, and betas.	REITs outperformed the S&P index for the 1963-1973 period, but not in 1974.
Burns and Epley (1982)	Quarterly returns on 35 Survivor REITs, 1970-1979.	Portfolio efficient frontiers.	Mixed-asset portfolios containing REITs outperformed S&P index and single asset portfolios.
Kuhle and Walther (1986)	Annual returns on 102 REITs, 1973-1985.	Net Returns.	REIT stocks outperformed S & P index during 1977-84, but underperformed the S&P Index during 1973-76.
Titman and Warga (1986)	Monthly returns on 36 survivor REITs, 1973-1982.	CAPM & APT based Jensen Index.	The performance of REIT stocks is similar to CRSP indexes; Five-factor APT does not provide better fit on the data than the CAPM.
Sagalyn (1990)	Quarterly returns on 20 survivor REITs, 1973-1987.	Jensen Index.	Survivor equity REITs outperformed S&P Index. The performance of a portfolio of all REITs was similar to that of the S&P Index.
Goebel and Kim (1990)	Monthly returns on 32 survivor REITs, 1984-1987.	Jensen Index.	REITs, especially finite-life REITs, underperformed Compared to the S&P Index.

2.1.2 Literature on REIT Performance

The dramatic events associated with the industry have attracted many studies on the performance of REIT stocks. Table 2.1 summarizes the findings of these studies. Although they helped investors better understand the performance of the REIT industry, these findings are inconclusive. Furthermore, the outcomes from REIT performance studies seem to be highly sensitive to the sample period studied.

For instance, in their pioneer work on REIT performance, Smith and Shulman [80] compared the performance of sixteen REITs to the S&P Index, savings accounts, and fifteen closed-end funds over the 1963-1974 period. They found that equity REITs outperformed savings accounts and the S&P Index for the 1963-1973 period. However, the performance of REIT stocks was so bad in 1974 that their REIT sample underperforms the S&P Index for the entire 1963-1974 period if the recession year of 1974 is included.

The research conducted by Kuhle and Walther [46] also suggests that REITs performed poorly during the mid 1970s. Kuhle and Walther calculated the annual net returns on 102 REITs for the 1973-1984 period, defining the net return on the REIT portfolio as the difference between the systematic-risk-adjusted returns on REITs and the returns on the S&P Index. They found that REITs provided less-than-average returns during the 1973-1976 recession period. They did not test whether these differences in performance were statistically significant.

The findings of Burns and Epley [12] were slightly different, however. They investigated whether the efficient frontier of mixed portfolios that consist of REIT stocks and other common stocks dominates the efficient frontier for a single asset type and the S&P Index for the 1970-1979 periods. They found that the mixed-asset efficient frontier did dominate the S&P Index and both of the single-asset efficient frontiers with respect to mean and variance at every risk and return level for the entire period, the 1970-1974 subperiod, and the 1975-1979 subperiod. However, they used the same data to construct the efficient portfolio and to evaluate performance. It is possible for some firms in depressed industries to outperform the market. But, how are investors going to know what these firms are ex ante?

The results from the studies on the performance of the REIT industry over the period between the late 1970s and early 1980s generally suggest that the performance of the REIT industry was similar or superior to that of the stock market portfolio. For instance, Kuhle and Walther [46] found that REITs outperformed the S&P Index in 1977-1984. Their findings are supported by Sagalyn [73]. She found that an equally-weighted portfolio of five survivor equity REITs consistently outperformed the S&P Index for the period from the third quarter of 1973 to the fourth quarter of 1987.

Titman and Warga [84] also found that the performance of REIT stocks is not significantly different from that of the stock market portfolio over the 1973-1982 period. They calculated and compared both the Capital Asset Price Model (CAPM)-based Jensen indexes and the Arbitrage Pricing Theory (APT)-based Jensen indexes on 16 equity REITs and 20 mortgage REITs. They found that both indexes for the entire period studied are not statistically different from zero. In other words, the market risk-adjusted returns on REIT stocks are about the same as the returns on the stock market index.

Studies on the performance of REIT stocks since the mid 1980s have come to different conclusions. For instance, Goebel and Kim [31] recently compared the performance of REITs, especially the finite-life REITs (FREITs), with the S&P Index. They found negative and significant Jensen Indexes of performance for equally-weighted portfolios of thirty-two survivor REITs. They concluded that REITs, especially FREITs, underperformed compared to the S&P Index over the January 1984-December 1987 period.

2.1.3 Problems with Previous Studies

Previous studies of REIT performance have greatly helped investors to better understand the risk and return characteristics of REIT stocks. However, there are three methodological flaws in these studies: their use of unrepresentative sample periods, the S&P Index, the survivors-only sample.

Unrepresentative Sample Periods

Some researchers used rather short sample periods in their previous studies on REIT performance. For instance, Goebel and Kim [31] covered only a five-year expansionary period for REITs. Titman and Warga [84] studied the eleven years during which the REIT industry experienced its crisis in the mid 1970s and the subsequent slow recovery.

The use of a short sample period to draw general inferences about the performance of REIT stocks presents a serious problem in such a volatile industry. The problem arises because the sample period may coincide with a boom or bust period in the REIT history. The results will therefore only reflect the performance of REIT stocks during that specific period, and can by no means tell us the whole story of the historical performance of REIT stocks.

The Unrepresentative S&P Index

The S&P Index has been the most widely used proxy for the stock market portfolio in previous studies on REIT performance. For example, Smith and Shulman [80], Goebel and Kim [31], and Sagalyn [73] have used the S&P Index in their studies. However, the S&P Index is not an appropriate performance benchmark because it does not include small stocks.

The S&P Index represents a portfolio of the 500 largest (Blue Chip) companies in 84 industries. It is not a sample of all publicly traded stocks. The average market value for a typical S&P 500 company was $4 billion in 1989 [35], more than forty times the size of a typical REIT. [1]

Findings in the finance literature suggest that small firms performed differently from larger firms over the past 60 years. For instance, Ibbotson Associates found that a dollar invested in the S&P Index fund at year-end 1925, with dividends reinvested, grew to $406.45 by year-end 1988, while the same investment in a small stock fund resulted in a payoff of $1,478.14 [35, pp. 31-33]. In other words, ex post, the S&P Index fund underperformed the small stock fund by a significant margin. Thus, the use of the S&P Index as a performance benchmark may make REIT stocks look like much better

[1] The average market value for a typical REIT was $91.28 million in my sample in 1989 and $100 million in the Webb and McIntosh Survey [89, p. 79] in 1985.

performers they really are.

A close examination of current literature supports this speculation. For instance, in her study on the performance of equity REITs over business cycles, Sagalyn [73] found that equity REITs outperformed the S&P Index during the period 1973-1987. However, in a study over the similar period from 1973 to 1982, Titman and Warga [84] found that the performance of equity REITs was comparable to that of the equally-weighted and value-weighted CRSP Indices. It is very likely that the exclusion of small stocks from the S&P Index contributed to the difference in the outcomes of these two studies. The issue remains unresolved.

Survivors-Only Sample

In most previous studies, researchers evaluated the performance of survivor REITs [80, 18, 12, 45, 84, 73, 31]. These survivor samples are small. For instance, the sample used by Sagalyn contains only 20 REITs, including 5 equity REITs. The inference of her finding that equity REITs outperform the S&P Index is inevitably limited by this small sample size.

In addition, the use of survivor-only samples lead to two other problems. First, the risk and return characteristics of the survivors-only sample are not achievable by investors ex ante. For instance, a commonly used buy-and-hold strategy in constructing a REIT data sample is to include all REIT stocks that are continuously listed in the major stock exchanges throughout the study period. The nature of ex post research means that researchers have the luxury of knowing which REITs have survived by the end of the investment period. In the real marketplace, however, investors will not be able to acquire such information at the beginning of the investment period. In other words, it is impossible to implement these buy-and-hold strategies ex ante.

Second, the use of a survivors-only sample may lead to an overestimation of REIT performance. The requirements for data continuity mean that any REITs that are short-lived and created after a certain cutoff point will be excluded, leaving only the survivors in the data sample. In other words, these data samples include only the REITs that survived harsh economic conditions in the period studied. REITs that went bankrupt or merged with other firms are excluded. In an industry that is known for its frequent exits and entries, the performance of survivors-only samples may not be a fair representation of the performance of the overall REIT industry.

Some researchers have recognized the problems associated with the use of the survivors-only sample in performance analysis. For instance, Sagalyn [73] alerts readers to the potential survivorship bias associated with her findings on equity REIT performance over business cycles. However, the effects of the survivorship bias on the REIT performance have not been carefully studied.

2.1.4 Summary and Research Questions

The crisis of the mid 1970s has also left REITs with a bad reputation among investors. Although there have been many studies on REIT performance, their findings remain inconclusive. Furthermore, these studies suffer from three major problems: their use of short sample periods, the survivor samples, and the unrepresentative performance benchmark.

This study intends to address three unresolved questions.

1. The long term performance of REIT stocks. Since most studies have centered around short-term periods, the question of how well REITs performed over the long term remains unsolved.

2. The stability of REIT performance over time. Although evidence suggests that REITs performed differently in different sampling periods, it is unclear whether these differences are statistically significant. In other words, we do not really know whether these findings tell us anything about how REITs will perform in the future. If REIT performance has indeed varied over time, the historical performance will have little power to predict the future performance of REITs.

3. The sensitivity of performance outcome to survivor sample and performance benchmarks. In most of the previous studies, researchers used survivor REIT samples to represent the REIT population and the S&P Index as the performance benchmark. Given the problems associated with the survivor sample and the S&P Index, the conclusions from the previous studies may be biased. Although some researchers have recognized the problems, no research has been done on how the choice of REIT samples and the performance benchmarks may affect the outcomes of performance studies.

2.2 Methodology and Hypotheses

In this study, I use an absolute performance measure, the Jensen Index of Performance [40] to estimate the performance of REIT portfolios. The Jensen Index is based on the CAPM. It compares the performance of a security or a portfolio to the standard performance benchmark, the security market line. By assuming that the CAPM holds period by period, and that the returns on securities are generated by the "market model," Jensen [40] derived a linear expression between the realized returns on any security and its systematic risk, the realized returns on the market portfolio, the risk-free interest rate, and a random error term:

$$\tilde{r}_{j,t} - \tilde{r}_{f,t} = \alpha_j + \beta_{j,m}(\tilde{r}_{m,t} - \tilde{r}_{f,t}) + \tilde{\epsilon}_{jt} \tag{2.1}$$

where

$\tilde{}$ denotes the random variable,

α_j is the Jensen Index of performance for portfolio j,

$\tilde{r}_{j,t}$ is the realized return on portfolio j at time t,

$\tilde{r}_{f,t}$ is the risk-free rate at time t,

$\beta_{j,m}$ is portfolio j's market risk,

$\tilde{r}_{m,t}$ is the realized return on the market portfolio at time t, and

$\tilde{\epsilon}_{j,t}$ is a random and serially independent error term with zero expected value.

As a performance benchmark, the Jensen Index represents the average incremental monthly rate of return on a REIT portfolio which can be attributed to the general characteristics of REITs. Because the sampling distribution of the Jensen Index, $\tilde{\alpha}$, is a student t distribution with T-2 degrees of freedom, where T is the number of observations, one can apply the least squares regression method to test the significance of the Jensen Indexes.

Furthermore, the security market line can be used and interpreted independent of the asset pricing framework. The Jensen Index is widely used in performance studies because it measures performance based upon a simple and realistic benchmark, a passive managed portfolio that invests in savings accounts and the stock market portfolio. For instance, the benchmark used in the Jensen Index can be interpreted as a portfolio with $\beta_{j,m}$ proportion invested in a stock market portfolio and $(1 - \beta_{j,m})$ proportion in short-term risk-free securities. A positive and significant Jensen Index indicates a superior performance of a REIT portfolio relative to this portfolio, while a negative and significant Jensen Index suggests an inferior performance by the REIT portfolio. The former is often referred to as the case in which the REIT portfolio outperforms the market portfolio and, in the latter case, the portfolio underperforms compared to the market portfolio.

2.2.1 Hypotheses

In the long term, we should expect that the REIT industry portfolio would perform similarly to the stock market portfolio on a risk-adjusted basis if the market is efficient and the CAPM holds. In other words, the null hypothesis – that the performance of REIT portfolios is consistent with the security market line – can be expressed as:

$$H_{00} : \alpha_j = 0$$
$$H_{a0} : \alpha_j \neq 0.$$

If REIT performance is consistent over time, the Jensen Indexes estimated from different sample periods should be the same. In other words, we should observe ex post:

$$H_{01} : \alpha_{j,t-k} = \alpha_{j,t+n}, \quad \forall\ k\ and\ n$$
$$H_{a1} : \alpha_{j,t-k} \neq \alpha_{j,t+n}.$$

If the S&P Index gives an unbiased estimate of REIT performance, the performance measure generated from using the S&P Index should be the same as that from using a more representative stock market portfolio. In other words, we should expect that:

$$H_{02} : \alpha_{S\&P} = \alpha_{EWCRSP}$$
$$H_{a2} : \alpha_{S\&P} \neq \alpha_{EWCRSP}$$

If the survivors-only sample gives the same performance measures as that of an unbiased REIT sample, the Jensen Index estimated based upon the survivor sample should not be different from the results generated from the

REIT population. Ex post, we should observe that:

$$H_{03} \;:\; \alpha_{survivorREITs} = \alpha_{REITpopulation}$$

$$H_{a3} \;:\; \alpha_{survivorREITs} \neq \alpha_{REITpopulation}$$

2.2.2 Small Stock Effect

The problem with performance estimates derived from using the S&P portfolio can also be analyzed through a modified model for the Jensen Index: (See Appendix A for the mathematical proof of this expression.)

$$\tilde{r}_{j,t} - \tilde{r}_{f,t} = \alpha_j + \beta_{j,S\&P}(\tilde{r}_{S\&P,t} - \tilde{r}_{f,t}) + \beta_{j,ss}(\tilde{r}_{ss,t} - \tilde{r}_{f,t}) + \tilde{\epsilon}_{j,t} \qquad (2.2)$$

where

$\tilde{r}_{ss,t}$ is the return on a small stock (SS) portfolio.
$\beta_{j,sp}$ is the weight in the S&P market portfolio,
$\beta_{j,ss}$ is the weight in the small stock market portfolio, and
$\tilde{\epsilon}_{j,t}$ is the random and serially independent error term with $E(\tilde{\epsilon}_{j,t}) = 0$.

Equation (2.2) shows the impacts on the performance estimates of excluding small stocks in the stock market portfolio. The null hypothesis that there is no small stock effect can be expressed as

$$H_{04} \;:\; \beta_{j,ss} = 0,$$

$$H_{a4} \quad : \quad \beta_{j,ss} \neq 0.$$

As long as the second term on the right hand side (RHS) of equation (2) does not equal zero, that is, $\beta_{j,ss} \neq 0$ *and* $(\tilde{r}_{ss,t} - r_{f,t}) \neq 0$, the use of the S&P Index will give biased performance estimates.

This two-factor performance benchmark can be represented by a three-dimensional security market plane. It can also be interpreted as a portfolio with $\beta_{j,S\&P}$ proportion invested in the S&P Index fund, $\beta_{j,ss}$ proportion in the SS portfolio, and $(1 - \beta_{j,S\&P} - \beta_{j,ss})$ proportion in short-term risk-free securities.

2.3 Data

This section describes the methodology used to construct unbiased REIT industry portfolios and the selection of both the stock market portfolios and the small stock portfolio.

2.3.1 Construction of Unbiased REIT Industry Portfolios

An unbiased REIT portfolio should be free of survivor bias and should reflect the realistic ex ante risk and return characteristics of a typical investment in the REIT industry. To avoid survivorship bias, eight REIT portfolios are constructed based on ex ante feasible strategies for four different categories of REIT stocks. These four categories are: all REIT stocks, equity REIT stocks, mortgage REIT stocks, and hybrid REIT stocks. Two portfolios, based respectively on equally-weighted and value-weighted strategies, are constructed for each of these categories to see if the size of the REITs has any impact on their performance.

These eight portfolios are free of survivor bias because their weights are based strictly upon historical information. For instance, when selecting REITs for each of these portfolios, no consideration is given to the fact that a REIT stock may or may not survive over the next holding period, i.e., the next month. More specifically, the construction of these ex ante REIT portfolios is based on the following strategies:

1. Include every REIT listed in the 1989 CRSP tapes during the period of

January 1970 to December 1989. Since this period covers several booms and busts in the U.S. real estate market, the study period should be a fair representation of the REIT history.

2. Assign weight $\frac{1}{n_{s,t}}$ to REIT i in month t in an equally-weighted portfolio, where $n_{s,t}$ is the number of REITs in a sample or subsample s in month t. The portfolios are modified on a monthly basis to reflect new entries and exits in the market.

3. Assign weight $\frac{V_{i,t}}{V_{s,t}}$ to REIT i in month t in a value-weighted portfolio, where $V_{i,t}$ *and* $V_{s,t}$ are the market values for REIT i and REIT sample s respectively at time t. Similar monthly adjustments are made to the value-weighted REIT portfolios to reflect new entries and exits in the market.

4. Assume that a firm is qualified to be a REIT throughout a period if its CUSIP number[2] remains the same during the period.

The REIT sample in this study includes 153 REIT stocks.[3] The sample is further divided into three subgroups: equity REITs, hybrid REITs, and mortgage REITs. The selection criteria are based upon: (1) the classification of the *1986 REIT Fact Book* [63, pp. XXIV-XXVI], or (2) the 75% rule.[4] The information on the asset structure of each REIT is based on the 1974, 1979,

[2]An 8-digit number assigned to each firm by the Center for Research in Securities Prices(CRSP).

[3]See Appendix B for more details on the REIT sample.

[4]A REIT is classified as an equity REIT if 75% of its assets are located in real estate equity, a mortgage REIT if 75% of its assets are in real estate mortgage, and a hybrid REIT if it is neither.

and 1989 editions of *Moody's Bank & Finance Manual.* The sample includes a total of 64 equity REITs, 25 hybrid REITs, and 64 mortgage REITs.

Monthly returns for REIT stocks listed on both the NYSE and the ASE are derived directly from the 1989 CRSP monthly tape. For REIT stocks listed in the NASDAQ system, monthly returns are calculated using price and dividend data from the NASDAQ daily file in the 1989 CRSP tape. The following formula is used to calculate the monthly returns on the REIT stocks in the NASDAQ file:

$$r_{i,t} = \frac{P_{i,t} * F_{i,t} - P_{i,t-1} + D_{i,t}}{P_{i,t-1}} \tag{2.3}$$

where

$r_{i,t}$ is the monthly rate of return on REIT i in period t;
$P_{i,t}$, $P_{i,t-1}$ are the stock prices of REIT i at the end of period t and $t-1$;
$D_{i,t}$ is the dividends per share paid during $t-1$ and t; and
$F_{i,t}$ is the adjustment factor for stock split and stock dividends. $F_{i,t} = 1$ when there is no stock split and stock dividend.

Table 2.2 provides summary statistics on the REIT sample used in this study for the 1970-1988 period. The average number of REITs included in the sample in a typical month is 60.24 with an aggregate market value of \$3.57 billion. The last column in Table 2.2 summarizes the representation ratio, a ratio of the market value of the sample over the market value of all REIT shareholders' equity.

There are two possible explanations for representation ratios lower than

Table 2.2: Comparison of Market Values: Sample vs. All REITs

(1) Year	(2) Number of REITs in the Sample	(3) Market Value of the Sample (billions)	(4) Market Value of All REIT Stocks (billions)	(5) (3) * 100/(4) Representation Ratio
1970	21	$1.00	$2.89	34.60%
1971	29	1.93	3.97	48.61
1972	37	2.66	5.11	52.05
1973	67	2.39	5.78	41.35
1974	64	0.96	4.66	20.60
1975	61	1.05	3.16	33.23
1976	58	1.39	2.64	52.65
1977	55	1.58	2.61	60.54
1978	55	1.46	2.60	56.15
1979	54	1.81	2.79	64.87
1980	56	2.24	2.92	76.71
1981	57	2.21	3.09	71.52
1982	55	2.87	3.49	82.23
1983	53	3.71	3.76	98.67
1984	62	4.99	5.50	89.91
1985	80	6.91	8.31	83.15
1986	93	9.17	9.61	95.42
1987	100	8.60	11.57	74.33
1988	96	9.69	13.20	73.41

Notes:
a. Column (2) and (3) are from the author's own data base; column (4) is from *1982 REIT Fact Book*, p. 33, *1986 REIT Fact Book*, p. 13, and *REIT Facts*, p. 60.
b. All data presented here are year-end values.

100%. First, some REITs are either closely held or traded infrequently on regional stock exchanges. These REITs are not included in the CRSP tape and therefore are not included in my sample. Second, there may be some errors in the data from the National Association of Real Estate Investment Trusts (NAREIT). For instance, the recession in the mid 1970s wiped out about 30% of the wealth in the U.S. stock market[5] and 59.8% of the market value of my sample in 1974. It is implausible that, according to the NAREIT, the very same recession reduced the market value of all REIT shareholders' equity by only 19.4% in the same period, especially if we consider that the NAREIT Share Price Index for all REITs dropped by 49.54% during the same period [63, p. 10].

2.3.2 The Choice of a Stock Market Portfolio

The application of equation (2.1) requires that the market portfolio, m, be ex ante efficient[6] and includes, theoretically, all available assets on the market. In practice, such a portfolio does not exist. Since the focus of this study is to measure REIT performance relative to the stock market portfolio, the universe of all assets is confined to the stock market in the United States.

The portfolio that most closely resemble the stock market portfolios in the United States is the stock market portfolio constructed by the Center for Research on Security Pricing (CRSP). The CRSP portfolio contains

[5]The equally-weighted CRSP Index, the value-weighted CRSP Index, and the S&P Index lost 29.59%, 27.23% , and 29.72% of their market values respectively in 1974. Source: 1989 CRSP monthly tape.

[6]An efficient portfolio has the lowest level of risk for a given level of return or the highest level of return with a given level of risk.

about 6,300 stocks traded on the New York Stock Exchange (NYSE) and the American Stocks Exchange (ASE) and over 9,900 stocks traded in the over-the-counter system (NASDAQ). Therefore, the CRSP portfolio should be a good surrogate for the stock market portfolio. The equally-weighted CRSP portfolio will be used as the stock market portfolio throughout the discussion of this chapter. The return series for the CRSP Index is derived from the 1989 CRSP tape.

2.3.3 The Market Portfolio of Small Stocks

The return series for the small stock portfolio are generated from the Ibbotson Associates publication, *Stocks, Bonds, Bills, and Inflation: 1989 Yearbook* [35, pp. 33-36]. The small stock portfolio represents a value-weighted portfolio of stocks in the ninth and tenth (smallest) deciles of the New York Stock Exchange (NYSE). Since the beginning of 1982, the return series for this portfolio has been represented by the returns on the Dimensional Fund Advisors' (DFA) Small Company Fund. The DFA Small Company Fund includes a broader mix of stocks. It includes not only the stocks traded on the NYSE, but also those traded on the American Stock Exchange (ASE) and the Over-the-Counter System (NASDAQ) with the same or smaller capitalization as the upper bound of the NYSE ninth decile. As of year-end 1988, the DFA Small Company Fund contained 2,250 stocks with an average capitalization of roughly $40 million per company [35, pp. 33-36].

2.4 REIT Performance: A Summary of Findings

How well did REITs perform relative to the stock market portfolio over the January 1970-December 1989 period? Table 2.3 summarizes the basic performance statistics for the eight REIT portfolios and the stock market portfolio.

A comparison of these statistics suggests that the performance of REIT stocks is slightly poorer than that of the stock market portfolio over the last two decades. For instance, the REIT portfolios generally provide lower mean returns than the stock market portfolio, and the return volatility of the REIT portfolios is compatible to that of the stock market portfolio. Therefore, the performance of the REIT portfolios is generally less attractive than that of the stock market portfolio on a total-risk adjusted basis. For instance, six out of eight REIT portfolios have higher volatility per unit of mean return, as measured by the coefficients of variation (CV), relative to the stock market portfolios over the period studied. Furthermore, all eight REIT portfolios have lower total-risk-adjusted excess returns than the stock market portfolio, as measured by the Sharpe Index of Performance [77]. These findings are preliminary since they do not reveal whether these performance differences are statistically significant.

Furthermore, the performance is not the same across different REIT portfolios. Equity REIT portfolios tend to perform better than mortgage REIT portfolios by significant margins of 1.06%-5.32% a year. They are also the only two REIT portfolios that have lower CV than the stock market portfolio. Equally-weighted portfolios also seem to perform better than value-weighted portfolios on both absolute and total-risk-adjusted bases.

2.4.1 REIT Performance Relative to the Stock Market Portfolio

To test whether the difference in performance between the REIT portfolios and a passive strategy of investing in the stock market portfolio and savings accounts is statistically significant, I regressed the excess returns of the eight REIT portfolios against the excess return on the equally-weighted CRSP portfolio based on the relation described in equation (2.1). Table 2.4 summarizes the results from these eight regressions. An examination of the Durbin-Watson statistics indicates that the regression residuals in all eight REIT portfolios are first-order serially independent.

The statistically insignificant intercept term, α, for the two all-REIT portfolios indicates that REITs as a whole performed similarly to the CAPM benchmark for the past two decades. When adjusted by its market risk, the equally-weighted all-REIT portfolio underperformed compared to the equally-weighted CRSP portfolio by 0.187% per month, or 2.267% per year and the value-weighted all-REIT portfolio underperformed compared to the same portfolio by 0.335% per month, or 4.095% per year. But the performance differences are not significantly different from zero even at the 0.10 significance level.

In general, the equity REIT portfolios performed much better than the

Table 2.3: Summary of Performance Statistics

January 1970-December 1989	Mean Return	Standard Deviation	CV[a]	Sharpe Index[b]
Equally-Weighted Portfolios of				
All REITs	0.883%	6.026%	6.828	0.051
Equity REITs	1.093	5.313	4.862	0.098
Hybrid REITs	1.000	6.686	6.687	0.064
Mortgage REITs	0.660	7.325	11.095	0.012
Value-Weighted Portfolios of				
All REITs	0.731	5.938	8.120	0.027
Equity REITs	0.984	4.977	5.056	0.083
Hybrid REITs	1.020	6.269	6.146	0.071
Mortgage REITs	0.524	6.975	13.303	-0.007
Equally-Weighted CRSP	1.234	6.326	5.124	0.105

Notes:
a. CV=Coefficients of variation, $CV = \frac{StandardDeviation}{Mean}$.
b. Sharpe Index, or SI, is defined as $SI_j = \frac{\bar{r}_j - \bar{r}_f}{\sigma_j}$, where $\bar{r}_j$ is the average monthly rate of return on portfolio j, $\bar{r}_f$ is the average monthly rate of return on the default-free Treasury bill three month to maturity, and σ_j is the standard deviation of the returns on portfolio j. The higher the Sharpe Index, the better a portfolio performs relative to other investment alternatives in the mean-variance space [77].

Table 2.4: REIT Performance Relative to the Equally-Weighted CRSP Index
January 1970–December 1989

$$\tilde{r}_{j,t} - \tilde{r}_{f,t} = \alpha_j + \beta_{j,m}(\tilde{r}_{CRSP,t} - \tilde{r}_{f,t}) + \tilde{\epsilon}_{jt} \ ^a$$

Dependent Variable	α_j (t stat.)	$\beta_{j,m}$ (t stat.)	Adj.R^2	Durbin Watson
Excess Return on Equally-Weighted Portfolios of				
All REITs	-0.187	0.750	0.618	1.899
	(-0.767)	(19.682)		
Equity REITs	0.094	0.644	0.586	2.169
	(0.420)	(18.432)		
Hybrid REITs	-0.058	0.733	0.480	2.095
	(-0.185)	(14.881)		
Mortgage REITs	-0.472	0.845	0.531	1.910
	(-1.442)	(16.476)		
Excess Return on Value-Weighted Portfolios of				
All REITs	-0.335	0.746	0.629	1.821
	(-1.418)	(20.140)		
Equity REITs	-0.074	0.633	0.646	2.159
	(-0.038)	(20.893)		
Hybrid REITs	-0.035	0.681	0.470	2.168
	(-0.012)	(14.584)		
Mortgage REITs	-0.580*	0.804	0.529	1.862
	(-1.858)	(16.418)		

Notes:

a. $\tilde{r}_{j,t}$, $\tilde{r}_{f,t}$, and $\tilde{r}_{CRSP,t}$ are the monthly returns on REIT portfolio j, three month Treasury bill, and the equally-weighted CRSP portfolio respectively at time t.

b. All β coefficients are significantly different from zero at the 99% level of confidence.

c. * indicates that α is significantly different from zero at 90% level of confidence.

mortgage REIT portfolios. Both equity REIT portfolios have larger Jensen Indexes than their mortgage counterparts. In addition, the equally-weighted equity REIT portfolio is the only portfolio that has a positive Jensen Index, while the value-weighted mortgage REIT portfolio is the only portfolio that underperformed the market portfolio at the 0.10 significance level.

A comparison between the four equally-weighted REIT portfolios and the four value-weighted REIT portfolios indicates that the former group generally performed better than the latter group. For instance, three out of the four equally-weighted REIT portfolios have larger Jensen Indexes than their value-weighted counterparts. Because relatively more weight is assigned to the smaller REITs in the equally-weighted REIT portfolios, the performance of smaller REITs is better represented in the equally-weighted portfolios than in the value-weighted portfolios. The fact that the equally-weighted REIT portfolios as a whole systematically performed better than the value-weighted REIT portfolios raises the possibility that smaller REITs, primarily small mortgage and equity REITs, performed better than the larger REITs during the period studied.

Finally, it is interesting to note that all β coefficients are smaller than one. This evidence clearly indicates that the REIT portfolios carry a smaller market risk compared to the stock market portfolio.

2.4.2 Stability of REIT Performance

One of our major concerns is whether REIT performance is stable over time. If REIT performance is unstable over time, short-term studies on

REIT performance, focusing on different boom and bust periods in the REIT history, may lead to very different conclusions. Furthermore, the historical performance of REITs would have little power to predict the future performance of the REIT industry.

To test the stability of REIT performance over time, I first break the entire study period into four five-year subperiods:

1. January 1970 to December 1974;

2. January 1975 to December 1979;

3. January 1980 to December 1984; and

4. January 1985 to December 1989.

These divisions are arbitrary. However, we know with hindsight that they correspond relatively well to the historical fluctuations of the real estate market in the past two decades, namely, the boom and bust in the early 1970s, the recovery in the late 1970s, the expansion in the early 1980s, and the glutted real estate market in the late 1980s. [7]

Table 2.5 reports the mean returns and the standard deviation of returns for each of the subperiods. Evidence suggests that REITs performed differently in different subperiods. For instance, during the subperiod of 1970-1974, all eight REIT portfolios earned negative returns on average. In

[7] See Wheaton [91] for more details on the history of the U.S. real estate market.

Table 2.5: Comparison of Means and Standard Deviations of Returns for Different Sample Periods

	1970-1974		1975-1979		1980-1984		1985-1989	
	Mean	SD*	Mean	SD*	Mean	SD*	Mean	SD*
Equally-Weighted Portfolios of								
All REITs	-1.288%	6.454%	2.575%	8.226%	1.956%	4.267%	0.388%	2.882%
Equity REITs	-1.132	5.347	3.024	6.923	1.864	4.150	0.430	3.205
Hybrid REITs	-1.255	7.330	3.157	8.930	2.117	4.690	0.330	3.193
Mortgage REITs	-1.824	7.884	1.959	10.219	2.051	5.349	0.354	3.164
Value-Weighted Portfolios of								
All REITs	-1.108	7.794	2.014	6.415	1.906	4.591	0.560	3.114
Equity REITs	-0.963	5.610	2.261	5.419	1.925	4.487	0.788	3.229
Hybrid REITs	-1.361	7.504	2.442	7.096	2.060	5.072	0.138	4.151
Mortgage REITs	-1.923	9.074	1.654	7.624	1.927	5.624	0.440	3.639

* SD = Standard deviation of returns.

Table 2.6: Tests on the Differences of Means
t statistics [a]

	1970-74 vs. 1975-79	1975-79 vs. 1980-84	1980-84 vs. 1985-89
Equally-Weighted Portfolios of			
All REITs	2.838**	-0.513	-2.340*
Equity REITs	3.649**	-1.104	-2.100*
Hybrid REITs	2.933**	-0.792	-2.419*
Mortgage REITs	2.251*	0.061	-2.097*
Value-Weighted Portfolios of			
All REITs	2.375*	-0.105	-1.864
Equity REITs	3.174**	-0.367	-1.580
Hybrid REITs	2.829**	-0.337	-2.252*
Mortgage REITs	2.318*	0.221	-1.705

Notes:

a.

$$t = \frac{\bar{R}_k - \bar{R}_l}{\sqrt{\frac{s_k^2}{N_k-1} + \frac{s_l^2}{N_l-1}}},$$

where $\bar{R}_k$ and $\bar{R}_l$ are the mean returns for subperiods k and l, s_k and s_l are the standard deviations of returns for subperiod k and l, $k > l$ in this case; and $N_1 = N_2 = 60$.

b. * and ** indicate that the t statistics are significantly different from zero at the 0.05 and 0.01 significance levels respectively.

the following two subperiods, however, all eight REIT portfolios had positive mean returns. Although they were still positive, the mean returns in the last five years of the 1980s were reduced to less than 40% of the levels achieved in the previous five-year period.

t-tests are used to test the significance of the difference between the mean returns in different subperiods. Assuming that each sample is drawn randomly, then, the sampling distribution of the difference between two sample means, $\bar{R}_k - \bar{R}_l$, is normally distributed. The difference between two mean returns can then be tested using:

$$t = \frac{\bar{R}_k - \bar{R}_l}{\sqrt{\frac{s_k^2}{N_k - 1} + \frac{s_l^2}{N_l - 1}}},$$

where $\bar{R}_k$ and $\bar{R}_l$ are the mean returns for subperiods k and l, s_k and s_l are the sample standard deviations of returns for subperiod k and l, $k > l$ in this case; and $N_1 = N_2 = 60$. If the t statistic is significant, we can reject the hypothesis that the difference between two mean returns is zero.

An examination of the results from the t-tests on the differences of the mean returns in Table 2.6 indicates that the mean returns are indeed significantly different from one subperiod to another. For instance, t statistics on the differences between the mean returns on the 1970-1974 subperiod and those on the 1975-1979 subperiod are positive and significant for all eight REIT portfolios. These significant t statistics indicate that all eight REIT portfolios had significantly higher mean returns in the 1975-1979 subperiod than in the 1970-1974 subperiod. All the equally-weighted REIT portfolios and the value-weighted hybrid REIT portfolio also had significantly lower mean returns in the 1985-1989 subperiod relative to the 1980-1984 subperiod, as indicated by their negative and significant t statistics.

On a systematic risk-adjusted basis, REIT performance was also unstable over time. For instance, an examination of the Jensen Indexes in Table 2.7 suggests that there are substantial variations in the systematic risk-adjusted performance in different subperiods. All the REIT portfolios performed well relative to the stock market portfolio in the 1980-1984 subperiod. The Jensen Indexes are positive for all eight REIT portfolios in this subperiod. In contrast, all eight REIT portfolios performed poorly in the 1970-1974 and 1985-1989 subperiods, as indicated by their negative Jensen Indexes.

A comparison between the Jensen Indexes for the equally-weighted and value-weighted portfolios also indicates that the performance variation over time is slightly greater for the equally-weighted REIT portfolios. For instance, all four equally-weighted REIT portfolios performed slightly worse than the market portfolio in 1970-1974. The equally-weighted all REIT portfolio even underperformed the market portfolio at the 0.10 significance level. During 1980-1984, three of these four portfolios outperformed the market portfolio at the respective 0.10 and 0.05 significance levels. In contrast, the performance variation over time is much smaller for the value-weighted REIT portfolios. Since the performance of small REITs is better represented in the equally-weighted portfolios than in the value-weighted portfolios, it is reasonable to infer that small REITs tend to have greater performance variation than larger ones over time.

Are the systematic risk-adjusted performance variations significantly

Table 2.7: The Jensen Indexes by Subperiods
Jensen Index
(t statistics)

REIT Portfolios	1970-1974	1975-1979	1980-1984	1985-1989
Equally-Weighted Portfolios of				
All REITs	-0.987*	-0.231	0.587**	-0.442
	(-1.715)	(-0.353)	(1.967)	(-1.831)
Equity REITs	-0.722	0.665	0.544*	-0.408
	(-1.444)	(1.110)	(1.634)	(-1.554)
Hybrid REITs	-1.185	0.437	0.772*	-0.425
	(-1.633)	(0.513)	(1.839)	(-1.245)
Mortgage REITs	-1.215	-1.289	0.601	-0.439
	(-1.586)	(-1.476)	(1.348)	(-1.434)
Value-Weighted Portfolios of				
All REITs	-0.943	-0.397	0.518	-0.272
	(-1.381)	(-0.899)	(1.346)	(-1.075)
Equity REITs	-0.627	0.106	0.487	-0.067
	(-1.244)	(0.305)	(1.192)	(-0.264)
Hybrid REITs	-0.282	-0.068	0.727	-0.747*
	(-0.333)	(-0.123)	(1.445)	(-1.865)
Mortgage REITs	-1.242	-0.988	0.502	-0.355
	(-1.447)	(-1.630)	(0.955)	(-0.921)

Note: * and ** indicate that the Jensen Indexes are significantly different from zero at the respective 90% level and 95% level of confidence.

different in different subperiods? The results of the Chow tests appear to support the notion that the performance of REITs is not consistent relative to the stock market portfolio over different subperiods.

The Chow test is a F test on the ratio of the excess sum of squared errors (the difference between the constrained sum of squared errors and the nonconstrained sum of squared errors) over the nonconstrained sum of squared errors. The constraint in this case is the consistency of the Jensen Indexes over time. If the Jensen Indexes are different in different time periods, the constraints will result in large increases in the excess sum of squared errors, and thus in statistically significant F scores.[8]

Table 2.8 is a summary of the Chow tests. Most of the REIT portfolios, except the value-weighted equity REIT portfolio, experienced significant changes over time in their performance relative to the stock market portfolio. For instance, the Jensen Index for the equally-weighted equity REIT portfolio in 1975-1979 was significantly different from that in 1970-1974 at the 0.10 significance level. The performance of both mortgage REIT portfolios also experienced significant changes between the second half of the 1970s and the first half of the 1980s. However, the most significant changes in REIT performance took place between the two subperiods in the 1980s.

Between the first half and the second half of the 1980s, six out of the eight REIT portfolios have statistically significant F statistics at the respective 90%, 95%, and 99% levels of confidence. Statistically speaking, the systematic risk-adjusted performance for these six REIT portfolios in the

[8]For a detailed discussion of the Chow Test, please refer to Chow [15, pp. 69].

Table 2.8: Chow Tests on the Stability of REIT Performance
F statistics [a]

REIT Portfolios	1970-74 1975-79	1975-79 1980-84	1980-84 1985-89
Equally-Weighted Portfolios of			
All REITs	0.754	1.330	7.163 * * *
Equity REITs	3.178*	0.031	5.044 **
Hybrid REITs	2.110	0.127	4.895 **
Mortgage REITs	0.004	3.806 *	3.701 *
Value-Weighted Portfolios of			
All REITs	0.442	2.448	2.945 *
Equity REITs	1.411	0.500	1.327
Hybrid REITs	0.044	1.127	5.255 **
Mortgage REITs	0.058	3.466 *	1.729

Notes:
a. The F scores are calculated with constraints on the α in equation (1). The degrees of freedom are 1 for the numerators and 116 for the denominators.
b. *, **, and * * * indicate that the F scores are significantly different from zero at the respective 90%, 95%, and 99% levels of confidence.

second half of the 1980s is significantly different from that in the first half of the decade. This finding is consistent with several structural changes in the REIT industry and the U.S. real estate market during this period: the increased leverage in REITs;[9] the overbuilding of office space and housing stocks;[10] and increased foreign participation[11] in the second half of the 1980s.

The results from the Chow tests also support the notion that larger REITs may perform more consistently over time. As Table 2.8 indicates, the value-weighted REIT portfolios experienced only three significant performance changes while the equally-weighted REIT portfolios experienced six changes. In particular, the value-weighted equity REIT portfolio did not experience any significant change in performance over these subperiods.

It is rather interesting to find that REIT portfolios performed similarly relative to the stock market portfolio except in the case of the equally-weighted equity REIT portfolio in the two subperiods in the 1970s. It clearly indicates that the damage done to the industry by the 1974 crisis extended to the 1975-1979 period. The small equity REITs were the only ones that managed to improve their performance relative to the stock market portfolio in this period, as indicated by the only significant F statistic for the equally-weighted equity REIT portfolio.

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[9]The REIT industry leverage rose from a five-year average of 54.75% in the first half of the 1980s to a four-year average of 60.76% in the second half of the decade [63, p. 13] and [64, p. 60].

[10]For instance, Wheaton [91, p. 4] reported that the average office vacancy rate in the 30 largest U.S. cities rose from 4.2% in 1980 to 17.2% in 1986.

[11]For instance, Bacow found that the total foreign direct investment in the U.S. real estate market increased from $12 billion in 1982 to about $26 billion in 1987 [4, p. 4].

2.4.3 Two Sources of Performance Measurement Bias

Two factors may have contributed to the differences in the performance estimates for REIT stocks: (1) the use of different market portfolios and (2) the bias associated with the survivors-only sample. In this section, I shall discuss in detail the effects that these factors have on the performance estimates.

The Use of the S&P Index and Inflated Performance

To examine how the use of the returns on the S&P Index may have changed the performance estimates for REITs, I regressed the monthly excess returns on the eight REIT portfolios against the monthly excess return on the S&P Index using equation (2.1). The regression results are summarized in Table 2.9. An examination of the Durbin-Watson statistics indicates that the residuals in all the regressions are first-order serially independent.

A comparison of Table 2.4 with Table 2.9 reveals that the regressions using the returns on the S&P portfolio generate much worse fits of the REIT return series than do the regressions using the returns on the equally-weighted CRSP Index. For instance, the excess returns on the S&P Index explain about 22.9% to 33.0% of the variations in the excess returns on the REIT portfolios. This is far less than the amount of variation, ranging from 47% to 62.9%, explained by the returns on the equally-weighted CRSP Index. This difference indicates the possibility that factor(s) are missing in the regression when the excess returns on the S&P portfolio are used in equation (2.1).

The effects of using the returns on the S&P Index to derive performance

Table 2.9: The Jensen Indexes Estimated with the S&P Index
January 1970–December 1989

$$\tilde{r}_{j,t} - \tilde{r}_{f,t} = \alpha_j + \beta_{j,m}(\tilde{r}_{S\&P,t} - \tilde{r}_{f,t}) + \epsilon_{jt} \ ^a$$

Dependent Variable	α (t stat.)	β [b] (t stat.)	Adj.R^2	Durbin Watson	S&P Bia[c]
Excess Return on Equally-Weighted Portfolios of					
All REITs	0.060	0.857	0.283	2.081	0.247
	(0.173)	(9.580)			
Equity REITs	0.319	0.744	0.275	2.126	0.225
	(1.046)	(9.400)			
Hybrid REITs	0.164	0.893	0.249	2.067	0.222
	(0.421)	(8.807)			
Mortgage REITs	-0.201	0.940	0.229	2.081	0.271
	(-0.462)	(8.340)			
Excess Return on Value-Weighted Portfolios of					
All REITs	-0.117	0.872	0.302	2.208	0.218
	(-0.350)	(10.014)			
Equity REITs	0.170	0.764	0.330	2.373	0.244
	(0.619)	(10.695)			
Hybrid REITs	0.233	0.832	0.248	2.329	0.268
	(0.639)	(8.732)			
Mortgage REITs	-0.347	0.926	0.246	2.146	0.233
	(-0.848)	(8.710)			

Notes:

a. $\tilde{r}_{j,t}$, $\tilde{r}_{f,t}$, and $\tilde{r}_{S\&P,t}$ are the monthly returns on REIT portfolio j, three month Treasury bill, and the S&P Index respectively at time t.

b. All beta coefficients are significantly different from zero at the 99% level of confidence.

c. The S&P Bias for a REIT portfolio is the Jensen Index estimated using the S&P Index less the Jensen Index estimated using the equally-weighted CRSP Index.

estimates become obvious when the Jensen Indexes in Table 2.4 and Table 2.9 are compared. The last column in Table 2.9 lists the differences between the Jensen Indexes calculated from these regressions and those calculated using the equally-weighted CRSP Index as the stock market portfolio. Although none of them are statistically significant, the Jensen Indexes estimated using the returns on the S&P Index are systematically higher than those estimated using the returns on the equally-weighted CRSP Index. The use of the excess returns on the S&P Index overstates the systematic risk-adjusted performance of the REIT portfolios by 0.218% to 0.268% per month (or 2.648% to 3.264% per year). Consequently, fewer REIT portfolios have negative Jensen Indexes when the excess returns on the S&P Index are used. Furthermore, none of these REIT portfolios significantly underperformed compared to the stock market portfolio.

Does the exclusion of small stocks from the S&P Index contribute to these differences in performance estimates? To address this issue, I regressed the excess returns on all eight REIT portfolios against the excess returns on both the S&P Index and the Small Stock portfolio. Table 2.10 summarizes the results from these regressions. The last column in Table 2.10 lists the differences between the two factor Jensen Indexes and the one factor indexes estimated using the excess return on the equally-weighted CRSP portfolio alone.

The results of these tests support the claim that using the returns on the S&P Index to evaluate REIT performance will miss the small stock factor and consequently overestimate the performance of REIT stocks. First, all coefficients for the small stock factor are statistically different from zero at

Table 2.10: The Two-Factor Jensen Indexes
January 1970–December 1989

$$\tilde{r}_{j,t} - \tilde{r}_{f,t} = \alpha_j + \beta_{S\&P,j}(\tilde{r}_{S\&P,t} - \tilde{r}_{f,t}) + \beta_{SS,j}(\tilde{r}_{SS,t} - \tilde{r}_{f,t}) + \tilde{\epsilon}_{j,t}\ ^{a}$$

Dependent Variable	α (t stat.)	$\beta_{S\&P}$ [b] (t stat.)	β_{SS} [b] (t stat.)	Adj.R^2	Durbin Watson	Bias [c]
Excess Return on Equally-Weighted Portfolio of						
All REITs	-0.172	0.851	0.643	0.568	1.961	0.015
	(-0.664)	(12.542)	(12.671)			
Equity REITs	-0.102	0.739	0.558	0.551	2.209	0.008
	(0.438)	(12.115)	(12.240)			
Hybrid REITs	-0.052	0.887	0.563	0.426	2.068	0.006
	(-0.157)	(10.225)	(8.688)			
Mort. REITs	-0.450	0.934	0.744	0.489	1.950	0.022
	(-1.315)	(10.422)	(11.108)			
Excess Return on Value-Weighted Portfolio of						
All REITs	-0.324	0.866	0.618	0.573	1.893	0.011
	(-1.277)	(13.032)	(12.432)			
Equity REITs	-0.006	0.759	0.517	0.601	2.194	0.001
	(-0.029)	(14.092)	(12.846)			
Hybrid REITs	0.004	0.823	0.517	0.413	2.175	0.008
	(-0.012)	(10.011)	(8.406)			
Mort. REITs	-0.565*	0.920	0.677	0.482	1.907	0.015
	(-1.724)	(10.706)	(10.531)			

Notes: a. α is the Jensen Index of Performance. $\tilde{r}_{j,t}$, $\tilde{r}_{f,t}$, $\tilde{r}_{S\&P,t}$, and $\tilde{r}_{SS,t}$ are the monthly returns on REIT portfolio j, three month Treasury bill, the S&P Index, and the value-weighted small stock portfolio respectively at time t.

b. All β coefficients are significantly different from zero at the 99% level of confidence.

c. Bias is the two-factor Jensen Index less the Jensen Index estimated using the equally-weighted CRSP Index alone.

d. * indicates that the Jensen Index is significantly different from zero at the 90% level of confidence.

the 0.01 level. In other words, we can reject the null hypothesis that there is no small stock effect for all eight REIT portfolios at the 99% level of confidence.

Furthermore, the Jensen Indexes estimated based on equation (2.2) closely resemble those estimated using the equally-weighted CRSP Index on equation (2.1). According to the last column in Table 10, for instance, the differences between the performance estimates from the two-factor model and those estimated using the equally-weighted CRSP Index on equation (1) are relatively insignificant. They amount to less than an insignificant 0.03% per month.

So far, the test results suggest that the use of the S&P Index, relative to the use of the equally-weighted CRSP Index, will lead to overestimates of REIT performance. This bias arises mainly because the S&P portfolio excludes small stocks.

Survivorship Bias and Performance Illusion

To examine the impact that the use of the survivors-only sample has on the REIT performance measure, I constructed eight more REIT portfolios based on the frequently-used ex post buy-and-hold strategy [12, 31, 73]. These survivor-only portfolios include twenty-five REITs that were traded continuously from December 1973 to January 1989.[12] Among them are thirteen equity REITs, three hybrid REITs, and nine mortgage REITs. The size of this survivor-only sample is similar to those used in previous studies

[12]See Appendix B for more details on the survivors-only sample.

such as Sagalyn [73], Titman and Warga [84], and Chen and Tzang [14]. For simplicity, the portfolios constructed in Section 2.3.1 are called population portfolios and the survivors-only portfolios are called the survivor portfolios.

Table 2.11 summarizes the Jensen Indexes of performance estimated for both the population portfolios and the survivor portfolios. The last column of Table 2.11 lists the differences in the Jensen Indexes between these two types of portfolios.

The results indicate that the survivor REITs performed much better than the REIT population during the period studied. For instance, all eight survivor REIT portfolios have higher Jensen Indexes than the REIT population portfolios. Using the survivor REIT sample resulted in higher performance estimates, with net gains ranging from a minimum of 0.112% per month (or 1.352% per year), in the case of the equally-weighted equity REIT portfolio, to a maximum of 0.841% per month (or 10.572% per year), in the case of the value-weighted mortgage REITs. Furthermore, all the Jensen Indexes estimated using the survivor sample are positive. The value-weighted equity REIT portfolio even outperformed the CRSP Index at the 95% level of confidence.

The improvement in performance is greater if the value-weighted survivor REIT portfolios are used in the test. For instance, the survivor biases for all four value-weighted REIT portfolios are larger. It appears that the Jensen Indexes for the value-weighted survivor portfolios are greater than those for the equally-weighted population portfolios. Thus, it is possible that survivor REITs may have characteristics that are very different from the general REIT population, with the possibility that large survivor REITs performed better

Table 2.11: Survivor Bias and The Jensen Indexes
January 1970-December 1989

REIT Portfolios	(1) Population Sample Jensen Index (t stat.)	(2) Survivor Sample Jensen Index (t stat.)	(2)-(1) Survivor Biases
Equally-Weighted Portfolio of			
All REITs	-0.187	0.121	0.308
	(-0.767)	(0.472)	
Equity REITs	0.094	0.206	0.112
	(0.420)	(0.785)	
Hybrid REITs	-0.058	0.130	0.188
	(-0.185)	(0.452)	
Mortgage REITs	-0.472	0.111	0.583
	(-1.442)	(0.287)	
Value-Weighted Portfolio of			
All REITs	-0.335	0.310	0.645
	(-1.418)	(1.311)	
Equity REITs	-0.074	0.490**	0.564
	(-0.038)	(1.958)	
Hybrid REITs	-0.035	0.198	0.233
	(-0.012)	(0.679)	
Mortgage REITs	-0.580*	0.261	0.841
	(-1.858)	(0.717)	

Note: * and ** indicates the significance at the 95% and 99% levels of confidence.

than the smaller survivor REITs, a finding that is different from that for the REIT population as a whole.

2.5 Conclusion

In conclusion, the results of this study suggest that, in the 1970-1989 period, REIT performance was similar to that of a passively managed portfolio consisting of three-month Treasury bills and a stock market portfolio. However, not all REITs are the same. For instance, the evidence suggests that the small REITs performed better than the larger REITs. Mortgage REITs, on average, performed much worse than equity REITs. The value-weighted mortgage REIT portfolio performed so badly that one can claim, with 90% confidence, that it underperformed the equally-weighted CRSP Index fund on a risk-adjusted basis during the last two decades.

However, REIT performance was not stable over the past two decades. The short-term (five year) variations in REIT performance were substantial and significant in some circumstances. Studies that focused on short time periods can come to very different conclusions on REIT performance. Consequently, the findings on short-term performance are not good predictors of short-term performance in any subsequent periods, nor are they reliable indicators of the long-term performance of REIT stocks.

The findings of this study also reveal that the use of the S&P Index and of survivor REIT samples lead to results that overstate the performance of the REIT industry portfolios relative to the stock market portfolio. For instance, the Jensen Indexes estimated using the S&P Index as the market proxy are systematically higher than those using the equally-weighted CRSP Index as the market proxy. The bias occurred primarily because the S&P portfolio excludes small stocks. The use of survivors-only REIT samples tends to give higher performance estimates than the use of an unbiased sample of the REIT population.

Chapter 3

The Return-Generating Process for Real Estate Investment Trusts

Abstract

This chapter investigates the return-generating process of Real Estate Investment Trusts (REITs). The results of the statistical tests are consistent with the hypothesis that the returns on REIT stocks are weighted averages of the returns on REIT assets and debts. Considerable evidence also suggests that the returns on REIT stocks are generated by the returns on commercial real estate properties and by the returns on long-term Treasury bonds for the 1971 to 1989 period. However, the returns on three-month Treasury bills appear insignificant in the REIT return-generating process. Ex post simulations also indicate that it is possible to replicate the risk and return characteristics of commercial real estate properties using equity REIT stocks and Treasury securities.

The return-generating process for REITs has been the focus of many empirical studies. For instance, Titman and Warga [84] found that REIT returns are generated by at least three factors. They failed to explain, however, what these factors were. Chen and Tzang [14] revealed that REIT returns are sensitive to the changes in the yields on Treasury securities, especially the yields on long-term Treasury bonds. Their findings are supported by the conclusion of Gyourk and Keim [32] that the returns on real estate stock portfolios are positively correlated with bond returns. However, they did not elaborate on why the returns on REITs should be sensitive to the yields or returns on bonds.

The interest in the return-generating process of REITs arises partially from the debate over whether REITs should be considered to be direct investments in real estate. Both researchers and practitioners are interested in using the information derived from securitized real estate to help understand the risk and return characteristics of the $8.7 trillion real estate market, especially the $3.77 trillion commercial real estate market [36]. The research results on this topic, however, are still few and preliminary. For instance, Giliberto [30] concluded that there is a common factor that influences the returns on both equity REITs and unsecuritized real estate properties, but, he failed to offer a clear explanation of this factor. Although it is interesting, his finding provides little direction about how to utilize the information embedded in REIT returns to improve our understanding of the risk and return characteristics of unsecuritized real estate properties.

This chapter has two objectives. The first is to develop a model of REIT return-generating process based upon the principle of value additivity. Myers [61] and Schall [74], among many others, showed that the value of a firm should be the sum of the values of its assets in a perfectly competitive capital market. According to Modigliani and Miller [59], capital structure should also be irrelevant in this market. In other words, the value of a firm should be simply the sum of its assets minus its liabilities. This principle of value additivity provides a convenient framework for developing a return-generating process for REITs: if the market for REITs is perfectly competitive, the returns on the REIT stocks should be the weighted average of the returns on the assets and debts of these REITs.

The second objective of this chapter is to investigate the possibility of using REIT stocks and fixed income securities to replicate the risk and return characteristics of unsecuritized real estate. If the returns on REIT stocks are indeed generated by the returns on REIT assets and debts, we should be able to replicate the risk and return characteristics of real estate properties by using equity REIT stocks, debts, and other REIT assets.

The results of the statistical tests are consistent with the hypothesis that the returns on REIT stocks are weighted averages of the returns on REIT assets and debts. Considerable evidence also indicates that the returns on REIT stocks are generated by the returns on real estate properties and long-term Treasury bonds. The returns on the three-month Treasury bills appear to be insignificant in the REIT return-generating process. Our ex post simulations suggest that it is indeed possible to use REIT stocks and Treasury securities to replicate the risk and return characteristics of real estate properties.

The following sections will describe, in more detail, the hypothesis, methodology, and findings from the statistical tests. The first section develops the hypotheses of the REIT return-generating process based upon the principle of value additivity. This is followed by discussions of the methodology, data sources, empirical findings, and simulations of the ex post risk and return characteristics of several synthetic portfolios. The chapter concludes with two questions on REIT return-generating factors for future research.

3.1 The Hypothesis of the REIT Return-Generating Process

Real estate investment trusts (REITs) are leveraged investment conduits that pool capital to invest in real estate properties, mortgages, construction loans, and mortgage-backed securities. REITs are dividend-driven, with little emphasis on "growth opportunities," since REITs are discouraged from engaging in any speculative activities. Because REITs invest primarily in assets with long-term contractual income streams, they generally have more stable income streams than manufacturing companies [73]. REITs must distribute a minimum of 95% of their income to their shareholders. This distributed income is also exempt from income taxes at the firm level. Buying a share of REIT stock is, in essence, equivalent to holding a share in a portfolio of real estate-based assets, minus the debts that the REIT assumes.

In this section, we first develop an equilibrium condition for REIT valuation based upon two assumptions: that the value of a given REIT is the sum of its individual asset values and that its capital structure is irrelevant. According to this equilibrium condition, the values of that REIT's stocks should be the sum of its assets minus its total outstanding debts. Using this result, we then derive a REIT return-generating model.

3.1.1 Assumptions

In order to derive an equilibrium condition for REIT valuation, we need to make two assumptions about the relationships between a given REIT's value and the values of its assets and liabilities.

Assumption 1. The total value of a REIT is the sum of its individual asset values.

Many researchers have demonstrated that value additivity is a necessary condition for equilibrium in the capital market if the capital market is perfectly competitive. For instance, Myers [61] demonstrated that Markowitz's portfolio selection method is not helpful in valuing the portfolio of assets held by the firm; in particular, the correlations between returns on assets held by the firm are irrelevant and only the market prices of these assets are relevant. Alberts [1] also questioned the value of firm diversification; he suggested that, in a perfect market, investor diversification should render firm diversification redundant. Using an arbitrage argument, Mossin [60] and Schall [74] showed that, in order to prevent any arbitrage profits, the market value of a set of income streams must be equal to the sum of the values of those streams if investors are averse to mean-variance risk and if there are zero transaction costs. In other words, the diversification effect is irrelevant to a firm's value.

Assumption 2: Capital structure is irrelevant. The value of a REIT is independent of the way the cash flows are divided between shareholders and debt holders. In other words, the total value of a REIT is the sum of its shareholders' equities and debts.

The argument that capital structure is irrelevant was first proposed by Modigliani and Miller [59]. They argued that a firm cannot change its value just by splitting its cash flows into different streams. The firm's value is determined by its real assets, not by the securities issued. Modigliani and

Miller, however, agreed that borrowing increases the expected rate of return on a shareholder's investment. At the same time, leverage also increases the risk of the firm's shares. Any increase in expected return will be offset by a corresponding increase in risk, and a higher required rate of return for shareholders.

3.1.2 The Hypotheses on the REIT Return-Generating Process

If the assumptions of value additivity and irrelevant capital structure hold, the total value of a REIT should be the sum of its assets or liabilities. In other words,

$$\tilde{V}_t = \tilde{D}_t + \tilde{E}_t = \sum_{i=1}^{m} \tilde{V}_{i,t}, \tag{3.1}$$

where

$\tilde{}$ denotes random variables;

$\tilde{V}_t$ is the total market value of the REIT's assets at time t;

$\tilde{D}_t$ is the market value of the REIT's debt at time t;

$\tilde{E}_t$ is the market value of the REIT shareholders' equities (or stocks) at time t; and

$\tilde{V}_{i,t}$ is the market value of REIT's asset i at time t.

For simplicity, assume that a given REIT assets consist of commercial real estate properties, $\tilde{P}$, real estate mortgages, $\tilde{M}$, and short-term assets, $\tilde{C}$; and that the REIT's liabilities consist of shareholders' equity, $\tilde{S}$, long-term debts, $\tilde{L}$, and short-term debt, $\tilde{D}$. Expanding and rearranging equation (3.1) yields:

$$\tilde{S}_t = \tilde{P}_t + \tilde{M}_t + \tilde{C}_t - \tilde{L}_t - \tilde{D}_t. \qquad (3.2)$$

The equilibrium relation between the changes in the value of the shareholders' equity and the changes in $\tilde{P}$, $\tilde{M}$, $\tilde{C}$, $\tilde{L}$, and $\tilde{D}$ is then:

$$d\tilde{S}_t = \psi_p d\tilde{P}_t + \psi_m d\tilde{M}_t + \psi_c d\tilde{C}_t - \psi_l d\tilde{L}_t - \psi_d d\tilde{D}_t \qquad (3.3)$$

where ψ_p, ψ_m, ψ_c, ψ_l, and ψ_d are measures of the sensitivity of the value of REIT stocks to the changes in $\tilde{P}$, $\tilde{M}$, $\tilde{C}$, $\tilde{L}$, and $\tilde{D}$ respectively. The expected values for ψ_p, ψ_m, ψ_c, ψ_l, and ψ_d equal one because a one-dollar change in each of the right-hand side (RHS) elements should affect the value of the REIT stocks by one dollar, if the assumptions of value additivity and irrelevant capital structure hold. Otherwise, there would be a positive arbitrage profit.

Dividing both sides of equation (3.3) by $\tilde{S}_{t-1}$ gives an expression for return on a REIT stock at equilibrium:

$$\tilde{R}_{s,t} = \frac{d\tilde{S}_t}{\tilde{S}_{t-1}} = \frac{\psi_p d\tilde{P}_t}{\tilde{S}_{t-1}} + \frac{\psi_m d\tilde{M}_t}{\tilde{S}_{t-1}} + \frac{\psi_c d\tilde{C}_t}{\tilde{S}_{t-1}} - \frac{\psi_l d\tilde{L}_t}{\tilde{S}_{t-1}} - \frac{\psi_d d\tilde{D}_t}{\tilde{S}_{t-1}}, \qquad (3.4)$$

or,

$$\tilde{R}_{s,t} = \frac{\tilde{P}_{t-1}\psi_p d\tilde{P}_t}{\tilde{S}_{t-1}\tilde{P}_{t-1}} + \frac{\tilde{M}_{t-1}\psi_m d\tilde{M}_t}{\tilde{S}_{t-1}\tilde{M}_{t-1}} + \frac{\tilde{C}_{t-1}\psi_c d\tilde{C}_t}{\tilde{S}_{t-1}\tilde{C}_{t-1}} - \frac{\tilde{L}_{t-1}\psi_l d\tilde{L}_t}{\tilde{S}_{t-1}\tilde{L}_{t-1}} - \frac{\tilde{D}_{t-1}\psi_d d\tilde{D}_t}{\tilde{S}_{t-1}\tilde{D}_{t-1}}, \qquad (3.5)$$

Let $\tilde{w}$ denote the weights of assets and debts relative to the value of REIT stocks, or

$$\begin{aligned}
\tilde{w}_{p,t-1} &= \frac{\tilde{P}_{t-1}}{\tilde{S}_{t-1}}, \\
\tilde{w}_{m,t-1} &= \frac{\tilde{M}_{t-1}}{\tilde{S}_{t-1}}, \\
\tilde{w}_{c,t-1} &= \frac{\tilde{C}_{t-1}}{\tilde{S}_{t-1}}, \\
\tilde{w}_{l,t-1} &= \frac{\tilde{L}_{t-1}}{\tilde{S}_{t-1}}, \\
\tilde{w}_{d,t-1} &= \frac{\tilde{D}_{t-1}}{\tilde{S}_{t-1}}.
\end{aligned}$$

For simplicity, we assume that the return on mortgages equals the costs on long-term debts, and that the return on short-term assets equals the interest rate on short-term liabilities. In other words, the returns on real estate properties, long-term mortgages and debts, and short-term assets and debts are:

$$\begin{aligned}
\tilde{R}_{p,t} &= \frac{d\tilde{P}_t}{\tilde{P}_{t-1}}, \\
\tilde{R}_{m,t} &= \frac{d\tilde{M}_t}{\tilde{M}_{t-1}} = \frac{d\tilde{L}_t}{\tilde{L}_{t-1}}, \\
\tilde{R}_{d,t} &= \frac{d\tilde{C}_t}{\tilde{C}_{t-1}} = \frac{d\tilde{D}_t}{\tilde{D}_{t-1}}.
\end{aligned}$$

Equation (3.5) can be rewritten as:

$$\tilde{R}_{s,t} = \psi_p \tilde{w}_{p,t-1}\tilde{R}_{p,t} + \psi_m(\tilde{w}_{m,t-1} - \tilde{w}_{l,t-1})\tilde{R}_{m,t} + \psi_d(\tilde{w}_{d,t-1} - \tilde{w}_{c,t-1})\tilde{R}_{d,t}. \quad (3.6)$$

If the assumptions of value additivity and irrelevant capital structure hold, then, we should observe ex post that the returns on REITs are generated by a three-factor model of the following form:

$$\tilde{R}_{s,t} = \alpha + \psi_p \tilde{w}_{p,t-1}\tilde{R}_{p,t} + \psi_m(\tilde{w}_{m,t-1} - \tilde{w}_{l,t-1})\tilde{R}_{m,t} + \psi_d(\tilde{w}_{d,t-1} - \tilde{w}_{c,t-1})\tilde{R}_{d,t} + \tilde{\epsilon}_t \quad (3.7)$$

where $\tilde{R}_{s,t}$, $\tilde{R}_{p,t}$, $\tilde{R}_{m,t}$, *and* $\tilde{R}_{d,t}$ are the observed returns on REIT stocks, real estate properties, long-term fixed income securities, and short-term interest-bearing assets respectively. $\tilde{w}_{p,t-1}$, $(\tilde{w}_{m,t-1} - \tilde{w}_{l,t-1})$, and $(\tilde{w}_{d,t-1} - \tilde{w}_{c,t-1})$ are the (net) investments measured as ratios over shareholders' equities in real estate properties, long-term fixed income securities, and short-term interest-bearing assets at time $t-1$ respectively. $\tilde{\epsilon}_t$ is a white noise error term.

If the returns on REIT stocks are indeed generated by this three-factor model, we should expect that:

Hypothesis 1. The returns on REIT stocks are the weighted average of the returns on REIT assets and debts, or

$$H_{01} \; : \; \tilde{w}_p + (\tilde{w}_m - \tilde{w}_l) + (\tilde{w}_d - \tilde{w}_c) = 1, \quad (3.8)$$

$$H_{a1} \ : \ \tilde{w}_p + (\tilde{w}_m - \tilde{w}_l) + (\tilde{w}_d - \tilde{w}_c) \neq 1. \tag{3.9}$$

Hypothesis 2. The returns on REIT stocks should respond one-on-one to the weighted returns on REIT assets and debts, or

$$H_{02} \ : \ \psi_p = \psi_m = \psi_d = 1, \tag{3.10}$$

$$H_{a2} \ : \ not\ H_{02}. \tag{3.11}$$

Hypothesis 3. The weights on commercial real estate properties should be greater than zero for equity REITs since equity REITs invest at least 75% of their assets in commercial real estate properties. We expect to reject the following null hypothesis in favor of the alternative hypothesis:

$$H_{03} \ : \ \tilde{w}_{p,t-1} = 0, \ for\ equity\ REITs, \tag{3.12}$$

$$H_{a3} \ : \ \tilde{w}_{p,t-1} > 0, \ for\ equity\ REITs. \tag{3.13}$$

Hypothesis 4. The weights on long-term fixed income assets must be greater than zero for mortgage REITs since mortgage REITs invest at least 75% of their assets in mortgages. We expect to reject the following null hypothesis in favor of the alternative hypothesis:

$$H_{04} \ : \ \tilde{w}_{m,t-1} - \tilde{w}_{l,t-1} = 0, \ for\ mortgage\ REITs, \tag{3.14}$$

$$H_{a4} \ : \ \tilde{w}_{m,t-1} - \tilde{w}_{l,t-1} > 0, \ for\ mortgage\ REITs. \qquad (3.15)$$

3.2 Methodology

This section outlines the details of testing methodology and data sources. Since null hypothesis (1) must be tested jointly with null hypothesis (2), we develop a new expression for the return-generating process.

3.2.1 Hypothesis Testing When Weights are Constant

Assuming that weights are constant over time, Equation (3.7) can be rewritten as

$$\tilde{R}_{s,t} = \alpha + \beta_p \tilde{R}_{p,t} + \beta_m \tilde{R}_{m,t} + \beta_d \tilde{R}_{d,t} + \tilde{e}_t, \tag{3.16}$$

where $\beta_p = \psi_p w_p$, $\beta_m = \psi_m(w_m - w_l)$, and $\beta_d = \psi_d(w_d - w_c)$.,

The joint hypothesis that the weights sum to one and that the returns on REIT stocks respond one-on-one to the weighted returns on REIT assets and debts can be stated as:

$$H_{05} \quad : \quad \beta_p + \beta_m + \beta_d = 1, \tag{3.17}$$

$$H_{a5} \quad : \quad \beta_p + \beta_m + \beta_d \neq 1. \tag{3.18}$$

Let $\sum \beta = \beta_p + \beta_m + \beta_d$. If the model has been specified correctly, each of the parameters will be unbiased so that $\sum \beta$ has an expected value of one and a standard deviation of $\sigma_{\sum \beta}$. Because $\sum \beta$ is the sum of three normally distributed random variables, $\sum \beta$ is also normally distributed. Therefore, the null hypothesis can be tested based upon t statistics of the following form [66, pp. 121–123]:

$$t = \frac{\sum \beta - 1}{\sigma_{\sum \beta}} \tag{3.19}$$

where the standard error of $\sum \beta$ is calculated using:

$$\sigma_{\sum \beta} = \sqrt{\sigma^2_{\beta p} + \sigma^2_{\beta m} + \sigma^2_{\beta d} + 2\sigma_{\beta p,\beta m} + 2\sigma_{\beta p,\beta d} + 2\sigma_{\beta d,\beta m}} \tag{3.20}$$

where $\sigma^2_{\beta p}$, $\sigma^2_{\beta m}$, *and* $\sigma^2_{\beta d}$ are the squares of the standard errors associated with each coefficient; and $\sigma_{\beta p,\beta m}$, $\sigma_{\beta p,\beta d}$, *and* $\sigma_{\beta d,\beta m}$ are the covariances between coefficients.

Hypotheses 3 and 4 can be restated as

$$H_{03} : \beta_p = 0, \ for \ equity \ REITs, \tag{3.21}$$

$$H_{a3} : \beta_p > 0, \ for \ equity \ REITs \tag{3.22}$$

$$H_{04} : \beta_m = 0, \ for \ mortgage \ REITs, \tag{3.23}$$

$$H_{a4} : \beta_w > 0, \ for \ mortgage \ REITs \tag{3.24}$$

3.2.2 Hypothesis Testing with the Weighted Return Series

The assumption of constant weights over time is rather restrictive. One way to relax this assumption is to calculate the actual weights for REIT assets and debts and develop three weighted return series. We can then use these weighted return series to test whether $\psi_p = \psi_m = \psi_d = 1$, or whether the returns on shareholders' equity respond one-on-one to the weighted returns on REIT assets and debts. Rearranging Equation (3.7) gives:

$$\tilde{R}_{s,t} = \psi_p(\tilde{w}_{p,t-1}\tilde{R}_{p,t}) + \psi_m[(\tilde{w}_{m,t-1} - \tilde{w}_{l,t-1})\tilde{R}_{m,t}] + \psi_d[(\tilde{w}_{d,t-1} + \tilde{w}_{c,t-1})\tilde{R}_{d,t}] + \tilde{e}_t, \tag{3.25}$$

where $\tilde{w}_{p,t-1}\tilde{R}_{p,t}$, $(\tilde{w}_{m,t-1} - \tilde{w}_{l,t-1})\tilde{R}_{m,t}$, and $(\tilde{w}_{d,t-1} - \tilde{w}_{c,t-1})\tilde{R}_{d,t}$ are the weighted returns on real estate properties, long-term fixed income securities, and short-term interest-bearing assets respectively.

If equation (3.25) has been specified correctly, the three slope coefficients will be normally distributed random variables. The estimators are unbiased so that they have an expected value of one and a standard deviation of σ_ψ. The null hypothesis can be tested based upon t statistics of the following form:

$$t = \frac{\psi - 1}{\sigma_\psi} \tag{3.26}$$

3.2.3 Data

The empirical tests cover the period from the fourth quarter of 1970 to the fourth quarter of 1989. Quarterly return series are used because monthly return series are not available for real estate properties.

Two different samples are used in the statistical tests, a sample of the REIT population and a sample of survivor REITs.

1. A sample of the REIT population is used to test the joint hypothesis that the weights sum to one and that the returns on REIT stocks respond one-on-one to the weighted returns on REIT assets and debts. This sample includes 153 REITs. The construction of this sample is strictly based on historical information. Therefore, it is possible for investors to achieve the risk and return characteristics of this portfolio ex ante. For details of this sample, please refer to the Data section in Chapter 2.

2. A sample of 15 survivor REITs is used in testing the hypothesis that the returns on REIT stocks respond one-on-one to the weighted returns on REIT assets and debts. These 15 REITs represent the universe of all survivor REITs whose stocks were continuously traded for the third quarter 1973-fourth quarter 1989 period and whose *10K Reports* were available to the author. Table 3.1 is a list of these 15 REITs. Quarterly returns are calculated as compounded monthly returns. Quarterly return series are also computed for the value-weighted and equally-weighted portfolios of these 15 REITs.

The year-end values of real estate properties, mortgages, short-term interest bearing assets, shareholders' equities, and long-term and short-term debts are computed from the *10K Reports* for these REITs. With respect to securities for which market quotations are readily available, the values are the market values of such securities. With respect to other securities and assets, the values are fair values as determined, in good faith, by REIT trustees [38, pp. 469]. For real estate properties, the "fair values" are the appraisal values. The values of real estate mortgages are the book values: original loan values less the amount of principal received.

The value of real estate properties includes the values of investment and foreclosure properties, and wholly owned subsidiaries and joint ventures whose major business is to invest in real estate properties. The value of mortgages is the sum of the values of long-term loans secured by real estate properties, long term construction loans with maturity of twelve months or longer, participating mortgages, and subsidiaries and joint ventures whose business involves long-term lending. The short-term assets include accounts receivable, cash, stocks, and short-term bonds.

The value of the shareholders' equities is the total value of all stocks or beneficial interests. Long-term debts include all long-term debts with or without convertible features. Short-term debts include short-term bank borrowing, unpaid tax liabilities, and accounts payable.

There are two potential problems associated with the data from *10K Reports*. Although the same accounting principles apply to all REITs,[1]

[1]Generally accepted accounting principles for real estate (GAAP) are applicable to REITs. For the most part, the principles are in accord with tax-basis accrual accounting

Table 3.1: Description of Survivor Sample

Name of REIT	Places Listed	Ticker Symbols	Data Ranges
Equity REITs			
BRT Realty Trust	ASE	BRT	73:3-89:4
Hotel Investors Trust	NYSE	HOT	72:3-89:4
HRE Properties	NYSE	HRE	70:3-89:4
Pennsylvania REIT	ASE	PEI	70:4-89:4
Pittsburgh W. Virginia Rail.	ASE	PW	70:1-89:4
Property Capital Trust	ASE	PCL	72:4-89:4
Washington REIT	ASE	WRE	71:3-89:4
Hybrid REITs			
1st Union Real Est. Eqty& Mtg.	NYSE	FUR	70:3-89:4
MGI Properties	NYSE	MGI	72:2-89:4
Mony Real Estate Investors	NYSE	MYM	71:1-89:4
Mortgage REITs			
Cenvill Investors, Inc.	NYSE	CVI	73:2-89:4
Lomas & Nettleton Mtg Inv.	NYSE	LOM	72:3-89:4
Presidential Rlty Corp. A	ASE	PDL	70:1-89:4
Realty Refund Trust	NYSE	RRF	73:1-89:4
Wells Fargo Mtg & Eqty Trust	NYSE	WFM	72:3-89:4

Sources:

1. Compustat tape.
2. Corporate 10K reports.
3. Moody's Bank & Finance Manual.

discrepancies in the valuation of non-market based assets may arise among different REITs because of the subjective valuation process. Furthermore, the values for some assets, such as real estate mortgages, may not reflect their current market values. In general, accountants make little effort to adjust the values of mortgages when there are changes in interest rates and default risk. Consequently, the weights determined in this chapter, based as they are upon the information from *10K Reports*, might be biased. However, the *10K Reports* are the best sources of information available.

The returns on real estate properties are represented by the returns on the Prudential Income Separate Accounts (PRISA) portfolio, a tax-exempt and unleveraged commingled real estate fund that invests exclusively in commercial real estate properties. The choice of the PRISA portfolio over the more widely used Russell-NCREIF (RN) Index was made for three reasons. First, the PRISA portfolio has a much longer time series than the RN Index; it is available from the fourth quarter of 1970 to the present. In comparison, the RN Index covers only the period from the first quarter of 1978 to the present.

Second, the PRISA portfolio constitutes a significant part of the RN Index portfolio. The risk and return characteristics of the PRISA portfolio are similar to those of the RN Index. Table 3.2 reports the risk and return characteristics of the PRISA and RN portfolios and their relationship with each other. The RN Index has only slightly lower mean returns and standard deviations than the PRISA portfolio, a result of better diversification in the

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[38].

Table 3.2: Comparison between the Quarterly PRISA Returns and the Quarterly Returns on the Russell-NCREIF Index
1978:1 - 1989:4

Portfolio	Mean Return	Standard Deviation	Maximum Return	Minimum Return	Correlation Coefficients PRISA	RN
PRISA	3.11%	1.84%	8.34%	0.33%	1.00	0.73**
Russell-NCREIF(RN)	2.82%	1.42%	6.43%	0.22%		1.00

** indicates that the correlation coefficient is significantly greater than zero at the 0.01 significance level.

RN Index than in the PRISA portfolio. The extreme values for the returns on both portfolios are also very close. Furthermore, the returns on these two portfolios are positively and significantly correlated.

Finally, the composition of real estate properties in the PRISA portfolio is similar to that of the survivor REIT sample. Table 3.3 compares the composition of commercial real estate holdings in the survivor REIT sample to that of the PRISA portfolio. The two portfolios are slightly different in their holdings by property type but very similar in their holdings by the geographic regions, as defined by the Frank-Russell Company (FRC). Compared to the survivor REIT sample, a larger proportion of the PRISA portfolio is invested in industrial and office properties but a smaller proportion is invested in retail and commercial residential properties.

The quarterly returns on the long-term fixed income securities are compounded from the monthly returns on a portfolio of ten-year Treasury bonds.

The returns on the short-term assets are calculated as the compounded monthly returns on a portfolio of three-month Treasury bills. Both monthly return series were compiled by Professor Eugene F. Fama of the University of Chicago, and are available on the 1989 CRSP tape.

Table 3.3: Portfolio Asset Compositions in 1981

Survivor Sample vs. PRISA

	Survivor Sample[1]	*PRISA*[2]
Property Type	100.0%	100.0%
Industrial	14.6%	27.6%
Office	26.2%	51.0%
Retail	34.1%	16.7%
Residential	10.4%	2.6%
Hotel/Motel	5.5%	1.9%
Raw Land	1.8%	
Non-Categorized	7.5%	
FRC Region	100.0%	100.0%
East	33.1%	34.4%
Midwest	19.6%	17.6%
South	17.1%	22.3%
West	22.7%	25.7%
Non-Categorized	7.5%	
Total Value (millions)	$851	$2,417

Sources:
1. Corporate *10K Reports*, and
2. Miles and McCue [58].

3.3 Summary of Findings

The findings from our tests are consistent with the REIT return-generating model (3.7). We fail to reject the null hypothesis that the returns on REIT stocks are the weighted average of the returns on REIT's assets and debts for all eight REIT portfolios. Furthermore, considerable evidence suggests that REIT returns are generated by the returns on commercial real estate and the returns on long-term bonds. However, the returns on three-month Treasury bills appear to be insignificant in the REIT return-generating process.

3.3.1 Testing of the Joint Hypotheses

If the returns on REIT stocks are generated by the three-factor model described in equation (3.16), we expect that the weights, βs, will sum to one for each REIT portfolio. Since equity REITs invest at least 75% of their assets in real estate properties, equity REIT portfolios should have positive and significant weights in the PRISA portfolio. Similarly, mortgage REIT portfolios should also have positive and significant weights in the ten-year Treasury bond portfolio because they have at least 75% of their assets invested in long-term real estate mortgages.

Table 3.4 summarizes the statistics from regressing the returns on eight REIT portfolios against the returns on the PRISA portfolio, the returns on the ten-year Treasury bond portfolio, and the returns on the three-month Treasury bill portfolio. The results seem to support the joint hypothesis that the weights sum to one and the returns on REIT stocks respond one-on-one to the weighted returns on REIT assets and debts. For example, none of the sums of the weights are significantly different from one for any of the eight REIT portfolios.

Investments in REIT stocks generally resemble investments in portfolios that are long in real estate properties and ten-year Treasury bonds, and short in three-month Treasury bills. However, not all of the weights behave the way we expected. For instance, the weights of the three month Treasury bills are negative and insignificant for all eight REIT portfolios. This indicates that REITs' direct exposures to the short-term interest rate is insignificant. Furthermore, although both of the mortgage REIT portfolios have positive and significant weights in the ten-year Treasury bond portfolio, none of the equity REIT portfolios have significant weights in real estate properties. Since equity REITs must invest at least 75% of their assets in real estate properties, the finding that equity REIT portfolios have insignificant weights in real estate properties is implausible.

This finding should not come as a surprise. The information on a current quarter returns on real estate properties is not available to investors until the middle of the following quarter due to the time required to compile and report the data. Thus, the current return on real estate properties cannot possibly impact the returns on REITs' stocks in the same quarter unless investors have direct access to the day-to-day real estate operation. However, it is very unlikely that the REIT investors have direct access to real estate operation because most of them are small and are not in real estate business. In other words, the fact that the PRISA portfolio carries only an insignificant weight for equity REIT portfolios may be due to the gap between the time the returns on real estate properties are realized and the time the information

Table 3.4: Regressions with Constant Weights and Current PRISA Returns

Fourth Quarter 1970–Fourth Quarter 1989

$$\tilde{R}_{s,t} = \alpha + \beta_p \tilde{R}_{p,t} + \beta_m \tilde{R}_{m,t} + \beta_d \tilde{R}_{d,t} + \tilde{e}_t \; ^a$$

Dependent Variable	α (t stat.[b])	β_p (t stat.[b])	β_m (t stat.[b])	β_d (t stat.[b])	Ad. R^2 (f stat.)	Durbin-Watson	$\sum\beta$ (t stat.[c])
Returns on Equally-Weighted Portfolios of							
All REITs	3.88	0.89	0.88*[c]	-2.74	0.06	1.96	-0.98
	(0.76)	(0.72)	(2.44)	(-0 94)	(2.37)		(-0.67)
Equity REITs	4.14	0.92	0.58*	-2.25	0.03	2.07	-0.74
	(0.97)	(0.90)	(1.96)	(-0.93)	(1.57)		(-0.81)
Hybrid REITs	5.76	1.05	0.57	-3.36	0.02	1.74	-1.74
	(1.12)	(0.84)	(1.58)	(-1.15)	(1.29)		(-1.05)
Mortgage REITs	2.81	0.67	1.32 **	-2.74	0.11	1.97	-0.75
	(0.46)	(0.45)	(3.06)	(-0.78)	(3.57*)		(-0.56)
Returns on Value-Weighted Portfolios of							
All REITs	12.7	0.72	1.03**	-1.69	0.11	1.80	0.05
	(0.27)	(0.63)	(3.14)	(-0.64)	(3.53*)		(-0.40)
Equity REITs	1.68	0.67	0.67**	-0.87	0.06	2.03	0.47
	(0.45)	(0.74)	(2.56)	(-0.41)	(2.24)		(-0.25)
Hybrid REITs	3.74	0.67	0.89**	-2.11	0.10	1.90	-0.54
	(0.96)	(0.64)	(2.93)	(-0.85)	(3.24*)		(-0.71)
Mortgage REITs	0.47	0.57	1.48**	-1.92	0.18	1.83	0.14
	(0.09)	(0.44)	(3.92)	(-0.62)	(5.58**)		(-0.32)

Notes:

a. $\tilde{R}_{p,t}$, $\tilde{R}_{m,t}$, $and \tilde{R}_{d,t}$ denote the quarterly returns on the PRISA portfolio, ten year Treasury bonds and three-month Treasury bills respectively.

b. $t = \frac{b_k - 0}{\sigma_k}$. c. $t = \frac{\sum \beta - 1}{\sigma_{\sum \beta}}$.

d. * and ** indicate significance at the 95% level and the 99% level of confidence (two-tailed) respectively.

is available to REIT investors. Therefore, it is more likely that the returns on REIT portfolios respond to the one-quarter lagged returns on the PRISA portfolio.

Table 3.5 reports the statistics from regressing the returns on eight REIT portfolios against the lagged returns on the PRISA portfolio, the returns on the ten-year Treasury bonds, and the returns on the three-month Treasury bills. The results suggest that the lagged return on the PRISA portfolio is a much better return-generating factor for the REIT portfolios. There are three points of evidence for this.

First, the weights for different components still sum to one for all eight REIT portfolios. For instance, none of the t statistics for $\sum \beta$ is statistically significant at the 0.05 significance level. In other words, the use of the lagged PRISA return is consistent with the return-generating model (3.16).

Second, more variation in REIT returns is explained by the return-generating factors after substituting the current PRISA return with the lagged PRISA return. For instance, the R^2s are higher when the lagged PRISA return is used than when the current PRISA return is used. The use of the lagged PRISA return explains additional 2-5% of the variations in the REIT portfolio returns.

Finally, the weights of the real estate properties are higher for all eight REIT portfolios when the lagged PRISA return is used than when the current PRISA return is used. In addition to the positive and significant weights in the ten-year Treasury bonds for all the value-weighted REIT portfolios and the equally-weighted mortgage and all REIT portfolios, the equally weighted equity REIT portfolio also has a positive and significant weight in the PRISA

Table 3.5: Regressions with Constant Weights and Lagged PRISA Returns

First Quarter 1971–Fourth Quarter 1989

$\tilde{R}_{s,t} = \alpha + \beta_p \tilde{R}_{p,t-1} + \beta_m \tilde{R}_{m,t} + \beta_d \tilde{R}_{d,t} + \tilde{e}_t$ [a]

Dependent Variable	α (t stat.[b])	β_p (t stat.[b])	β_m (t stat.[b])	β_d (t stat.[b])	Ad. R^2 (f stat.)	Durbin-Watson	$\sum\beta$ (t stat.[c])
Returns on Equally-Weighted Portfolios of							
All REITs	2.51	1.77	0.74*[c]	-3.51	0.09	1.93	-1.00
	(0.61)	(1.75)	(2.49)	(-1.38)	(3.58*)		(-0.90)
Equity REITs	2.46	1.98*	0.46	-3.13	0.08	2.06	-0.68
	(0.71)	(2.31)	(1.83)	(-1.45)	(3.23*)		(-0.89)
Hybrid REITs	3.93	1.66	0.46	-3.58	0.04	1.71	-1.46
	(0.95)	(1.63)	(1.53)	(-1.40)	(2.04)		(-1.10)
Mortgage REITs	1.85	1.51	1.18*	-3.67	0.13	1.93	-0.98
	(0.38)	(1.24)	(3.31)	(-1.20)	(4.78**)		(-0.74)
Returns on Value-Weighted Portfolios of							
All REITs	0.92	1.22	0.92**	-2.26	0.13	1.77	-0.12
	(0.24)	(1.31)	(3.35)	(-0.97)	(4.76**)		(-0.55)
Equity REITs	1.14	0.92	0.60**	-0.95	0.08	2.02	0.57
	(0.37)	(1.19)	(2.69)	(-0.50)	(3.09*)		(-0.26)
Hybrid REITs	2.92	1.27	0.84**	-2.82	0.14	1.88	-0.71
	(0.83)	(1.45)	(3.27)	(-1.28)	(4.89**)		(-0.89)
Mortgage REITs	0.30	1.51	1.34**	-3.27	0.21	1.79	-0.42
	(0.07)	(1.42)	(4.27)	(-1.22)	(7.52**)		(-0.61)

Notes:

a. $\tilde{R}_{p,t-1}$ is the one quarter lagged return on the PRISA portfolio; $\tilde{R}_{m,t}$ and $\tilde{R}_{d,t}$ denote the quarterly returns on ten year Treasury bonds and three-month Treasury bills respectively.

b. . $t = \frac{b_k - 0}{\sigma_k}$

c. $t = \frac{\sum\beta - 1}{\sigma_{\sum\beta}}$.

d. * and ** indicate significance at the 95% level and the 99% level of confidence (two-tailed) respectively.

portfolio. However, the value-weighted equity REIT portfolio still has a statistically insignificant weight in the PRISA portfolio.

To cross-examine the results, I also regress the returns on both the equally-weighted and value-weighted portfolios of survivor REITs against the same group of independent variables. Table 3.6 summarizes the regression statistics. It is apparent that we fail to reject the hypothesis that the returns on both portfolios of survivor REITs are weighted average of the returns on their assets and debts, as indicated by the negative but insignificant t statistics for $\sum \beta$s for both portfolios. Furthermore, the return-generating process (3.16) explains the returns on the survivor REITs slightly better than the returns on the REIT population. This is evident by the higher R^2s for the regressions using the returns on the survivor REIT sample relative to those using the returns on the sample of REIT population. Finally, the weights in the PRISA portfolio are also insignificant for these two portfolios of survivor REITs. There are two possible explanations to the insignificant weights in the PRISA portfolio. First, the lagged PRISA return may still be an unsatisfactory factor for REIT returns. For instance, the PRISA returns are appraisal based and may fail to reflect the changes in expectations of future cash flows and discount rates embedded in the returns on the stock market index. Second, the market for REIT stocks may be slow to respond to the information in the PRISA returns. These issues will be discussed in detail in a later section.

In summary, the findings are consistent with the joint hypothesis that the returns on REIT stocks are the weighted averages of the returns on the assets and debts of REITs. Considerable evidence suggests that returns on

Table 3.6: Regressions with Constant Weights: The Survivor Sample

First Quarter 1971–Fourth Quarter 1989

$$\tilde{R}_{s,t} = \alpha + \beta_p \tilde{R}_{p,t-1} + \beta_m \tilde{R}_{m,t} + \beta_d \tilde{R}_{d,t} + \tilde{e}_t \ ^a$$

Dependent Variable	α (t stat.[b])	β_p (t stat.[b])	β_m (t stat.[b])	β_d (t stat.[b])	Ad. R^2 (f stat.)	Durbin-Watson	$\sum\beta$ (t stat.[c])
Returns on Equally-Weighted Portfolios of Survivor REITS	5.33 (1.27)	1.25 (1.39)	0.94** (3.47)	-3.62 (-1.52)	0.19 (5.77**)	2.12	-1.43 (-1.13)
Returns on Value-Weighted Portfolios of Survivor REITS	3.29 (0.80)	1.70 (1.95)	1.12** (4.24)	-3.75 (-1.61)	0.27 (8.47**)	2.01	-0.94 (-0.92)

Notes:

a. $\tilde{R}_{p,t-1}$ is the one quarter lagged return on the PRISA portfolio; $\tilde{R}_{m,t}\ and \tilde{R}_{d,t}$ denote the quarterly returns on ten year Treasury bonds and three-month Treasury bills respectively.

b. $t = \frac{b_k - 0}{\sigma_k}$

c. $t = \frac{\sum\beta - 1}{\sigma_{\sum\beta}}$.

d. ** indicates significance at the 99% level of confidence (two-tailed).

REITs are generated primarily by two factors: the returns on real estate properties and the returns on the long-term debts. However, the returns on short-term interest bearing assets do not have significant weights. Since the lagged PRISA return appears to be a better proxy for the return on real estate properties, it will be used exclusively in the following analysis.

3.3.2 Hypothesis Testing with Weighted Returns

If the returns on REIT stocks are generated by the three-factor model (3.25), we can expect that all slope coefficients ψs from regressing the returns on REIT stocks against the weighted returns on REIT assets and debts equal one. In other words, changes in the weighted returns on REIT assets and liabilities should result in proportional changes in REIT returns. In general, our findings are consistent with this prediction.

Table 3.7 summarizes the statistics from regressing the returns on 15 individual survivor REITs and the equally-weighted and value-weighted portfolios of these 15 REITs against the lagged weighted returns on the PRISA portfolio, the weighted returns on the ten-year Treasury bonds, and the weighted returns on the three-month Treasury bills. The equations for all 15 individual REITs are estimated simultaneously as a system of seemingly unrelated equations. The resulting estimators are efficient, unbiased, and robust to heteroscedasticity [95, 83]. The coefficients for the two portfolios are estimated using ordinary least squares (OLS). The residuals from all the regressions are first-order serially independent, as indicated by the robust Durbin Watson statistics.

The results of this statistical analysis are generally consistent with our null hypothesis. First, all the ψ coefficients for the returns on the two portfolios are not significantly different from one. In other words, we fail to reject the null hypothesis that the returns on REIT stocks respond one-on-one to the weighted returns on REIT assets and debts. Furthermore, most of the coefficients for the returns on individual REITs are not significantly different from one. For instance, the returns on all fifteen REITs respond one-on-one to the weighted returns on the three month Treasury bills.

However, there is some anomalous evidence. For instance, three of the REITs underreact to the lagged weighted returns on the PRISA portfolio. Furthermore, the returns on nine of the fifteen REITs also underreact to the weighted return on the ten-year Treasury bonds, with the highest occurrence for the mortgage REITs. These anomalies may occur due to speculative noise associated with individual REITs. They may also be caused by the non-stochastic appraisal returns and the non-stochastic book values on which the weights for real estate mortgages are based.

In summary, our findings suggest that the returns on REIT stocks respond one-on-one to the returns on real estate properties, long-term bonds, and short-term interest bearing assets. This is consistent with the hypothesis of the REIT return-generating process (3.25).

Table 3.7: Regressions on Weight-Adjusted Returns

First Quarter 1974-Forth Quarter 1989

$\tilde{R}_{s,t} = \alpha + \psi_p(w_{p,t-1}\tilde{R}_{p,t-1}) + \psi_m[(w_{m,t-1} - w_{l,t-1})\tilde{R}_{m,t}] + \psi_d[(w_{d,t-1} - w_{c,t-1})\tilde{R}_{d,t}] + \tilde{e}_t$ [a]

Dependent Variable	α (t stat.[b])	ψ_p (t stat.[b])	ψ_m (t stat.[b])	ψ_d (t stat.[c])	Adj. R^2	Durbin Watson
Equity REITs						
BRT	6.44	0.88	-0.30**[c]	1.76	0.02	2.22
	(1.16)	(-0.17)	(-4.70)	(0.57)		
HOT	-0.19	1.16	-0.33	-2.82	0.08	2.30
	(-0.07)	(0.27)	(-1.68)	(-1.40)		
HRE	1.09	0.26	1.92	1.09	0.00	2.02
	(0.49)	(-1.20)	(0.66)	(0.68)		
PCL	-3.99	2.54	1.64	3.67	0.07	2.21
	(-1.08)	(1.69)	(0.66)	(1.35)		
PEI	2.46	0.22**	-0.13**	1.29	0.12	2.13
	(1.43)	(-5.12)	(-12.86)	(0.40)		
PW	3.01	-0.07	-0.74	-3.12	0.01	2.61
	(1.10)	(-1.47)	(0.43)	(1.15)		
WRE	2.27	0.68	-0.38**	-2.80	0.11	1.84
	(0.84)	(-0.85)	(-5.31)	(0.67)		
Hybrid REITs						
FUR	0.27	0.49**	0.12**	1.47	0.12	2.04
	(0.11)	(-3.00)	(-11.19)	(0.35)		
MGI	-1.81	1.91	0.71	0.72	0.07	1.99
	(-0.55)	(1.18)	(-0.20)	(-0.06)		
MYM	4.26	1.14	0.33**	2.08	0.17	2.10
	(2.07)	(0.11)	(-4.16)	(1.28)		
Mortgage REITs						
CVI	4.55	1.14	0.35	4.47	0.06	2.06
	(0.99)	(0.18)	(-1.47)	(1.07)		
LOM	-1.23	3.49	0.72**	0.43	0.42	2.10
	(-0.44)	(1.46)	(-2.68)	(-0.69)		
PLA	5.97	0.04**	-0.04**	1.35	0.03	2.26
	(2.12)	(-9.55)	(-21.03)	(0.396)		
RRF	1.78	-61.18	0.46**	0.27	0.18	2.50
	(0.52)	(-0.83)	(-3.00)	(-0.39)		
WFM	0.09	2.31	0.12**	0.89	0.09	1.97
	(0.02)	(1.46)	(-4.17)	(-0.09)		
EW Sample	4.44	1.69	1.19	7.59	0.14	2.10
	(1.33)	(0.95)	(0.34)	(1.70)		
VW Sample	2.77	2.02	1.50	7.97	0.21	2.00
	(0.84)	(1.40)	(0.90)	(1.83)		

Notes: a. $\tilde{R}_{p,t-1}$ is the lagged return on the PRISA portfolio; $\tilde{R}_{m,t}$ *and* $\tilde{R}_{d,t}$ are the returns on the ten year Treasury bonds and three month Treasury bills respectively. $\tilde{w}_{p,t-1}$, $(\tilde{w}_{m,t-1} - \tilde{w}_{l,t-1})$, and $(\tilde{w}_{d,t-1} - \tilde{w}_{c,t-1})$ are the (net) investments measured as ratios over shareholders' equities in the PRISA portfolio, ten year Treasury bonds, and three month Treasury bills at time $t-1$ respectively. $\tilde{\epsilon}_t$ is a white noise error term.

b. $T_\alpha = \frac{\alpha_i - 0}{\sigma}$. c. $T_\beta = \frac{\beta_i - 1}{\sigma}$.

d. * And ** indicate significance at the 95% level and the 99% level of confidence (two-tailed) respectively.

3.4 Extensions and Implications

If the returns on REIT stocks are indeed generated by the returns on real estate properties, long-term bonds, and short-term bills, it should be possible to replicate the risk and return characteristics of real estate properties. This could be achieved, for instance, by constructing synthetic portfolios that consist of REIT stocks, ten-year Treasury bonds, and three-month Treasury bills. If successful, these synthetic portfolios of real estate properties could provide investors with liquid vehicles to invest in the otherwise illiquid and expertise/capital intensive commercial real estate market. Furthermore, these portfolios could also provide owners of commercial real estate with the means to hedge and diversify the risk in their real estate investments. Finally, the returns on these synthetic portfolios could also provide a basis for a sound measurement of the risk and return characteristics of commercial real estate investment.

Can we use synthetic portfolios to replicate the risk and return characteristics in the PRISA portfolio ex ante? One way to answer this question is to simulate the ex post performance of some synthetic PRISA portfolios. If these synthetic portfolios perform well ex post, they may perform well ex ante.

In this section, we examine the ex post performance of four possible synthetic portfolios relative to the PRISA portfolio. These portfolios are constructed using the equally-weighted or value-weighted portfolios of equity REITs, ten-year Treasury bonds, and three-month Treasury bills.

Rearranging equation (3.16) gives an equation to estimate the weights for these synthetic portfolios:

$$\tilde{R}_{p,t-1} = \delta_s \tilde{R}_{s,t} - \delta_m \tilde{R}_{m,t} - \delta_d \tilde{R}_{d,t} + \tilde{\zeta}_t. \tag{3.27}$$

There are three reasons for using the lagged PRISA return to determine the weights. First, the lagged return on the PRISA portfolio has a much better fit than the current PRISA return, as we discussed in previous section. Second, due to the delay in the arrival of the PRISA return, investors rely on the previous quarter PRISA return to evaluate performance and to make investment and management decisions. In other words, the lagged return on the PRISA portfolio is more important to investors than the theoretical "current return." Finally, the return on the synthetic portfolios with the weights estimated using the lagged PRISA returns are highly correlated, ex post, with the current PRISA returns, as I will demonstrate later.

Ex post simulation requires that we break the sample period into two subperiods. The synthetic portfolios would be first constructed using the information from the first period. The ex post performance of these synthetic portfolios could then be evaluated using the information from the second period. To avoid the bias associated with the selection of sampling periods, we break up the sample period in two different ways. First, the sampling period is divided into a subperiod from the first quarter of 1971 to the fourth quarter of 1979 and a subperiod from the first quarter of 1980 to the fourth quarter of 1989. The second way is to break the sample period into a subperiod of the first quarter of 1971 to the fourth quarter of 1984 and a subperiod of the first quarter of 1985 to the fourth quarter of 1989.

Four synthetic portfolios are constructed, two based on the information from the subperiod of first quarter 1971 to fourth quarter 1979 and two on the information from the subperiod of first quarter 1971 to fourth quarter 1984. The weights for these four portfolios are reported in Table 3.8. For instance, if an investor were to invest $194 in synthetic portfolio (1) at the beginning of 1980, the portfolio would involve a long position of $4 in the equally-weighted equity REIT portfolio and of $193 in the three-month Treasury bills, and a short position of $3 in the ten-year Treasury bonds at the time. Synthetic portfolio (4) would consist of investments of $3 in the value-weighted equity REIT portfolio, $1 in the ten-year Treasury bonds, and $157 in the three-month Treasury bills, with a total investment of $161 in the first quarter of 1985. The relative weights are adjusted every quarter so that they are constant throughout the respective investment periods.

Table 3.9 summarizes the ex post risk and return characteristics of these portfolios relative to the PRISA portfolio. The findings suggest that the risk and return characteristics of these synthetic portfolios are compatible, if not superior, to those for the PRISA portfolio.

As investment vehicles, all four synthetic portfolios outperformed the PRISA portfolio ex post in the respective investment periods. For instance, the average quarterly returns on the two synthetic portfolios for the first quarter 1980 - fourth quarter 1989 period are 3.88% and 3.94% respectively, more than one hundred basis points higher than that on the PRISA portfolio. Since the standard deviations of the returns for all four synthetic portfolios are also smaller than those for the PRISA portfolio for the corresponding periods, the risk levels per unit of mean return for the synthetic portfolios,

Table 3.8: Synthetic Portfolio Weights

Synthetic Portfolio	Investment in Equally-Weighted Equity REITs Portfolio δ_s (t stat.)	Investment in Value-Weighted Equity REIT Portfolio δ_s (t stat.)	Investment in 10-Year Treasury Bonds δ_m (t stat.)	Investment in 3-Month Treasury Bills δ_d (t stat.)	Ad. R^2 (F stat.)
Estimated Based on 1971:1-1979:4					
(1)	0.04** (2.91)		-0.03 (-0.53)	1.93** (15.96)	0.60 (27.07**)
(2)		0.04* (2.37)	-0.04 (-0.69)	1.96** (15.78)	0.57 (24.09**)
Estimated Based on 1971:1-1984:4					
(3)	0.04* (2.36)		0.01 (0.15)	1.54** (14.93)	0.30 (14.43**)
(4)		0.03 (1.33)	0.01 (0.33)	1.57** (14.68)	0.25 (10.04**)

Note:
1. Weights are estimated by regressing the lagged PRISA returns against the returns on three RHS variables with the regression line passing through the origin, or

$$\tilde{R}_{p,t-1} = \delta_s \tilde{R}_{s,t} + \delta_m \tilde{R}_{m,t} + \delta_d \tilde{R}_{d,t} + \tilde{\zeta}_t.$$

where $\tilde{R}_{p,t-1}$ is the lagged return on the PRISA portfolio; $\tilde{R}_{s,t}$, $\tilde{R}_{m,t}$, *and* $\tilde{R}_{d,t}$ denote the returns on equity REIT portfolio, ten-year Treasury bonds, and three-month Treasury bills respectively.
2. * and ** indicate significance at the 95% level and 99% level of confidence (two-tailed) respectively.

as measured by the coefficients of variation (CVs), are much lower than those of the PRISA return series. In other words, all four synthetic portfolios outperform the PRISA portfolio on the absolute and total risk-adjusted basis.

The synthetic portfolios are also good long-term hedge vehicles for the PRISA portfolio. The returns on all four synthetic portfolios move positively with both the PRISA returns and the lagged PRISA returns, with stronger positive co-movement for synthetic portfolio (1) and (2) in the first quarter 1980 - fourth quarter 1989 subperiod. This is reflected by the significant and positive correlation coefficients between the returns on synthetic portfolios (1) and (2) and the two PRISA return series. The returns on the synthetic portfolios can explain as much as 38% of the variations in the PRISA returns for the period of first quarter 1980 to fourth quarter 1989. Although the synthetic portfolios are good long-term hedges for both current and lagged PRISA returns, it is interesting to note that the correlation coefficients between the returns on the synthetic portfolios and those on the current PRISA portfolio are higher than those between the returns on the synthetic portfolios and the lagged return on the PRISA portfolio, especially if we consider that the weights for these portfolios are estimated using lagged PRISA returns.

It appears that the synthetic portfolios are poor hedging tools for shorter periods (five years). This is indicated by the less robust correlation coefficients between the returns on the synthetic portfolios (3) and (4) and the PRISA return series. For instance, only the correlation coefficient between the return on synthetic portfolio (4) and the current PRISA return is significant at the 0.05 significance level. In other words, the strategy of using REIT stocks and Treasury securities to replicate the risk and return characteristics of real estate properties would work better in the long term than in the short term.

In summary, it appears that it is possible to use synthetic portfolios to replicate, if not outperform, the ex post risk and return characteristics of the PRISA portfolio. Ex post, all four synthetic portfolios outperformed the PRISA portfolio for the periods evaluated. Furthermore, the returns on the two synthetic portfolios are positively and significantly correlated with the returns on the PRISA portfolio over the 1980-1989 period. However, it is important to realize that these synthetic portfolios are better hedge vehicles for investments in real estate properties in the long term than in the short term.

These findings have major implications for real estate investments in the future. First, the findings imply that it is possible to derive the risk and return characteristics of real estate ownership without actually engaging in the illiquid and expertise/capital intensive investments in real estate properties. This liquid investment alternative is especially important to small investors who have neither sufficient capital, nor sufficient knowledge and expertise, to invest in direct ownership of commercial real estate properties.

Furthermore, the synthetic portfolios are not only an investment tool, but also a vehicle for risk hedging and portfolio diversification. For instance, the risk associated with the existing holdings in real estate properties can be hedged away by shorting the synthetic portfolios. This application may be especially important for owners of real estate properties who seek to lower their risk exposure in the real estate market.

Finally, using this investment strategy, investors can also replicate the risk and return characteristics of specific property types and specific geographic regions. Many REITs invest in specific property types and geographic regions; Hotel Investor Trust, for instance, invests exclusively in hotels and related facilities. Another example is the Washington Real Estate Investment Trust which owns income-producing properties principally in the Washington D.C. metropolitan area [64]. With some careful analysis, investors should be able to construct synthetic portfolios to replicate the risk and return characteristics of the real estate properties owned by these REITs. As the number of specialized REITs increases, this investment alternative would provide investors with more real estate investment options and risk hedging tools.

Table 3.9: Ex Post Performance Comparison: PRISA and Synthetic Portfolios

Portfolios	Mean Return	Standard Deviation	CV[a]	Correlation Coefficients Port.(1)	Port.(2)	$PRISA_t$	$PRISA_{t-1}$
1980:1-1989:4							
Portfolio (1)	3.88	1.36	0.35	1.00	1.00**[b]	0.62**	0.53**
Portfolio (2)	3.94	1.38	0.35		1.00	0.61**	0.50**
$PRISA_t$	2.67	1.49	0.56			1.00	0.68**
$PRISA_{t-1}$	2.72	1.54	0.57				1.00

Portfolios	Mean Return	Standard Deviation	CV[a]	Correlation Coefficients Port.(3)	Port.(4)	$PRISA_t$	$PRISA_{t-1}$
1985:1-1989:4							
Portfolio (3)	2.40	0.59	0.25	1.00	0.99**	0.32	0.28
Portfolio (4)	2.47	0.56	0.23		1.00	0.37*	0.31
$PRISA_t$	1.95	0.81	0.42			1.00	0.15
$PRISA_{t-1}$	1.96	0.82	0.42				1.00

Notes:

a. CV - Coefficient of Variation. $CV = \frac{Standard\ Deviation}{Mean}$.

b. * and ** indicate that the correlation coefficients are significant at the 95% and 99% level of confidence (one-tailed) respectively.

3.5 Questions for Future Research

The return-generating process for REIT stocks developed in this paper is generally consistent with the empirical evidence. However, the three factors can only explain a small amount of the variations in REIT returns. The problem is especially serious for equity REITs; only about 8% of the return variations are explained by the proposed return-generating factors. Furthermore, the lagged PRISA return is still not significant in explaining the returns on the value-weighted equity REIT portfolio, a finding that is implausible given that equity REITs must invest 75% of their assets in real estate properties.

There are two possible explanations for the weak performance of the return-generating model developed in this paper. First, the REIT market may be slow to incorporate the information embedded in the PRISA returns. In other words, REIT returns may be generated by the PRISA returns in previous quarters. Second, the PRISA return may be a poor proxy for the returns on real estate properties because it fails to reflect changes in the market expectation of future income. The true return on real estate properties might include a stock market factor.

This section briefly investigates these two possible explanations in order to raise questions for future research. I hope that the results from this section will stimulate more research in the future.

3.5.1 The Underreaction of REIT Returns to PRISA Returns

A possible explanation for the poor performance of the PRISA returns is that REIT returns may be slow to respond to the PRISA returns. REIT investors may only gradually absorb the information in the PRISA returns. The historical information in the PRISA returns could then be used to predict REIT returns. If this is true, the market for REIT stocks may be inefficient.

Assume that it takes four quarters for investors to fully absorb the information embedded in the PRISA returns. Let $\tilde{R}_{I,t}$ be a new instrumental variable for the past four quarter returns on the PRISA portfolio. $\tilde{R}_{I,t}$ can be calculated as the fitted value of the following expression,

$$\tilde{R}_{p,t} = \alpha + \gamma_1 \tilde{R}_{p,t-1} + \gamma_2 \tilde{R}_{p,t-2} + \gamma_3 \tilde{R}_{p,t-3} + \gamma_4 \tilde{R}_{p,t-4} + \tilde{\epsilon}_t \tag{3.28}$$

where $\tilde{R}_{p,t}$, $\tilde{R}_{p,t-1}$, $\tilde{R}_{p,t-2}$, $\tilde{R}_{p,t-3}$, and $\tilde{R}_{p,t-4}$ are the returns on the PRISA portfolio at time *t*, *t-1*, *t-2*, *t-3*, and *t-4* respectively. Estimating equation (3.28) gives the weights for the instrumental variable $\tilde{R}_{I,t}$ as:

$$\tilde{R}_{I,t} = 2.48 + 0.38\tilde{R}_{p,t-1} + 0.39\tilde{R}_{p,t-2} + 0.12\tilde{R}_{p,t-3} - 0.07\tilde{R}_{p,t-4} \tag{3.29}$$

The t statistics for the constant and lagged PRISA returns are 4.11, 3.27, 3.15, 0.95, and -0.58 respectively.

The statistics from the regressions using this instrumental variable are summarized in Table 3.10. The results suggest that the instrumental variable is a much better factor in explaining the returns on the REIT portfolios than is the lagged PRISA return, especially for the value-weighted equity REIT portfolio. The weight in the instrument variable is positive and significant for the value-weighted equity portfolios. The use of the instrument variable also explains an additional 5% of the variations in the returns on the value-weighted equity REIT portfolio. In other words, the 2-4 quarter lagged PRISA returns do carry important information that can help us predict REIT returns.

Furthermore, the weights for the different components still sum to one for all eight REIT portfolios, as predicted by the joint hypothesis H_{05}. For instance, none of the t statistics for $\sum\beta$ is statistically significant at the 0.05 significance level. In other words, the use of the instrumental variable is consistent with the REIT return-generating model (3.16).

In summary, the previous returns on the PRISA portfolio indeed influence the returns on the REIT portfolios, especially the equity REIT portfolios. The instrumental variable of the previous PRISA returns is much more powerful in explaining the return variations in the REIT portfolios than the one quarter lagged PRISA return. This finding certainly raises a question about the efficiency of the REIT market. More research is needed in order to address this question adequately.

Table 3.10: Regressions with Stationary Weights and Instrumental Variable

Fourth Quarter 1970–Fourth Quarter 1989

$$\tilde{R}_t = \alpha + \beta_I \tilde{R}_{I,t} + \beta_m \tilde{R}_{m,t} + \beta_d \tilde{R}_{d,t} + \tilde{\epsilon}_t \ ^a$$

Dependent Variable	α (t stat.[b])	β_I (t stat.[b])	β_m (t stat.[b])	β_d (t stat.[b])	Ad.R^2 (f stat.)	DW	$\sum\beta$ (t stat.[c])
Returns on Equally-Weighted Portfolios of							
All REITs	-1.34	2.53*[c]	0.99**	-2.60	0.13	2.04	0.93
	(-0.24)	(2.19)	(2.87)	(-1.07)	(3.96**)		(-0.03)
Equity REITs	-0.47	2.29*	0.68*	-1.97	0.10	2.13	1.00
	(-0.10)	(2.39)	(2.38)	(-0.98)	(3.30*)		(0.00)
Hybrid REITs	0.61	2.57*	0.68*	-3.03	0.08	1.81	0.21
	(0.11)	(2.20)	(1.95)	(-1.24)	(2.75*)		(-0.30)
Mortgage REITs	-3.19	2.78*	1.47**	-2.95	0.16	2.07	1.30
	(-0.48)	(1.98)	(3.50)	(-1.00)	(5.03**)		(0.09)
Returns on Value-Weighted Portfolios of							
All REITs	-2.94	2.05	1.12**	-1.58	0.16	1.86	1.59
	(-0.58)	(1.91)	(3.52)	(-0.70)	(4.81**)		(0.25)
Equity REITs	-2.38	1.96*	0.76**	-0.78	0.13	2.13	1.94
	(-0.59)	(2.32)	(3.02)	(-0.44)	(4.02**)		(0.50)
Hybrid REITs	0.12	1.78	0.97**	-1.95	0.14	1.94	0.80
	(0.03)	(1.78)	(3.26)	(-0.93)	(4.32**)		(-0.09)
Mortgage REITs	-3.83	2.03	1.58**	-1.97	0.22	1.88	1.64
	(-0.64)	(1.62)	(4.27)	(-0.75)	(6.64**)		(0.23)

Notes:

a. $\tilde{R}_{I,t}$, $\tilde{R}_{m,t}$, $\tilde{R}_{d,t}$, and $\tilde{R}_{z,t}$ denote the quarterly returns on the instrumental variable, the ten year Treasury bonds, the three month Treasury bills, and the equally weighted CRSP Index.

b. $t = \frac{\beta - 0}{\sigma_\beta}$.

c. $t = \frac{\sum \beta - 1}{\sigma_{\sum \beta}}$.

d. * and ** indicate significance at the 95% level and the 99% level of confidence (two-tailed) respectively.

3.5.2 Market Return as a Return-Generating Factor

There may be a second reason why the PRISA return is a poor proxy for the return on real estate properties. Since it is appraisal-based, the PRISA return may not capture the variations in market expectations. The true return on real estate properties may be a function of both appraisal-based returns and the returns on the market portfolio. However, there is no prior knowledge about the structure of this function.

To investigate the potential influence that returns on the stock market portfolio have on REIT returns, I simply add the return on the stock market portfolio, $\tilde{R}_z$, to equation (3.16):

$$\tilde{R}_{s,t} = \alpha + \beta_p \tilde{R}_{I,t} + \beta_m \tilde{R}_{m,t} + \beta_d \tilde{R}_{d,t} + \beta_z \tilde{R}_{z,t} + \tilde{e}_t \tag{3.30}$$

Since the instrumental variable $\tilde{R}_{I,t}$ is a better proxy for the return on the PRISA portfolio, equation (3.30) includes the instrumental variable instead of the lagged return on the PRISA portfolio. The regression results from equation (3.30) are summarized in Table 3.11. It is evident that the return on the stock market does influence the returns on the REIT portfolios. First, the introduction of the returns on the stock market portfolio drastically increases the amount of return variation in the REIT portfolios, especially in the equity REIT portfolios, which is explained by the RHS factors. For instance, by adding the returns on the stock market portfolio to the REIT return-generating process, the model explains an additional 69% of the return variations in the value-weighted equity REIT portfolio.

Furthermore, the weights still sum to one for all eight REIT portfolios, indicating that the introduction of the stock market factor is consistent with the joint hypothesis H_{05}. In other words, the returns on the REIT portfolios are the weighted averages of the returns on the PRISA portfolio, the ten-year Treasury bond portfolio, the three-month Treasury bill portfolio, and the stock market portfolio.

In summary, the addition of the return on the stock market portfolio as a return-generating factor has significantly improved the explanatory power of the return-generating model. This indicates that the return on the stock market should be a return-generating factor for REITs. How to incorporate the stock market return into the return-generating process of REIT stocks will be a challenge to future researchers.[2]

[2]To examine the issue of whether investors can use the stock market portfolio and the Treasury securities to replicate the risk and return characteristics of real estate properties, I constructed four synthetic portfolios using the equally-weighted or value-weighted CRSP portfolio and the Treasury securities. The methodology used to construct these portfolios is the same as that outlined in Section 4. The ex post performance of these four portfolios is only slightly poorer than the four synthetic portfolios constructed using equity REITs and the Treasury securities for the same periods studied. Thus, it may be possible to replicate the risk and return characteristics of real estate properties using only the stock market portfolio and the Treasury securities.

Table 3.11: Regressions with the Stock Market Return and Instrumental Variable

First Quarter 1971–Fourth Quarter 1989

$$\tilde{R}_{s,t} = \alpha + \beta_I \tilde{R}_{I,t} + \beta_m \tilde{R}_{m,t} + \beta_d \tilde{R}_{d,t} + \beta_z \tilde{R}_{z,t} + \tilde{\varepsilon}_t \; ^a$$

$\tilde{R}_{s,t}$	α (t stat.[b])	β_I (t stat.[b])	β_m (t stat.[b])	β_d (t stat.[b])	β_z (t stat.[b])	Ad. R^2 (F stat.)	Durbin-Watson	$\sum\beta$ (t stat.[c])
Returns on Equally-Weighted Portfolios of								
All REITs	-7.61*	1.99*	0.37*	-1.77	0.72**	0.71	1.38	1.31
	(-2.29)	(2.35)	(2.11)	(-1.10)	(11.90)	(44.31**)		(0.24)
Equity REITs	-6.39*	2.11**	0.15	-1.80	0.63**	0.72	1.66	1.09
	(-2.33)	(3.00)	(1.00)	(-1.35)	(12.48)	(47.46**)		(0.08)
Hybrid REITs	-6.57	2.23*	0.16	-2.43	0.70**	0.65	1.63	0.65
	(-1.82)	(2.41)	(0.82)	(-1.38)	(10.66)	(34.46**)		(-0.25)
Mortgage REITs	-8.47	1.64	0.77**	-1.49	0.81**	0.33	1.55	1.73
	(-1.86)	(1.41)	(3.19)	(-0.67)	(9.67)	(31.76**)		(0.41)
Returns on Value-Weighted Portfolios of								
All REITs	-7.45	1.34	0.59**	-0.51	0.64**	0.69	1.06	2.06
	(-.234)	(1.65)	(3.47)	(-0.33)	(11.05)	(40.75**)		(0.85)
Equity REITs	-5.10*	0.97	0.31**	0.34	0.58**	0.77	1.75	2.19
	(-2.29)	(1.70)	(2.62)	(0.32)	(14.18)	(60.46**)		(1.37)
Hybrid REITs	-5.64	1.66*	0.59**	-1.65	0.59**	0.66	1.69	1.18
	(-1.77)	(2.03)	(3.46)	(-1.06)	(10.09)	(35.86**)		(0.15)
Mortgage REITs	-9.34*	1.64	1.01**	-1.25	0.67**	0.62	1.25	2.07
	(-2.22)	(1.53)	(4.53)	(-0.61)	(8.67)	(30.31**)		(1.54)

Notes:

a. $\tilde{R}_{I,t}$, $\tilde{R}_{m,t}$, $\tilde{R}_{d,t}$, and $\tilde{R}_{z,t}$ denote the quarterly returns on the instrumental variable, the ten year Treasury bonds, the three month Treasury bills, and the equally weighted CRSP Index.

b. $t = \frac{\beta - 0}{\sigma_\beta}$.

c. $t = \frac{\sum\beta - 1}{\sigma_{\sum\beta}}$.

d. * and ** indicate significance at the 95% level and the 99% level of confidence (two-tailed) respectively.

3.6 Conclusion

In conclusion, the results of the statistical tests are consistent with the hypothesis that the returns on REIT stocks are the weighted average of the returns on the assets and debts of these REITs. Considerable evidence suggests that the returns on REIT stocks are generated by the returns on real estate properties and long-term bonds. The returns on the short-term Treasury bill portfolio appear to be insignificant to the REIT return-generating process.

Furthermore, the results from our ex post simulations indicate that it is possible to use synthetic portfolios, which include equity REIT portfolios, portfolios of ten-year Treasury bonds, and short-term Treasury bills, to replicate the risk and return characteristics of commercial real estate properties. This finding indicates that it will be possible to use synthetic portfolios as long-term investment and risk-hedging vehicles in commercial real estate markets.

However, the returns on REIT stocks are found to react positively and significantly to the past returns on the PRISA portfolios and the current returns on the stock market portfolio. The former finding may indicate that the REIT market is inefficient in processing the information from the PRISA returns. The latter finding suggests that the returns on the stock market portfolio may be a significant factor in generating REIT returns. How to incorporate the stock market factor into the REIT return-generating model developed in this paper remains unclear. More research is needed to explore these two issues. I hope that the findings of this paper will stimulate more research in the future.

Chapter 4

The Random Walk Hypothesis Revisited: The Case of REITs

Abstract

This chapter investigates the random walk hypothesis for the stock prices of Real Estate Investment Trusts (REITs). Four alternative hypotheses are also tested: they apply to the sources of possible irrational price behavior, the January effect, the small firm effect, the market overreaction, and fads. The random walk hypothesis is rejected for the January 1970–December 1989 period. Inefficiency arises in the REIT market mainly because of the January effect and the "underreaction" from the investors of small REITs to new information. Short-term market overreaction does not appear to be a significant source of inefficiency in the REIT market. There is some evidence of long-term mean-reversion in REIT returns, but it is not clear whether this is caused by the deviation of the market prices from fundamental REIT values or the influence of business cycles in the REIT industry.

The random walk hypothesis was first introduced in an obscure doctoral dissertation by Louis Bachelier [3], who observed that the changes in security prices are independent of one another and thus unpredictable. Since the

1950s, this random walk hypothesis has been a foundation for many pricing theories and paradigms in modern financial economics [56]. If prices follow a random walk, the market is said to be at least weak-form efficient. In a fully efficient market, market prices reflect the fundamental values of the underlying assets and are accurate indicators of asset allocation [24, 10]. In other words, investors and firms alike can expect to get "fair" prices from the market.

Research on the market efficiency of real estate investment trusts (REITs) is sparse relative to the vast literature on the efficiency of the stock market. Moreover, in the limited number of studies conducted, the findings are inconclusive. On one hand, researchers found that autocorrelations of REIT returns are not significantly different from zero [49, 29], evidence consistent with the random walk hypothesis. On the other hand, there is also some evidence contrary to the random walk hypothesis in the REIT market. For instance, researchers found that, after initial public offerings (IPO), REIT returns are negative and significant; they suggested possible overvaluation at the IPO [86, 5]. There is also evidence of January effects in a small sample of REITs [16].

There are two problems associated with the existing findings. First, the dependence on the autocorrelation coefficients for inference about the efficiency of the REIT market may lead to a false conclusion that the REIT market is efficient. This is because the significance test on the autocorrelation coefficients is weak in detecting some of the long-term transitory components in the price process [82]. As a result, we may fail to reject the random walk hypothesis even though it is false (Type I error). Second, there are no explanations as to why anomalous evidence could arise in the REIT market other than the possible January effect. Since REITs are the only source of market-based information on risk and return characteristics on the $8.7 trillion real estate market [36], more studies on the efficiency of the REIT market are needed.

This chapter addresses two questions. First, is the market for REIT stocks efficient? In addition to the conventional test on the significance of the autocorrelation coefficients of REIT returns, I employ a more powerful variance ratio test on the random walk hypothesis. The effects of variable expected return and different holding periods are also cross-examined. Second, what causes the breakdown of the market if the market for REITs is indeed inefficient? Is it because "the prevailing approach to valuing real estate is unsophisticated and unreliable," as Stephen E. Roulac [71] suggests; or is it because of the "animal spirits" [44] in REIT investors' decision?

Four alternatives to the random walk hypothesis are tested in this paper, namely, the January effect hypothesis, the small firm effect hypothesis, the market overreaction hypothesis, and the fad hypothesis. The testing of these alternative hypotheses will not only help to answer my question about whether REIT prices follow a random walk, but also offer a plausible explanation about the sources of market inefficiency if the random walk hypothesis is indeed rejected.

The test results generated in this chapter do not support the random walk hypothesis for REIT prices. The random walk hypothesis is rejected for the January 1970–December 1989 period. Short-term market overreaction does not appear to be a significant source of inefficiency in the REIT market.

Inefficiency arises in the REIT market mainly because of the "underreaction" from the investors of small REITs and the January effect. Thus, it is implausible that the REIT market is "excessively volatile," as suggested by many real estate professionals [79, 53, 73, 75]. I also found long-term mean-reversion in REIT returns. However, it is not clear whether this is caused by the long–term deviation of the market prices from fundamental REIT values or by the historical booms and busts in the REIT industry.

Based on these findings, it is possible to draw a profile of REIT price behavior. The prices of larger REITs would respond promptly to shocks such as changes in long-term interest rates and the general condition of the stock market. The impacts would then be felt in the prices of smaller REITs with some lags. In other words, the prices of larger REITs and the prices of smaller REITs are positively cross-autocorrelated. Furthermore, investors can expect large increases in REIT prices every January, with larger gains in the prices of smaller REITs than in the prices of larger REITs. However, this abnormal January gain also exists in the stock market and in the market for long-term bonds.

These findings also suggest several ways to exploit the inefficiency in the REIT market. For instance, since the higher returns on larger REITs this month would probably lead to higher returns on the smaller REITs next month, a strategy of buying (selling) smaller REITs after abnormal gains (losses) on larger REITs should result in positive expected abnormal returns. Furthermore, since the expected returns on REITs in January are higher than in any other month, investing in REITs at the end of December and liquidating the position at the end of January would give investors a higher return than would a similar strategy in any other month.[1]

The following sections will explain, in more detail, how I come to these conclusions. In section one, I discuss the random walk hypothesis and four alternative hypotheses. This is followed by discussions of testing methodology, data sources, and research findings. The last section concludes this chapter.

[1] However, investors should recognize that the January effect also exists in the stock market and the market for long-term bonds. Thus, investments in REITs in January might not earn an abnormal return relative to similar investments in stocks and long-term bonds.

4.1 Review of the Random Walk Hypothesis

In this section, I review in detail the random walk hypothesis and four alternative hypotheses.

4.1.1 The Random Walk Hypothesis

One basic characteristic of an efficient market is that prices follow a random walk. If they follow a random walk, REIT prices should incorporate all relevant information from historical prices. Thus, it is impossible to predict future price behavior based upon historical prices [10].

Suppose that the market sets the price of a REIT at time t so that its expected return from t to $t+1$ is equal to some constant r, which is the same for every period. Different REITs have different r's due to their differences in risk. Let $\tilde{P}_t$ be the market price, $\tilde{P}_{e,t}$ be the equilibrium price at time t, and $\tilde{D}_s$ be the dividend at time t, where $\tilde{}$ denotes random variables. I_t is the information set available to investors at time t. The market prices securities correctly only if prices reflect the present value of expected future dividend streams, or

$$\tilde{P}_t = \tilde{P}_{e,t} = E[(\sum_{s=t}^{\infty} \frac{\tilde{D}_s}{(1+r)^{s-t}})|I_t], \ \forall \infty > s > t. \tag{4.1}$$

Rearranging (4.1) gives an expression for expected return under rational expectations.

$$E(\tilde{R}_t) = E[(\frac{\tilde{P}_{t+1}}{\tilde{P}_t} - 1 + \frac{(1+r)\tilde{D}_t}{\tilde{P}_t})|I_t] = r. \tag{4.2}$$

Ex post, REIT returns are generated by the following process:

$$\tilde{R}_t = r + \tilde{\epsilon}_t. \tag{4.3}$$

If the REIT market is efficient, $\tilde{\epsilon}_t$ must be white noise. That is, $\tilde{\epsilon}_t$ must be an independently, identically distributed normal variable with an expected value of zero.

Equation (4.3) is a simple statement of the joint hypotheses of a random walk price process and a constant expected return. It predicts that, if the REIT market is efficient and the expected return is constant, the best prediction of the expected returns for period t is the constant expected return r. In other words, the expected returns at t are independent of all information available at $t - k$, where $\infty > k > 0$.

It is obvious that any test of the efficient market hypothesis should be a test of the joint hypothesis of some equilibrium model and that $\tilde{\epsilon}_t$ is white noise. Equations (4.1) through (4.3) can be easily extended to incorporate state-dependent expected returns such as those discussed in Merton [54], Long [52], and Cox, Ingersoll, and Ross [17]. However, in this paper, I focus on testing the joint hypothesis of the random walk and constant expected return.

The joint hypotheses of efficient markets and constant expected return are generally tested based upon the significance of the autocorrelation coefficients of returns. If REIT returns are independent of past returns, $\tilde{\epsilon}_t$ is serially independent.

The existing findings on the REIT market efficiency are inconclusive. On one hand, the findings from early inquiries into the autocorrelations of returns on the REIT market are generally in favor of the random walk hypothesis. For instance, Liu [49, p. 147] found that autocorrelations of nominal returns on equity REITs are close to zero on average for the second quarter 1978–third quarter 1986 period. Geltner [29, pp. 192–194] also failed to reject the hypothesis that the quarterly returns on NAREIT's equity portfolio follow a random walk based upon the Q statistics on the autocorrelation coefficients.

On the other hand, there is evidence against the REIT market efficiency hypothesis. For instance, overvaluation of REIT shares at the initial public offering (IPO) was suggested by Wang, Chan, and Gau [86] and Balogh and Corgel [5]. In their event study, Wang, Chan, and Gau found a significantly negative average initial return of 3.92 percent on the first trading day after the IPO. Balogh and Corgel also reported that the market-adjusted 90-day holding period returns for REITs are negative and significant. Others have also suggested that REIT stocks are undervalued on the secondary market. For instance, Derven [21] argued that REITs are selling at a discount from their asset values in the stock exchanges. Consequently, some REITs were taken over because raiders intended to realize their "hidden value." For instance, in defending their takeover of Institutional Income Properties Inc. (IIP), a REIT that was traded publicly at one time, the new owners claimed that the stock market did not value IIP fairly [85].

There are two explanations for these differences. First, the findings on the mispricing of REIT stocks may not imply that the REIT market is inefficient. For instance, it is not clear whether the negative returns after IPOs result from high underwriting fees to investment bankers or from the failure of the market to value the underlying assets. The underwriting fees of the IPOs for investment bankers range from 8% to 20% of the total capital raised [38]. Since a REIT is basically an investment conduit, the formation of a REIT adds few additional values to justify the huge underwriting fees. Thus, the negative and significant returns after the IPOs may only reflect the unwillingness of investors to accept the inflated values created by the investment bankers at the IPOs. Furthermore, the claims about undervalued REITs in the secondary market were never substantiated by empirical research.

Another possible explanation is that the tests on autocorrelation coefficients are weak. These tests do not detect the type of general serial correlations in which the market prices converge to their fundamental values slowly over a long period of time [82]. With more powerful tests and more specific alternatives, the conclusions could have been very different.

This is what happened in the stock market. Findings from tests on short-term autocorrelations of stock market returns prior to the 1980s overwhelmingly support the random walk hypothesis: the predictable variation in security returns was both statistically and economically small. Fama [23] provides an excellent summary of efficient market hypothesis tests on the stock market conducted prior to 1970. "[T]here is no other proposition in economics which has more solid empirical evidence supporting it than the efficient market hypothesis," concluded Michael C. Jensen [41].

Equipped with more sophisticated models and more specific alternative hypotheses, financial economists have revealed evidence contrary to the efficient market hypothesis since the end of 1970s. For instance, Lo and

MacKinlay [50] rejected the random walk hypothesis for stock returns based on variance ratio tests. De Bondt and Thelar [19, 20] and Fama and French [25] found evidence of a long-term transitory component in stock prices. Lo and MacKinlay [51] and Lehmann [47] also revealed evidence of market overreaction. In other words, the earlier failure to reject the random walk hypothesis for stock prices could have been caused by the weakness of autocorrelation tests.

On the basis of the evidence from the stock market in general, I conclude that testing the random walk hypothesis requires more than just a simple significance test of the autocorrelations. More powerful tests, such as the variance ratio test, and more specific alternative hypotheses on REIT price behavior are needed. In the following subsections, I outline four specific alternative hypotheses. Detailed discussion of the variance ratio tests and the testing methodology for these four alternative hypotheses are postponed to the next section.

4.1.2 Alternatives to the Random Walk Hypothesis

Conventional tests of the joint hypothesis of the random walk price process and constant expected return are weak: they do not detect the type of generalized serial correlations in which the market prices slowly converge to their fundamental values over a long period of time [82]. They also reveal no information as to why and how REITs are mispriced. Therefore, it is important to identify and test alternative hypotheses about the price behavior that may cause the market to break down. Among the alternatives tested here are the January effect hypothesis of Rozeff and Kinney [72], Keim [42], and Colwell and Park [16]; the small firm effect hypothesis of Lo and MacKinlay [51]; the overreaction hypothesis of De Bondt and Thaler [19, 20], Lehmann [47], and Lo and MacKinlay [51]; and the fad hypothesis of Shiller [78], Summers [82], and Fama and French [25].

The January Effect

Considerable evidence exists on the January effect in the stock and bond markets. For instance, Rozeff and Kinney [72] reported that January returns are higher than those for any other month in the U.S. stock market. The same results were found in the U.S. bond market by Chang and Pinegar [13] and Park and Reinganum [65]. What is more interesting is that the January effect is related to firm size. For instance, Banz [6] and Keim [42] reported that smaller firms earn higher abnormal returns than larger firms in January. The existence of the January effect is anomalous to the efficient market hypothesis since it implies the predictability of securities' prices.

Since REITs are traded in stock markets and are small in capitalization,[2] the January effect may also exist in REIT returns. This hypothesis is supported by the findings of Colwell and Park [16]. They found that the average return on REITs in January is higher than that in any other month, and the abnormally high return in January tends to disappear for large REITs. Furthermore, the January effect for mortgage REITs appears to

[2]REITs are characterized by their small capitalizations. The average capitalization of REITs was about $91.28 million in 1989 [34], in contrast to the average capitalization of $4 billion for a typical S&P 500 company.

be larger than that for equity REITs. However, they did not explain why the January effect exist in REIT returns.

There is still no satisfactory model of the January seasonality in stock returns. A frequently cited reason for the higher return in January is the tax-loss-driven selling pressure in December and the subsequent buying pressure in January. This argument is implausible, however. First, it cannot explain the large differences between the small drops in December prices and the large increases in January prices. It also fails to explain the behavior of tax-exempt investors such as pension funds. Furthermore, the January effect also exists in the stock market in the United Kingdom (UK) where the fiscal year ends on the fifth of April [39]. The UK stock prices do not exhibit mean-reversion in April or in any other month outside of January. If the tax-saving argument is sound, one would expect an April effect in the UK stock market instead of a January effect.

This study will address two important questions. First, does the January effect exist in REIT returns? Since the sample of Colwell and Park [16] includes only 61 REITs that are listed in the NYSE and ASE, their findings may not be applicable to all REITs, especially those small REITs that are traded over-the-counter. A confirmation of the previous findings of Colwell and Park to a larger and more representative sample is needed. Second, what causes the January effect in the REIT market? Is the January effect in REIT returns caused by the same factors as those in the stock and bond markets?

Small Firm Effect Hypothesis

The small firm effect hypothesis predicts that the prices of smaller firms tend to react more slowly to new information compared to those of larger firms. In other words, there is a positive cross-autocorrelation between past returns on larger firms and current returns on smaller firms. If the small firm effect exists in the REIT market, it would be possible to use lagged returns on larger REITs and lagged common factors to predict returns on smaller stocks. It is also possible that the returns on a portfolio of REIT stocks are positively autocorrelated. The random walk hypothesis can be rejected if I can find evidence of the small firm effect.

The findings from previous research on common stocks seem to support the small firm effect hypothesis. For instance, Lo and MacKinlay [51] found that the returns of smaller stocks in one period are positively correlated with the returns of larger stocks in the prior period, but not vice versa. Other findings also suggest that returns on smaller stocks can be predicted by lagged common factors. For instance, Keim and Stambaugh [43] found that between 8% and 13% of the return variations in small stocks can be predicted using lagged yield spreads.

No study has been conducted to explore whether the small firm effect exists in the REIT market. Since there is a large variation in REIT capitalization,[3] I suspect that the small firm effect exists in the REIT market given the large differences in information availability and the differences in

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[3]REIT capitalizations range from several million dollars to several hundred million dollars.

trading frequency between smaller REITs and larger REITs. Like blue chip stocks, shares of larger REITs are traded on the NYSE and ASE. Changes in these larger REITs are closely tracked and extensively analyzed by Wall Street analysts. Information on these REITs is readily available and the market for the shares of these REITs is active. On the other hand, shares of most smaller REITs are traded over the counter.[4]

There is little information on the composition of the asset portfolios of these smaller REITs and on their management. Few, if any, Wall Street analysts are interested in analyzing the impact of new information on the values of these smaller REITs. In other words, it is difficult and costly to acquire information about smaller REITs relative to larger REITs. The lack of exposure and interest in smaller REITs also limits the market and reduces the trading frequencies for smaller REITs. In other words, the market for the smaller REITs is thinner than that for the larger REITs.

It is possible that the lack of information on the smaller REITs coupled with the thin market for them cause underreaction in smaller REIT prices to new information. For instance, it may take a long time for the investors in smaller REITs to react to new information. Even when they finally react, the level of adjustment may be insufficient. As a result, positive cross-autocorrelations may exist between the prices of smaller REITs and those of larger REITs.

[4]According to the National Association of Real Estate Investment Trusts (NAREIT), 43% of publicly traded REITs are listed in the over-the-counter systems [63].

Overreaction Hypothesis

The market overreaction hypothesis predicts that, if the market overreacts, extreme movements in stock prices will be followed by subsequent price movements in the opposite direction. The more extreme the initial price movement, the greater the subsequent adjustment [19].

Overreaction may be caused by the irrational behavior of investors. Keynes once observed that for most investors in securities markets, a decision "can only be taken as a result of animal spirits–of a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of benefits multiplied by quantitative probabilities." [44] De Bont and Thaler [19] also suggested that investors tend to overvalue recent information and undervalue prior data in forming their expectations.

The fact that REIT shares are traded in stock markets might subject REIT prices to a herd mentality of optimism and pessimism. REIT prices may temporarily swing away from their fundamental value, creating excess volatility. Such a tendency to overreact implies that REIT prices might be negatively autocorrelated, since what comes up must go down and vice versa. Consequently, changes in past prices could be used to predict future price changes, a clear violation of the random walk hypothesis.

Recent studies of the market overreaction hypothesis appear to center around whether it is possible to derive positive arbitrage profits from simple contrarian portfolios of common stocks. A contrarian strategy is characterized by selling the winners and buying the losers, that is, simultaneously purchasing securities that have performed poorly in the past and selling securities that have performed well [47, 51]. In essence, contrarian trading strategies exploit the negative serial correlation in past asset returns. If the REIT market indeed overreacts, investors should be able to use contrarian strategies to earn positive expected profits because current losers in the REIT market are likely to emerge as winners in the subsequent period and the reverse is true for current winners.

A number of studies conducted in this area reported positive expected profits from some contrarian investment strategies in the stock market and the long-term bond market [19, 20, 47, 68]. For instance, Lehmann [47] found that the "winners" and "losers" in one week experience sizable return reversals in the subsequent week. Using his contrarian strategy, investors could make significant arbitrage profits after adjusting for bid-ask spreads and transaction costs.

The interpretation of the positive expected contrarian profits from these studies is ambiguous, however. Overreaction leads to positive contrarian profits. But the reverse is not necessarily true, because the positive contrarian profits may be a result of positive cross-autocovariances across securities. Lo and MacKinlay [51] tested each of these two components of stock prices separately. They found that, on the basis of statistical tests, both autocorrelations and cross-autocorrelations contributed significantly to the expected profits.

The overreaction hypothesis appears to be a potentially useful model to explain the large volatility that exists in REIT returns. Many real estate professionals have suggested that REIT returns are too volatile relative to appraisal return series [84, 75, 73]. Most research efforts to explain this difference tend to focus on the smoothing problem in appraisal returns. For instance, Ross and Zisler [70] devoted an entire issue of *Real Estate Research*, a Goldman, Sachs & Company investment newsletter, to the problem of estimating the appropriate variance level for real estate investments using appraisal return series. Geltner [29] also discussed the issue of adjusting the smoothing problem in appraisal series in his dissertation. While it is possible that the smoothing problem in the appraisal return series causes the difference in volatility between REIT returns and appraisal returns, I believe that overreaction in the REIT market may also be plausible. Since no researcher has previously studied this issue in the REIT market, the issue of overreaction deserves further investigation.

Fads

Inefficiency in the REIT market can come in the form of temporary but slowly decaying deviations of REIT prices from their fundamental value, or fads. Summers [82] demonstrated that this pattern of long-term mean reversion is difficult to detect with conventional tests of autocorrelation coefficients. "Thus the inability of these tests to reject the hypothesis of market efficiency does not mean that they provide evidence in favor of its acceptance" [82, p. 592].

There is some evidence on long-term mean reversion in stock returns. For instance, Fama and French [25] found a significant and negative autocorrelation in long holding-period returns on stocks. In their study, predictable variations are estimated to be about 40% of the 3-5 year return variances for portfolios of smaller firms and 25% for portfolios of larger firms. These findings are supported by Jegadeesh [39], who found that the returns on the equally-weighted index of the U.S. stock market exhibited mean reversion over the 1926-1988 period.

The evidence on the long-term temporary component in stock prices is still inconclusive. For instance, the findings of significant mean reversion by Fama and French [25] and Jegadeesh [39] are completely dependent upon the data for the pre-war period; no mean reversion was found for the post-war period in either study. Therefore, their findings of mean reversion in the returns on the stock market index might be artifacts of the Great Depression in the early 1930s. Furthermore, in another study of transitory components in stock prices, Poterba and Summers [68] failed to reject the hypothesis of random walk price behavior at conventional significance levels although they found a negative autocorrelation in returns over long horizons.

I believe it is possible that REIT prices contain a long-term transitory component in light of typical investment behavior in the REIT market. Most REIT investors are small.[5] Since it is costly and time-consuming to collect and analyze information about REITs, the rewards for timely information collection and analysis on real estate assets might not justify the costs to these small investors. Consequently, investors are slow to incorporate new information in REIT prices, leading to a long-term temporary deviation in REIT prices from their fundamental values. Therefore, it is important to

[5]REITs were originally created as vehicles for small investors to invest in real estate. By law, REITs must have at least 100 shareholders and no more than 50% of the shares can be held by 5 or fewer shareholders [63].

study whether the prices of REIT stocks exhibit a long-term temporary component similar to evidence discovered in the stock market.

4.2 Models and Methodology

This section discusses, in detail, the models and methodology used to test the random walk hypothesis and the four alternative hypotheses. The conventional test of the autocorrelation coefficients is first discussed. It is followed by a description of the more powerful variance ratio test on the joint hypothesis of the random walk price process and constant expected return. Procedures for testing the four alternative hypotheses are also outlined in the following discussion.

4.2.1 Tests of the Autocorrelation Coefficients

The conventional test of the random walk hypothesis focuses on the significance of the autocorrelation coefficients of returns. If REIT prices follow a random walk, past returns should be poor sources of information about expected returns in the subsequent period. The best prediction of the expected return conditional on historical returns is a constant r. That is,

$$E(R_t|R_{t-1},\ R_{t-2},\ \ldots) = E(R_t) = r. \tag{4.4}$$

If REIT prices follow a random walk and the expected return is constant, the regression of R_t on R_{t-k}, $\forall k$, $E(R_t|R_{t-k})$, should be constant. In other words, if

$$E(R_t|R_{t-k}) = \alpha + \rho_k R_{t-k} \tag{4.5}$$

where ρ_k is the autocorrelation coefficient for lag k, the joint hypothesis of market efficiency and constant expected equilibrium return implies that autocorrelation of the returns on any security are zero for all lags, or

$$H_{o1} \; : \; \rho_k = 0, \; \forall k > 0, \tag{4.6}$$

$$H_{a1} \; : \; \rho_k \neq 0, \; \forall k > 0. \tag{4.7}$$

The hypothesis that a particular autocorrelation coefficient is zero can be tested using Bartlett [7], which demonstrates that if a time series has been generated by a white noise process, the sample autocorrelation coefficients for $k > 0$ are approximately distributed according to a normal distribution with mean zero and standard deviation $\frac{1}{\sqrt{T-k}}$, where T is the number of observations in the series and k is the number of lags in the autoregressive function.

The joint hypothesis that all of the autocorrelation coefficients are zero can be tested using the Q statistics introduced by Box and Pierce [9]. They show that the statistic

$$Q = T \sum_{k=1}^{K} \rho_k^2 \tag{4.8}$$

is asymptotically distributed as a chi square with K degrees of freedom.

The assumption of constant expected returns has certain limitations. The expected returns might not be constant, for instance, if they are dependent upon some state variables such as interest rates.[6] The variable expected

[6]Examples of state-dependent equilibrium models can be found in Merton [54], Long

return may result in the rejection of the random walk hypothesis when the prices of REITs indeed follow a random walk.

REITs are tax-exempt real estate investment conduits. Restricted by IRS Code Section 856 [38, pp. 433–443], REITs invest most of their capital in long-term real estate mortgages and real estate properties and derive most of their income from rents and interest.[7] REITs have long enjoyed the stability of their investment income streams. Since REITs are obliged to distribute at least 95% of their incomes,[8] REIT dividend streams are much more stable than industrial stocks [73].

The bond-like features of REITs are reflected in the sensitivity of REIT returns, especially mortgage REIT returns, to the changes in both short-term and long-term interest rates. As I discussed in the previous chapter, the return- generating process for REITs can be described by a three-factor model and white noise. These three factors are: the returns on a three-month Treasury bill portfolio, the returns on a ten-year Treasury bond portfolio, and the returns on a portfolio of real estate properties. To avoid committing Type I error in my test,[9] I will cross-examine my results against the autocorrelation coefficients of excess returns from the three-factor model.

A severe data problem arises in applying this three-factor model: there is

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[52], and Cox, Ingersoll, and Ross [17]

[7] REITs are discouraged from short-term speculation. For instance, REITs are required to hold real property for a minimum of four years. REITs are also restricted from investing in "growth opportunities" such as raw land.

[8] In reality, REITs distribute more than 100% of their income. See, for instance, Wang, Erickson, and Gau [87].

[9] Type I error would occur if I reject the random walk hypothesis when REIT prices indeed follow a random walk.

no monthly return series for commercial real estate properties. One solution is to replace the returns on real estate properties with the returns on the stock market portfolio. In other words, I assume that the returns on REIT stocks are generated by the returns on the stock market, and on long-term Treasury bonds and short-term Treasury bills. This solution may be appropriate because the stock market portfolio includes many firms that invest in real estate such as REITs and real estate companies. The returns on the equally-weighted portfolio compiled by the Center for Research in Security Prices (CRSP) are used as the returns on the stock market portfolio.

Therefore, the return generating process of REITs is

$$\tilde{R} = \alpha + \tilde{X}\beta + \tilde{\epsilon} \tag{4.9}$$

where $\tilde{R}$, α, *and* $\tilde{\epsilon}$ are $T*1$ vectors, $\tilde{X}$ is a $T*3$ matrix of return-generating factors, and β is a $3*1$ vector of coefficients.

If the REIT market is efficient and REIT returns are generated by equation (4.9), $\tilde{\epsilon}$ must be white noise. That is, $\tilde{\epsilon}$ is an independently and identically distributed normal variable. The joint hypothesis of the efficient REIT market and the three-factor return-generating model of (4.9) can then be formulated based upon the features of the residuals from equation (4.9).

Define the residuals, $\tilde{\epsilon}$, as the differences between the observed returns and the expected returns predicted by the three-factor model. Rearranging equation (4.9) gives an expression for residuals:

$$\tilde{\epsilon} = \tilde{R} - \alpha - \tilde{X}\beta. \tag{4.10}$$

The joint hypothesis of the efficient REIT market and the three-factor return generating process can be formulated as

$$H_{02} \;:\; \rho_k = 0, \; \forall\, k > 0 \tag{4.11}$$

$$H_{a2} \;:\; \rho_k \neq 0. \tag{4.12}$$

where ρ_k is the *k-th* order autocorrelation coefficient for the residuals.

4.2.2 Variance Ratio Test

The variance ratio test is a simple specification test. It exploits the fact that the variance of the increments of a random walk is linear in the sampling interval. If the logarithm of the stock prices, including accumulated dividends, is generated by a random walk, the variances should be proportional to the return horizon. For instance, the variance of bimonthly sampled log-price relatives must be twice as large as the variance of a monthly sample. By comparing the variance estimates per unit of time obtained from weekly and monthly prices, I can then evaluate the plausibility of the random walk theory.

The idea of testing the relationship between the variability of returns at different horizons was pioneered by Alexander [2]. After years of refinement, the variance-ratio test is "close to the most powerful test of the null hypothesis of market efficiency with constant required return against a plausible alternative hypothesis," according to Poterba and Summers [68,

p. 28].

Based on the findings of White [92] and White and Domowitz [94], Lo and MacKinlay [50] developed a variance-ratio test of the random walk model that is robust to changing variances. This feature is very important. There are empirical findings that the volatilities of return series change over time and deviate from normality [27, 55, 67]. The random walk hypothesis restricts the residuals of equation (4.3) to be independently and identically distributed (*i.i.d.*) normal variables. Since I am interested in the lack of capability to forecast returns, it is important that I do not reject the random walk hypothesis because of heteroscedasticity or nonnormality.

Let $\bar{J}(q)$ be the variance ratio of interval q. For monthly returns,

$$\bar{J}(q) = \frac{\hat{\sigma}^2(q)}{\hat{\sigma}^2 q} \tag{4.13}$$

where $\hat{\sigma}^2(q)$ and $\hat{\sigma}^2$ are return variances for q month and one month respectively. $\bar{J}(q)$ converges to one if returns are serially independent. If some of the price variation is due to transitory factors, autocorrelation at some lags should be negative and the variance ratio will be negative. If the expected returns respond sluggishly to changes in common factors, returns will be positively autocorrelated and will be statistically greater than zero.

Let $\bar{V}(q) = \bar{J}(q) - 1$ be the normalized variance ratio. Lo and MacKinlay [50, pp. 44–50] show that asymptotically,

$$\bar{V}(q) \approx \sum_{j=1}^{q-1} \frac{2(q-j)}{q} \hat{\rho}(j) \tag{4.14}$$

where $\hat{\rho}(j)$ is the jth-order autocorrelation coefficient. A heteroscedasticity-consistent estimator of asymptotic variance, $\sigma(q)$ of $\bar{V}(q)$, can be calculated using:

$$\hat{\sigma(q)} \equiv \sum_{j=1}^{q-1} [\frac{2(q-j)}{q}]^2 \hat{\delta}(j) \tag{4.15}$$

where

$$\hat{\delta}(q) = \frac{\sum_{k=j+1}^{T-1} (R_k - R_{k-1} - \hat{\mu})^2 (R_{k-j} - R_{k-j-1} - \hat{\mu})^2}{[\sum_{j=1}^{T-1} (R_k - R_{k-1} - \hat{\mu})^2]^2}, \tag{4.16}$$

$$\hat{\mu} \equiv \frac{1}{T-1} \sum_{k=1}^{T-1} (R_k - R_{k-1}), \ and \tag{4.17}$$

T is total number of observations. The standardized test statistic,

$$Z^*(q) = \frac{\sqrt{T-1}\bar{V}(q)}{\sqrt{\sigma(q)}} \tag{4.18}$$

is asymptotically standard normal despite the presence of general heteroscedasticity. The joint hypothesis of constant expected return and the random walk price process can be formulated as:

$$H_{03} \ : \ \bar{V}(q) = 0 \tag{4.19}$$

$$H_{a3} \ : \ \bar{V}(q) \neq 0 \tag{4.20}$$

4.2.3 Models for Alternative Price Processes

In this section, I will describe the testing methodology for the four alternative hypotheses: the January effect hypothesis, the market overreaction hypothesis, the small firm effect hypothesis, and the fad hypothesis.

The January Effect

If the January effect exists, I expect that the twelfth-order autocorrelation coefficients of returns will be positive and significant. Furthermore, a January dummy variable should explain a significant portion of the variations in REIT returns.

Let D be a January dummy variable. D equals one if the month is January and zero otherwise. The null hypothesis of no January effect predicts that the coefficient for D, θ, equals zero in the following regression:

$$\tilde{R} = \alpha + D\theta + \tilde{\epsilon} \tag{4.21}$$

where $\tilde{R}$, α, D, *and* $\tilde{\epsilon}$ are $T \times 1$ vectors.

However, I am interested in not only whether there is a January effect in the REIT market, but also what causes this effect. Since previous findings suggest that the January effect exists in the stock market, I suspect that the January effect in the REIT market is caused by the positive and significant autocorrelation in January returns on the stock and bond market portfolios.

Let us assume that the returns on REITs are generated by a process that is the sum of (1) the three-factor model, (2) a January seasonal dummy variable, and (3) white noise. Expanded from equation (4.9), I have:

$$\tilde{R} = \alpha + \tilde{X}\beta + D\theta + \tilde{\epsilon} \tag{4.22}$$

The terms are defined the same as those explained in equations (4.9) and (4.21).

If the returns on REITs are generated by equation (4.9) and the January effect is a result of the January effect in the stock and bond markets, θ, must be zero. The joint hypothesis of the return-generating model of (4.9) and the January effect induced by the stock and bond markets can be stated as

$$H_{04} \; : \; \theta = 0, \tag{4.23}$$

$$H_{a4} \; : \; \theta > 0. \tag{4.24}$$

Small Firm Effect

If the prices of smaller REITs react to new information more slowly than those of larger REITs, I should detect three patterns. First, the returns on smaller REITs should be positively autocorrelated. Second, the returns on smaller REITs should be cross-autocorrelated with the returns on larger REITs, with the former lagging behind the latter. In other words, I can use the lagged returns on larger REITs to predict the returns on smaller REITs. Finally, lagged REIT return-generating factors can also be used to predict the returns on smaller REITs.

The question of whether lagged return-generating factors can be used to predict the expected returns on REIT stocks may be described as

$$\tilde{R}_t = \alpha + \tilde{X}_{t-k}\beta + \tilde{\epsilon}_t, \ \forall\ k > 0. \tag{4.25}$$

where $\tilde{X}_{t-k}$ is a $(T-k) \times N$ matrix of ex-ante variables, or, in this case, lagged REIT return-generating factors. The random walk hypothesis implies that prices reflect all information in historical prices. That is, the regression coefficients equal zero. In other words,

$$H_{05} \ : \ \beta = 0, \tag{4.26}$$

$$H_{a5} \ : \ \beta \neq 0. \tag{4.27}$$

In this chapter, I am primarily concerned with the predicting power of lagged returns on equally-weighted market portfolios, short-term Treasury bills, and long-term Treasury bonds. Because of rapidly declining cross-autocorrelation coefficients, I focus on first-order cross-autocorrelation.

The problem of heteroscedasticity may arise in parameter estimation because residual variance may be correlated with the level of independent variables. The existence of heteroscedasticity violates the assumption of constant variance, consequently, parameter estimates are inefficient. Since I have no prior knowledge about the structure of the heteroscedasticity, I will use White's [92] heteroscedasticity-consistent variance-covariance matrices in estimation. White's variance-covariance matrices do not rely on a specific formal model of the structure of the heteroscedasticity. Thus, general "inferences can be drawn" from the estimators [92, p. 817].[10]

Market Overreaction, Cross-Autocovariances of Returns, and Contrarian Profits

To test the market overreaction hypothesis and the hypothesis of positive cross-autocovariances between individual returns, I have

$$w_{it}(k) = -\frac{1}{N}(R_{i,t-k} - R_{m,t-k}), \ \forall\, i = 1, \cdots, N. \tag{4.28}$$

where $R_{i,t-k}$ is the return on security i at t-k, $R_{m,t-k}$ is the return on the equally-weighted REIT market index, and $R_{m,t-k} \equiv \sum_{i=1}^{N} \frac{R_{i,t-k}}{N}$.

$W_t(k)$ is an arbitrage portfolio whose weights sum to zero. The profit of this portfolio, $\phi_t(k)$, is:

$$\phi_t(k) = \sum_{i=1}^{N} w_{it}(k) R_{it}. \tag{4.29}$$

Substituting (4.28) into (4.29) and taking expectation gives:

$$E[\phi_t(k)] = C_k + O_k - \sigma^2(\hat{\mu}) \tag{4.30}$$

where C_k is the expected profit derived from only the off-diagonals of the autocovariances matrix, O_k is the expected profit derived from only the diagonals, and $\sigma^2(u)$ is the expected profit from the cross-sectional variance of the mean returns, independent of the autocovariances. Mathematically,

[10]For a detail discussion on White's method, please refer to White [92, 93] and Newey and West [62].

$$C_{kt} \equiv R_{m,t-k}R_{mt} - \hat{\mu_m^2} - \frac{1}{N}\sum_{i=1}^{N}(R_{i,t-k}R_{it} - \hat{\mu_i^2}) \tag{4.31}$$

$$O_{kt} \equiv -\frac{N-1}{N^2}\sum_{i=1}^{N}(R_{i,t-k}R_{it} - \hat{\mu_i^2}) \tag{4.32}$$

where $\hat{\mu_i}$ *and* $\hat{\mu_m}$ are the sample means of the returns on security i and the equally-weighted market portfolio respectively. Then the estimator $\hat{C}_k$, $\hat{O}_k$, *and* $\sigma^2(\hat{\mu})$ are given by

$$\hat{C}_k = \frac{1}{T-k}\sum_{t=k+1}^{T} C_{kt} \tag{4.33}$$

$$\hat{O}_k = \frac{1}{T-k}\sum_{t=k+1}^{T} O_{kt} \tag{4.34}$$

$$\sigma^2(\hat{\mu}) = \frac{1}{N}\sum_{i=1}^{N}(\hat{\mu_i} - \hat{\mu_m})^2 \tag{4.35}$$

Lo and MacKinlay [51] show that consistent estimator, $\hat{\sigma_c^2}$, $\hat{\sigma_o^2}$, *and* $\hat{\sigma_\phi^2}$, may be obtained by using the following relationship:

$$\hat{\sigma_c^2} = \frac{1}{T-k}[\hat{\gamma}_{ck}(0) + 2\sum_{j=1}^{q}\alpha_j(q)\hat{\gamma}_{ck}(j)] \tag{4.36}$$

$$\hat{\sigma_o^2} = \frac{1}{T-k}[\hat{\gamma}_{ok}(0) + 2\sum_{j=1}^{q}\alpha_j(q)\hat{\gamma}_{ok}(j)] \tag{4.37}$$

$$\hat{\sigma_\phi^2} = \frac{1}{T-k}[\hat{\gamma}_{\phi_k}(0) + 2\sum_{j=1}^{q}\alpha_j(q)\hat{\gamma}_{\phi_k}(j)] \tag{4.38}$$

where $\hat{\gamma}_{ck}(j)$, $\hat{\gamma}_{ok}(j)$, $\hat{\gamma}_{\phi_k}(j)$ are the sample j-th order autocovariances of the time series C_{kt}, O_{kt}, *and* $\phi_t(k)$ respectively. That is,

$$\hat{\gamma}_{ck}(j) = \frac{1}{T-k} \sum_{t=k+j+1}^{T} (C_{k,t-j} - \hat{C}_k)(C_{kt} - \hat{C}_k) \tag{4.39}$$

$$\hat{\gamma}_{ok}(j) = \frac{1}{T-k} \sum_{t=k+j+1}^{T} (O_{k,t-j} - \hat{O}_k)(O_{kt} - \hat{O}_k) \tag{4.40}$$

$$\hat{\gamma}_{\phi_k}(j) = \frac{1}{T-k} \sum_{t=k+j+1}^{T} [\phi_{t-j}(k) - E(\phi_{t-j}(k))][\phi_t(k) - E(\phi_t(k))] \tag{4.41}$$

and $q \sim O(T^{\frac{1}{4}})$ and $\alpha_j(q) \equiv 1 - \frac{j}{q+1}, \quad q < T$.

Z tests can be applied to test the following hypotheses. If the returns on REIT stocks are both cross-sectionally and serially independent, the autocovariances matrix is zero for all nonzero k. Hence, $\hat{C}_k = \hat{O}_k = 0$ and $E[\phi_t(k)] = \sigma^2(\hat{\mu})$. If the returns on REIT stocks are cross-sectionally independent and serially dependent, individual security returns are negatively autocorrelated over some holding period. Then, $\hat{C}_k = 0$, and $E[\phi_t(k)] = \hat{O}_k > 0$. If the returns on REIT stocks are cross-sectionally dependent and serially independent, it is possible to predict i's returns using past returns for security j, where $j \neq i$, or a common factor. Formally, $\hat{O}_k = 0$, *and* $E[\phi_t(k)] = \hat{C}_k > 0$. Finally, if the returns on REIT stocks are both cross-sectionally and serially dependent,[11] $E[\phi_t(k)] = \hat{C}_k + \hat{O}_k > 0$.

[11]That is, the return on each security i can be predicted using the past returns from both security i and security j, where $j \neq i$, or a common factor.

Fads

Assume that the REIT return-generating process is the sum of a permanent component and a transitory component. The former is a random walk process while the latter is the sum of a first-order autoregressive function (AR(1)) and white noise. Let the natural logarithm of a REIT price, $\tilde{P}_t$, be the sum of a random walk, $\tilde{X}_t$, and a stationary element, $\tilde{Y}_t$, or

$$
\begin{aligned}
\tilde{P}_t &= \tilde{X}_t + \tilde{Y}_t, && (4.42)\\
\tilde{X}_t &= \tilde{X}_{t-1} + \mu + \tilde{\delta}_t && (4.43)\\
\tilde{Y}_t &= \alpha\tilde{Y}_{t-1} + \tilde{\epsilon}_t,\ \forall\, \alpha < 1 && (4.44)
\end{aligned}
$$

where μ is the expected drift, and $\tilde{\delta}_t$ and $\tilde{\epsilon}_t$ are white noises. In this process, shocks, $\tilde{Y}_t$, are absorbed gradually over time since $\alpha < 1$[12]. In other words, the market corrects for its mispricing slowly.

The holding period returns are

$$
\tilde{R}_{t,t+\tau} = \tilde{P}_{t+\tau} - \tilde{P}_t = [\tilde{X}_{t+\tau} - \tilde{X}_t] + [\tilde{Y}_{t+\tau} - \tilde{Y}_t] = E(\tilde{R}_t) + \tilde{\zeta}_t \qquad (4.45)
$$

where τ is the length of the holding period. The mean reversion of the stationary price component, $\tilde{Y}_t$, causes a negative serial correlation in returns.

[12]If $\alpha = 1 + E(\tilde{R})$, the price process will be speculative bubbles without any upper bound. These bubbles are unlikely due to the limits on valuation errors set by speculators or real investment opportunities. See Blanchard and Watson [8] for more detail.

Summers [82, p. 595] shows that the k-th order autocorrelation coefficient of returns, ρ_k, is

$$\rho_k = \frac{-\alpha^{k-1}(1-\alpha)^2\sigma_y^2}{2(1-\alpha)\sigma_y^2 + \sigma_\zeta^2}. \tag{4.46}$$

Equation (4.46) predicts that, if the REIT price process is described by the fad hypothesis, all autocorrelation coefficients should be negative and decaying with k. If α is close to one,[13] Summers [82] shows that it is almost impossible to reject the random walk hypothesis based upon the conventional Bartlett or Box-Pierce Tests of autocorrelation coefficients. This is true even if market valuations frequently deviate significantly from the rational expectation of the present value of future cash flows.

The test of the fad hypothesis focuses on the first-order autocorrelation coefficients for different holding period returns. Fama and French [25, pp. 249–250] show that the mean reversion of the stationary price component, Y_t, causes negative autocorrelation in returns. Furthermore, while the random walk component tends to push the autocorrelation coefficients towards zero, the stationary price component pushes the autocorrelation coefficients to -0.5 as the length of holding period increases. These two implications of the fad hypothesis can be tested by examining the slopes of the following first-order autoregressive function for different holding periods:

$$\tilde{R}_{t,t+\tau} = \alpha + \beta_\tau \tilde{R}_{t-\tau,t} + \tilde{\delta}_t, \tag{4.47}$$

[13]It takes a long time for the market to correct for its mistake.

To derive the heteroscedasticity-robust estimator, White's heteroscedasticity-consistent variance-covariance matrices will be used. The estimators have conventional inferences. The random walk and fad hypotheses predict that, respectively,

$$H_{06} \; : \; \beta_\tau = 0, \; \forall \; \tau \geq 1 \; (random \; walk),$$
$$H_{a6} \; : \; \beta_\tau < 0, \; \forall \; \tau \geq 1 \; (fad).$$

4.3 Data

Most data used in this chapter come from the 1989 CRSP tapes and from the S&P Financial Services [81]. There are two samples used in the tests, a sample of survivor REITs and a sample of REIT population. The survivor REIT sample consists of 25 survivor REIT. Monthly returns on these survivor REITs over the period of January 1970 through December 1989 are derived from the 1989 CRSP monthly return file. Please refer to Appendix B for a list of these survivor REITs.

The REIT population sample consists of 153 REITs. Appendix B lists these REITs. These REITs are further categorized into three groups: equity REITs, hybrid REITs, and mortgage REITs. Monthly returns on equally-weighted and value-weighted portfolios for each of the four categories, all REITs, equity REITs, hybrid REITs, and mortgage REITs, are calculated using the method outlined in Chapter 2. Consequently, there are eight return series derived from the REIT population sample. They are the returns on

- equally-weighted portfolio of all REITs (EWA);
- equally-weighted portfolio of equity REITs (EWE);
- equally-weighted portfolio of hybrid REITs (EWH);
- equally-weighted portfolio of mortgage REITs (EWM);
- value-weighted portfolio of all REITs (VWA);

- value-weighted portfolio of equity REITs (VWE);
- value-weighted portfolio of hybrid REITs (VWH); and
- value-weighted portfolio of mortgage REITs (VWM).

To investigate the effects of firm sizes on the autocorrelation in returns, I sort the REITs into three equal-size portfolios, large, medium, and small, within each asset category based upon their market values at the end of the first year in which these stocks were publicly traded. Since most firms included in the sample existed for only fractions of the sample period, it is impossible to use the market values at a particular time as the basis for constructing the portfolios. In addition, the market values for most REITs are relatively stable over time and thus the use of beginning market values will not cause any serious bias.

Equally-weighted and value-weighted returns are then calculated for each of these portfolios. There are a total of 24 size-sorted returns series analyzed. They include:

- Returns on eight portfolios of large REITs. Returns on an equally-weighted large REIT industry portfolio, an equally-weighted equity REIT portfolio, an equally-weighted hybrid REIT portfolio, and an equally-weighted mortgage REIT portfolio are denoted by EWAL, EWEL, EWHL, and EWML respectively. Returns on a value-weighted large REIT industry portfolio, a value-weighted equity REIT portfolio, a value-weighted hybrid REIT portfolio, and a value-weighted mortgage REIT portfolio are denoted by VWAL, VWEL, VWHL, and VWML respectively.

- Returns on eight portfolios of medium REITs. Returns on an equally-weighted medium REIT industry portfolio, an equally-weighted equity REIT portfolio, an equally-weighted hybrid REIT portfolio, and an equally-weighted mortgage REIT portfolio are denoted by EWAM, EWEM, EWHM, and EWMM respectively. Returns on a value-weighted medium REIT industry portfolio, a value-weighted equity REIT portfolio, a value-weighted hybrid REIT portfolio, and a value-weighted mortgage REIT portfolio are denoted by VWAM, VWEM, VWHM, and VWMM respectively.

- Returns on eight portfolios of small REITs. Returns on an equally-weighted small REIT industry portfolio, an equally-weighted equity REIT portfolio, an equally-weighted hybrid REIT portfolio, and an equally-weighted mortgage REIT portfolio are denoted by EWAS, EWES, EWHS, and EWMS respectively. Returns on a value-weighted small REIT industry portfolio, a value-weighted equity REIT portfolio, a value-weighted hybrid REIT portfolio, and a value-weighted mortgage REIT portfolio are denoted by VWAS, VWES, VWHS, and VWMS respectively.

Weekly returns are compounded daily returns calculated for the weeks ending on Wednesdays. Daily returns are derived from the 1989 CRSP daily return file. The equally-weighted CRSP Index (EWC) is used as the market portfolio.

Returns on the ten-year Treasury bond portfolio are used as proxies for the returns on long-term fixed income assets for REITs. Returns on the three-month Treasury bill portfolio represent the returns on short term assets. Both series were compiled by Professor Eugene Fama of University of Chicago and are available in the 1989 CRSP bond tape.

4.4 Summary of Findings

This section summarizes the test results on the random walk hypothesis and four alternative hypotheses. The significance of the autocorrelation coefficients is first examined with both monthly and weekly return series. The impact of variable expected returns is also investigated. The choices of holding period and equilibrium model do not seem to influence the outcome in the tests of autocorrelations. The remainder of the paper, therefore, focuses on testing the joint hypothesis of the random walk price process and constant returns. The results of the variance ratio test on the joint hypothesis of the random walk price process and constant expected returns are then reported. Finally, four possible sources of market inefficiency are examined: the January effect, short-term market overreaction, small firm effect, and long-term mean reversion (fads).

4.4.1 Autocorrelations of REIT Returns

This subsection reports the findings of the significance tests on the autocorrelation coefficients of nominal monthly returns on the REIT portfolio and individual REITs. The sensitivity of the autocorrelation coefficients to variable expected return and the choice of holding period is also investigated. Since these tests are rather weak, the findings from these tests are exploratory in nature.

Autocorrelations of Monthly Returns On REIT Portfolios

Table 4.1 summarizes autocorrelation coefficients with eight REIT portfolios for up to 12 lags for the period of January 1970 to December 1989. The evidence is mixed regarding the null hypothesis that returns on REIT portfolios are individually and identically distributed normal variables.

First, the findings are different for the equally-weighted and value-weighted portfolios. I can clearly reject the null hypothesis that all autocorrelation coefficients up to 12 lags are zero for all four equally-weighted REIT portfolios at the 0.1 significance level. On the other hand, none of the Q statistics for the value-weighted REIT portfolios are significant. Since the value-weighted portfolios assign more weights to larger REITs than do the equally-weighted portfolios, the differences in Q statistics between the equally-weighted portfolios and the value-weighted portfolios suggest that weaker autocorrelations exist in the returns on larger REITs.

Furthermore, the significant Q statistics for the equally-weighted REIT portfolios are basically results from the positive and significant twelfth-order autocorrelations in the returns on these portfolios. Actually, the twelfth-order autocorrelation coefficients are significantly greater than zero for all eight REIT portfolios. When I use their own twelve-month lagged returns alone, I can predict a minimum of 1.77% of variation in the returns on the value-weighted hybrid REIT portfolio and a maximum of 5.34% of variation in the returns on the equally-weighted all-REIT portfolio. The findings clearly suggest that the twelfth-order autocorrelation is a significant source of inefficiency in the REIT market.

Finally, the returns on all except one of the REIT portfolios are first-order positively autocorrelated, although only one, the first-order autocorrelation of returns on the equally-weighted all-REIT portfolio, is statistically significant. This seems to be consistent with the small firm effect hypothesis.

Table 4.1: Autocorrelation Coefficients of REIT Portfolio Returns

January 1970-December 1989

lag	EWA[a]	EWE[a]	EWH[a]	EWM[a]	VWA[a]	VWE[a]	VWH[a]	VWM[a]
1	0.137**	0.073	0.100	0.121	0.110	0.020	-0.040	0.100
2	0.015	-0.039	-0.049	0.060	-0.010	-0.110	-0.070	0.020
3	-0.016	-0.011	-0.070	-0.040	-0.010	0.030	0.030	-0.020
4	0.032	-0.010	-0.060	0.070	0.080	0.010	-0.050	0.100
5	0.055	0.046	0.150**	0.020	0.100	0.120	0.140	0.090
6	0.059	0.085	0.040	0.030	0.110	0.050	-0.030	0.120
7	-0.065	-0.060	-0.090	-0.060	-0.040	-0.100	-0.030	-0.020
8	0.026	0.010	-0.019	0.060	0.010	0.000	0.010	0.010
9	-0.027	-0.050	0.000	0.000	-0.020	-0.020	-0.030	-0.020
10	0.023	0.060	-0.040	0.040	0.000	0.010	0.010	0.010
11	0.137**	0.130**	0.070	0.120	0.030	0.040	-0.040	0.050
12	0.231***	0.210***	0.210***	0.220***	0.165**	0.150**	0.133**	0.170***
$Q_{l=12}$	24.2**	19.4*	23.4**	22.0**	16.8	14.6	12.1	17.62
Sig Q[c]	1, 11, & 12	11 & 12	5,7,&12	1&12	1	None	None	None

Notes:

a. EWA, EWE, EWH, and EWM denote the equally-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively; VWA, VWE, VWH, and VWM denote the value-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively.

b. *, **, and *** indicate that coefficients are significantly different from zero at the 90%, 95% and 99% levels of confidence respectively.

c. The lag numbers (between 1-12) upon which the Q statistics are significantly different from zero at the 90% level of confidence.

Autocorrelations of Monthly Returns on Individual REITs

Table 4.2 summarizes the average autocorrelation coefficients for monthly returns on 25 survivor REITs. These survivor REITs have no missing monthly returns for the June 1973–November 1989 period. Since autocorrelation coefficients are not cross-sectionally independent, the reported standard deviations cannot be used to draw the usual inferences.

It is interesting to notice that the average first and second- order autocorrelation coefficients are negative, regardless of the sampling periods. The autocorrelation coefficients decay rapidly as the number of lags increases. Although I do not know whether they are statistically significant,[14] they are certainly very different from my findings of the positive first-order autocorrelation coefficients on REIT portfolio returns. The negative autocorrelation coefficients clearly suggest the possibility of overreaction in individual REIT prices. Why does the weighted average of these negative individual returns pose a positive first-order autocorrelation?

There are two possible explanations. First, the difference in results may arise because of sampling differences. The sample for the portfolio returns is the REIT population, while the sample for the individual returns is a group of well-established, seasoned, and frequently-traded survivor REITs. The shareholders of the latter sample clearly have more information about the underlying assets of the REITs in which they invest and thus they can respond to new information more promptly than can those in the former

[14]The significance test on the market overreaction hypothesis is postponed to a later section.

group. Therefore, those who invest in survivor REITs are much more likely to overreact than are average REIT investors. Consequently, the returns on these survivor REITs are first-order negatively autocorrelated, while the returns on the REIT population are first-order positively autocorrelated.

This explanation is implausible, however. As Table 4.3 indicates, the first-order autocorrelation coefficient of the returns on an equally-weighted portfolio of these survivor REITs is also positive. This certainly eliminates the possibility that the difference between the first-order autocorrelation coefficients for the REIT portfolio returns and those for individual REIT returns can be attributed to sampling differences.[15]

The second explanation is the small firm effect hypothesis: positive cross-autocovariances exist among individual REIT returns. The slow response in the prices of smaller REITs to new information relative to that of larger REITs raises the possibility that the returns of smaller REITs are positively cross-autocorrelated with the returns of larger REITs. The positive cross-autocorrelations in the returns on individual REITs can subsequently result in positive autocorrelations in portfolio returns, even though the returns on some individual REITs may be negative.

If this explanation is a good approximation of REIT price behavior, I expect that there would be significant and positive cross-autocorrelations between the returns on larger REITs and the returns on smaller REITs. Furthermore, the returns on smaller REITs should be more strongly autocorrelated than the returns on larger REITs. I will further investigate

[15]Notice that the twelfth-order autocorrelation of returns on this portfolio is significantly greater than zero.

this small firm effect in Section 4.4.3.

Table 4.2: Average Autocorrelation Coefficients for Monthly Individual REIT Returns

	1973:6–1989:11		1973:6– 1979:12		1980:1–1989:11	
Lag	Mean[a]	Std Dev [b]	Mean[a]	Std Dev [b]	Mean[a]	Std Dev [b]
1	-0.086	0.071	-0.115	0.092	-0.046	0.092
2	-0.035	0.074	-0.042	0.085	-0.022	0.083
3	-0.014	0.079	0.027	0.105	-0.050	0.105
4	0.026	0.059	0.043	0.103	-0.013	0.070
5	0.029	0.090	-0.018	0.093	0.040	0.119
6	-0.005	0.055	-0.014	0.097	0.018	0.062
7	-0.000	0.073	-0.004	0.079	0.015	0.090
8	-0.004	0.071	0.004	0.099	-0.025	0.090
9	-0.011	0.069	-0.027	0.101	0.015	0.065
10	0.025	0.062	0.024	0.083	-0.006	0.078
11	0.004	0.073	0.011	0.085	-0.019	0.070
12	0.074	0.075	0.120	0.101	0.001	0.076

Notes:
a. Average autocorrelation coefficients of monthly returns for 25 survivor REITs. For a list of these survivor REITs, please refer to Appendix B.
b. Std Dev = Standard deviation.

Table 4.3: Autocorrelation Coefficients of Monthly Returns on an Equally-Weighted Portfolio of Survivor REITs

June 1973–November 1989

Lag	Autocorrelation Coefficient
1	0.057
2	-0.026
3	-0.031
4	0.079
5	0.019
6	0.001
7	-0.055
8	0.013
9	-0.061
10	0.014
11	0.060
12	0.182**
$Q_{l=12}$	11.286
Sig Q^b	None

Notes:
a. ** indicates that the autocorrelation coefficient is significantly different from zero at the 99% level of confidence.
b. The lag numbers (between 1-12) upon which the Q statistics are significantly different from zero at the 90% level of confidence.

Autocorrelations of Residuals from a Three-Factor Model

To investigate the influence that the changes in the expected returns have on autocorrelation coefficients, I derive a set of new return series. These series are calculated according to equation (4.10). The changes in the expected returns predicted by the three-factor model (4.9) are excluded from these series. The joint hypothesis of independently and identically distributed REIT portfolio returns and the return-generating model (4.9) predicts that all the autocorrelation coefficients of these new series should be zero.

Table 4.4 summarizes the autocorrelation coefficients for the residuals for all eight REIT portfolios. It is clear that the changes in the expected returns do not contribute to all the autocorrelations in the REIT portfolio returns. The residuals which are exempt from the influence of the changes in the expected returns, are still significantly autocorrelated for most of the REIT portfolios, although they have different lag structures from those for the REIT portfolio returns. I can reject the joint hypothesis of the three-factor return-generating model (4.9) and white noise for the returns on almost all portfolios. In other words, the constraint on the constant expected return does not seem to affect the significance of the autocorrelation coefficients. Therefore, in the remainder of the paper, I focus on the joint hypothesis of the random walk price process and the constant expected return.

Autocorrelations of Weekly Returns

To eliminate the possibility that the random walk hypothesis is rejected because of a mere artifact of the monthly holding period, I also investigate the autocorrelation coefficients with weekly returns. Weekly returns are calculated for a group of 16 survivor REITs that have no missing weekly returns for the period of January 1973 to December 1989. Table 4.5 summarizes the autocorrelation coefficients up to 52 lags[16] for the entire sample period and two subperiods.

The evidence reveals that there is a strong positive autocorrelation for the weekly returns. The first-order autocorrelation coefficients are significantly greater than zero for all sample periods at the 0.01 significance level. This finding is consistent with the positive autocorrelations in the monthly returns on the REIT portfolios.

Furthermore, there exists a significant and positive serial correlation between the returns in the first week of the current year and the returns in the first week of the previous year for the entire study period as well as for the January 1973-December 1979 subperiod. This is revealed by the significant and positive fifty-first and fifty-second order autocorrelation coefficients. This finding is again consistent with the positive twelfth-order autocorrelation of the monthly return on the REIT portfolios. Moreover, it suggests that the twelfth-order autocorrelation of monthly returns is contributed almost exclusively by the positive and significant autocorrelations between the returns in the first week of the year. The same pattern does not exist for the subperiod of January 1980 to December 1989, however. The reason for this difference is unclear.

To summarize, the random walk hypothesis is also rejected for the weekly

[16]The number of trading weeks is 51.7 per year on average over the sample period.

returns. The outcomes from using weekly returns are generally consistent with those from using monthly returns. Therefore, I will focus my attention on monthly returns in the following discussion.

Table 4.4: Autocorrelation Coefficients of Residuals

January 1970-December 1989 [a]

Lag	EWA[b]	EWE[b]	EWH[b]	EWM[b]	VWA[b]	VWE[b]	VWH[b]	VWM[b]
1	0.038	-0.085	-0.060	0.025	0.065	-0.085	-0.125*	0.038
2	0.128**	0.037	-0.033	0.160**	0.098	-0.112*	-0.030	0.111*
3	0.069	0.019	0.074	0.055	0.132**	0.085	0.083	0.156**
4	0.129**	0.117	-0.084	0.103	0.168***	-0.022	-0.095	0.171**
5	0.103	0.049	0.147**	0.064	0.090	0.128**	0.141**	0.031
6	0.177***	0.179***	0.107	0.108	0.194***	0.105	-0.093	0.186***
7	-0.006	-0.063	-0.055	0.032	0.033	-0.130**	-0.034	0.078
8	0.054	0.003	-0.003	0.106	0.078	0.030	0.040	0.073
9	-0.039	-0.064	0.062	-0.027	-0.036	0.010	-0.044	-0.057
10	0.025	0.007	-0.041	0.097	0.025	-0.046	-0.018	0.092
11	0.244***	0.200**	0.132**	0.190***	0.080	0.021	-0.026	0.077
12	0.006	-0.080	0.028	0.063	-0.006	-0.048	0.021	0.023
$Q_{l=12}$	36.4***	28.0***	19.3*	29.4*	29.9***	19.2*	16.5	32.8***
Sig Q[d]	4-12	6-12	5-8& 11-12	4-12	2-12	2-3& 5-12	1 & 4-10	3-12

Notes:

a. The residuals are calculated from a revised version of the REIT return-generating model developed in Chapter 3. In the revised model, REIT returns are generated using the returns on the equally-weighted CRSP portfolio, the short-term Treasury bill portfolio, and the long-term Treasury bond portfolio.

b. EWA, EWE, EWH, and EWM denote the equally-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively; VWA, VWE, VWH, and VWM denote the value-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively.

c. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 significance levels respectively.

d. The lag numbers (between 1-12) upon which the Q statistics are significantly different from zero at the 90% level of confidence.

Table 4.5: Autocorrelation Coefficients of Weekly Returns on an Equally-Weighted Portfolio of Survivor REITs

Lag	1973-1989	1973-1979	1980-1989
1	0.222***	0.234***	0.195***
2	0.065	0.054	0.087**
3	0.033	-0.016	0.144***
4	-0.053	-0.099	0.051
5	-0.071**	-0.107**	0.016
6	-0.015	-0.046	0.048
7	-0.024	-0.044	0.015
8	-0.012	0.002	-0.054
9	0.029	0.063	-0.053
10	0.052	0.097	-0.065
11	-0.018	-0.01	-0.039
12	-0.068**	-0.085	-0.032
51	0.086**	0.143***	-0.051
52	0.095***	0.122**	0.026

Notes:
a. Weekly returns are cumulative daily returns calculated every Wednesday.
b. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 significance levels respectively.

Table 4.6: Variance Ratio Tests on Monthly Portfolio Returns
January 1970-December 1989

q	V^a_{EWA} (Z-score)	V^a_{EWE} (Z-score)	V^a_{EWH} (Z-score)	V^a_{EWM} (Z-score)	V^a_{VWA} (Z-score)	V^a_{VWE} (Z-score)	V^a_{VWH} (Z-score)	V^a_{VWM} (Z-score)
2	0.140 **	0.077**	0.101**	0.123**	0.115**	0.027**	-0.029**	0.104**
	(10.134)	(7.167)	(8.243)	(9.744)	(11.913)	(3.299)	(-3.029)	(11.140)
4	0.220 **	0.078**	0.148**	0.220**	0.162**	0.056**	-0.087**	0.168**
	(9.678)	(4.391)	(7.518)	(10.240)	(9.647)	(-3.923)	(-5.318)	(10.264)
6	0.281**	0.084**	0.192**	0.294**	0.262**	-0.030	-0.084**	0.277**
	(10.471)	(4.021)	(8.349)	(11.414)	(12.798)	(-1.760)	(-4.221)	(13.733)
12	0.411**	0.167**	0.262**	0.430**	0.494**	0.015	-0.062*	0.539**
	(12.224)	(6.350)	(9.030)	(12.975)	(17.718)	(0.630)	(-2.337)	(19.508)

Notes:

a. V_{EWA}, V_{EWE}, V_{EWH}, and V_{EWM} are the normalized variance ratios for the equally-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively; V_{VWA}, V_{VWE}, V_{VWH}, and V_{VWM} are the normalized variance ratios for the value-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively.

b. * and ** indicate that the variance ratios are significantly different from zero at the 95% and 99% levels of confidence respectively.

4.4.2 Variance Ratio Tests on the Random Walk Hypothesis

Table 4.6 summarizes the variance ratios and the Z statistics for four equally-weighted and four value-weighted REIT portfolios. Four different time intervals are used in the test. The test is robust despite the presence of heteroscedasticity.

The random walk hypothesis is rejected at the 99% level of confidence for the returns on all four equally-weighted REIT portfolios. The variance ratios are significantly greater than zero for all equally-weighted REIT portfolios.

Furthermore, the rejections are not due to the changing volatilities of returns since the test statistic Z is robust to heteroscedasticity.

The rejection of the random walk hypothesis is slightly weaker for the returns on the four value-weighted REIT portfolios. Although I can reject the random walk hypothesis for all four value-weighted REIT portfolios with $q = 2$ and 4, the variance ratios for the value-weighted equity REIT portfolio with $q = 6$ and 12 are insignificant. Moreover, six variance ratios are negative, indicating negative serial correlations in the returns for some value-weighted equity and hybrid REIT portfolios. If negative autocorrelations indicate market overreaction in REIT prices, this finding may suggests that a larger proportion of the return variances for larger REITs is a result of "market overreaction," since larger REITs are over-represented in the value-weighted portfolios. This makes intuitive sense because larger REITs are traded more often. The level of speculative noise in their return variances is inevitably higher.

To summarize, I reject the random walk hypothesis for all eight REIT portfolios with the statistically more powerful variance-ratio test. Furthermore, the rejection of the random walk hypothesis is not due to the presence of heteroscedasticity.

4.4.3 Sources of REIT Market Inefficiency

There are four possible sources of inefficiency in the REIT market. First, the REIT market may be inefficient because returns are influenced by factors, such as the January effect, that are not fundamental to future cash flows and the discount rate. Second, the market may be inefficient because the prices of smaller REITs respond to new information more sluggishly compared to the prices of larger REITs. This sluggishness may result not only in positive cross-autocovariances between returns on smaller REITs and those on larger REITs, but also in positive autocovariances in the returns on REIT portfolios. Third, the REIT market may be inefficient because investors overreact to shocks. The overreaction from investors would lead to negative autocovariances in REIT returns in the short run since what goes up must come down. Finally, REIT prices may deviate significantly from their fundamental values for a long period of time. This form of inefficiency is reflected by a long-term mean reversion in REIT prices. The results of statistical tests on these four alternative price processes are summarized below.

The January Effect

Tables 4.7 and 4.8 summarize the means and standard deviations of the returns and the results from the regressions of the returns on the REIT portfolios against the January dummy variable. These tables provide strong evidence about the influence of the January effect in the REIT market. First, the mean returns in January are the highest of all the 12 months. Most of the gains in annual returns are realized in January. For instance, January returns contribute to about 68% of total annual returns on the equally-weighted portfolio of all REITs. Second, the January effect is also evident in the coefficients for the January dummy variable. For instance, all the coefficients are positive and significant at all conventional significance levels. The January dummy variable alone explains from 4% to 12% of the variations in the REIT portfolio returns.[17]

Furthermore, the strength of the January effect seems to be inversely correlated with REIT size: the larger the REIT size, the smaller the January effect. This is reflected by lower returns in January, lower θ coefficients, and lower R^2s for the value-weighted REIT portfolios relative to the equally-weighted REIT portfolios. Since the value–weighted portfolios assign more weight to larger REITs, the weaker January effect for the value-weighted REIT portfolios seems to suggest that the January effect is weaker for larger REITs than for smaller REITs, a result consistent with the findings of Colwell and Park [16].

It is also evident that the twelfth-order autocorrelations of the REIT portfolio returns are caused mainly by the January effect. Table 4.9 summarizes the autocorrelation coefficients for eight new REIT return series that exclude January returns. With the exception of the returns on two mortgage portfolios, the eleventh-order[18] autocorrelation coefficients are statistically insignificant. In other words, the twelfth-order autocorrelation

[17] As a comparison, none of the dummy variables for other months are significantly different from zero. These results are not reported here due to limited space.

[18] Since January returns are excluded from the sample, the eleven-month lag is the same as the previous twelve-month lag.

coefficients of returns on six of the eight REIT portfolios are contributed exclusively by the January effect.

To investigate the sources of the January effect on REIT returns, I apply equation (4.22) to the returns on the eight REIT portfolios. According to the regression statistics reported in Table 4.10, the results seem to suggest that the January effect in the REIT market is caused primarily by the influence from the stock and bond markets. For instance, the coefficients for the January dummy variable are insignificant for the residuals in six of the eight REIT portfolios. In other words, when the influence from the stock and bond markets is eliminated, the January effect on REIT portfolios also disappears.

The January effect does not appear to be the only source of inefficiency for the REIT market, however. If REIT portfolio returns are indeed generated by a combination of the three-factor model, a January seasonal factor, and white noise, I should expect the residuals from equation (4.22) to be serially independent. In other words, all autocorrelation coefficients of residuals should be zero for all eight REIT portfolios. If there are elements, other than the January effect, that cause the REIT prices to be autocorrelated, the residuals would be serially dependent. As Table 4.11 indicates, the Q statistics for the residuals from five of the eight REIT portfolios are statistically significant. In other words, the returns on five of the eight REIT portfolios are still serially correlated even after I eliminate the influences from the January seasonality and the positive changes in the expected returns.

In summary, the January effect does exist in the REIT market. However, its existence is caused mainly by the influences of the stock and bond markets. Furthermore, the January effect is by no means the only major source of inefficiency in the REIT market.

Table 4.7: Statistics of Monthly Returns

Month	EWA*	EWE*	EWH*	EWM*	VWA*	VWE*	VWH*	VWM*
January								
Mean	7.199%	7.369%	7.871%	7.032%	4.836%	5.095%	6.182%	4.678%
Std Dev	9.298	7.755	11.803	10.678	7.731	6.262	10.114	8.719
February								
Mean	0.752	0.780	1.068	0.385	0.871	0.757	0.648	0.302
Std Dev	4.863	4.353	4.238	6.916	4.083	2.695	3.971	5.648
March								
Mean	1.808	1.998	0.84[illegible]	1.541	2.138	2.439	0.963	1.861
Std Dev	6.269	6.101	6.981	7.551	6.103	5.836	6.172	6.791
April								
Mean	-0.286	0.509	1.209	-1.064	-1.184	-0.114	1.279	-1.685
Std Dev	5.398	3.957	5.398	7.547	6.340	3.727	4.273	8.909
May								
Mean	-0.385	0.142	-1.451	-0.581	-1.001	-0.682	-1.094	-1.503
Std Dev	4.386	3.811	7.000	5.304	3.928	3.653	6.415	4.261
June								
Mean	0.252	0.429	1.927	-0.589	0.295	1.224	2.666	-0.556
Std Dev	4.068	4.047	5.537	4.428	5.569	3.905	5.710	6.429
July								
Mean	1.424	1.488	1.075	1.560	1.301	0.769	1.091	1.865
Std Dev	2.728	3.115	3.011	3.235	2.565	2.744	2.873	2.679
August								
Mean	0.293	0.197	0.377	0.319	0.853	0.769	0.522	0.668
Std Dev	6.958	5.244	6.432	8.948	7.534	5.841	6.335	8.768
September								
Mean	0.452	0.530	0.426	0.342	0.791	0.692	2.266	0.493
Std Dev	4.042	3.354	5.836	5.147	5.422	5.203	7.139	6.022
October								
Mean	-0.930	-0.957	0.284	-1.288	-0.198	0.056	-0.342	0.047
Std Dev	6.259	6.357	5.649	7.106	6.700	6.764	6.535	7.297
November								
Mean	0.093	0.488	-1.675	0.686	-0.100	0.011	-0.505	0.135
Std Dev	6.548	5.478	6.947	7.657	7.016	5.686	6.038	8.454
December								
Mean	-0.079	0.142	0.040	-0.422	0.175	0.796	-1.437	-0.015
Std Dev	6.142	4.855	4.284	8.468	5.373	4.080	4.608	6.567

* EWA, EWE, EWH, and EWM denote the equally-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively; VWA, VWE, VWH, and VWM denote the value-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively.

Table 4.8: Significance Tests on the January Dummy Variable

January 1970-December 1989

Portfolio	θ^a (t statistic)	R^2
Equally-Weighted Portfolios of		
All REITs	6.89 (5.14)	0.10
Equity REITs	6.85 (5.88)	0.12
Hybrid REITs	7.50 (5.03)	0.09
Mortgage REITs	6.95 (4.19)	0.07
Value-Weighted Portfolios of		
All REITs	4.48 (3.29)	0.04
Equity REITs	4.48 (3.97)	0.06
Hybrid REITs	5.63 (3.95)	0.06
Mortgage REITs	4.53 (2.82)	0.03

Notes: a. The θs are estimated using

$$\tilde{R}_{j,t} = \alpha + \theta D_t + \tilde{\epsilon}_{j,t}.$$

b. All θs are significantly greater than zero at the 0.01 significance level.

Table 4.9: Autocorrelation Coefficients of Non-January REIT Returns

January 1970-December 1989[a]

lags	EWA[b]	EWE[b]	EWH[b]	EWM[b]	VWA[b]	VWE[b]	VWH[b]	VWM[b]
1	0.317***	0.182***	0.214***	0.299***	0.222***	0.073	0.027	0.224***
2	-0.018	-0.079	0.092	-0.018	-0.017	-0.132**	-0.005	0.005
3	0.131**	0.050	0.211***	0.107	0.094	0.103	0.045	0.079
4	0.174***	0.132**	0.156**	0.171**	0.166**	0.106	0.072	0.179***
5	0.105	0.075	0.162**	0.077	0.117	0.105	0.065	0.105
6	0.082	0.091	0.004	0.051	0.091	-0.030	-0.108	0.113
7	0.185***	0.123	0.113	0.183***	0.136**	0.072	0.097	0.148**
8	0.117	0.050	0.105	0.138**	0.034	0.027	0.032	0.029
9	0.073	0.077	0.064	0.070	0.030	0.027	0.049	0.025
10	0.126	0.115	0.054	0.125	0.020	0.022	0.005	0.035
11	0.120	0.051	0.087	0.158**	0.116	0.077	0.049	0.143**
$Q_{l=11}$	58.3***	25.8**	44.1 ***	55.7***	37.3***	19.0*	9.6	38.9***
Sig Q[d]	all	all	all	all	all	2-8& 12	none	all

Notes:

1. Autocorrelation coefficients are calculated without January returns. Returns in December and February are treated as if they are contiguous. There are some biases with the results because the k-th order autocorrelation coefficients include some $k+1$-th order elements.

b. EWA, EWE, EWH, and EWM denote the equally-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively; VWA, VWE, VWH, and VWM denote the value-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively.

c. *, **, and *** imply significance at the 0.1, 0.05, and 0.01 significance levels respectively.

d. The lag numbers (between 1-11) upon which the Q statistics are significantly different from zero at the 90% level of confidence.

Table 4.10: Statistics from the Three-Factor Return-Generating Model

January 1970-December 1989

$$\tilde{R}_t = \alpha + \beta_1 \tilde{R}_{EWC,t} + \beta_2 \tilde{R}_{TB3M,t} + \beta_3 \tilde{R}_{TB10Y,t} + D\theta + \tilde{\epsilon}_t^a$$

	α (t stat.)	β_1 (t stat.)	β_2 (t stat.)	β_3 (t stat.)	θ (t stat.)	Adj R S (f stat.)
Equally-Weighted Portfolios of						
All REITs	0.08	0.71**	-0.68	0.21*	2.10*	0.63
	(0.146)	(11.07)	(-0.81)	(2.55)	(2.20)	
Equity REITs	0.25	0.61**	-0.14	-0.03	2.62**	0.60
	(0.47)	(12.57)	(-0.17)	(-0.28)	(2.66)	
Hybrid REITs	0.23	0.69**	-0.48	-0.01	2.68	0.48
	(0.34)	(6.83)	(-0.44)	(-0.01)	(1.72)	
Mortgage REITs	-0.20	0.78**	-1.16	0.57**	1.78	0.56
	(-0.27)	(10.06)	(-1.05)	(4.98)	(1.48)	
Value-Weighted Portfolios of						
All REITs	-0.11	0.72**	-0.50	0.37**	-0.38	0.64
	(-0.19)	(14.59)	(-0.51)	(4.37)	(-0.42)	
Equity REITs	0.05	0.63**	0.22	0.04	0.17	0.64
	(0.11)	(15.46)	(0.24)	(0.45)	(0.22)	
Hybrid REITs	0.34	0.64**	-0.58	0.23**	1.24	0.47
	(0.49)	(8.02)	(-0.52)	(2.26)	(0.91)	
Mortgage REITs	-0.35	0.76**	-1.03	0.76**	-0.40	0.58
	(-0.49)	(12.18)	(-0.90)	(6.15)	(-0.35)	

Notes: a. $\tilde{R}_t$, $\tilde{R}_{EWC,t}$, $\tilde{R}_{TB3M,t}$, and $\tilde{R}_{TB10Y,t}$ denote the monthly returns on REIT portfolios, the equally-weighted CRSP Index, the three-month Treasury bills, and the ten-year Treasury bonds at month t respectively. D is the January dummy variable. The equation is estimated using White's heteroscedasticity-consistent estimators.

b. * and ** imply significance at the 0.05 and 0.01 significance levels respectively.

Table 4.11: Autocorrelation Coefficients of the Residuals From the Three-Factor Return-Generating Model

January 1970-December 1989[a]

lag	EWA[b]	EWE[b]	EWH[b]	EWM[b]	VWA[b]	VWE[b]	VWH[b]	VWM[b]
1	0.055	-0.062	-0.057	0.030	0.062	-0.086	-0.098	0.029
2	0.120	0.022	-0.019	0.141*	0.075	-0.122	-0.025	0.079
3	0.040	0.017	0.044	0.016	0.090	0.078	0.050	0.095
4	0.108	0.112	-0.095	0.080	0.118	-0.032	-0.100	0.100
5	0.111	0.080	0.149**	0.062	0.070	0.124	0.136**	0.040
6	0.126	0.163**	0.095	0.037	0.140**	0.090	-0.119	0.119
7	-0.004	-0.039	-0.065	0.004	0.011	-0.137	-0.044	0.033
8	0.057	0.010	0.014	0.094	0.050	0.023	0.038	0.024
9	-0.045	-0.073	0.042	-0.019	-0.050	0.000	-0.047	-0.071
10	0.016	0.009	-0.017	0.071	0.016	-0.056	0.000	0.066
11	0.265***	0.248***	0.148**	0.171**	0.062	0.014	-0.007	0.069
12	-0.015	-0.098	0.023	0.045	-0.028	-0.059	0.015	0.027
$Q_{L=12}$	33.7***	32.2***	18.7*	19.4*	16.3	19.6*	15.2	14.5
SIG Q[3]	5-12	6& 7 11-12	6-8 11-12	2 & 11-12	4,& 6-9	2-3 & 5-12	5-9	NONE

Notes:

a. The residuals are calculated as the differences between the observed returns and the predicted returns from the three factor-January seasonal model.

b. EWA, EWE, EWH, and EWM denote the equally-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively; VWA, VWE, VWH, and VWM denote the value-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively.

c. *, **, and *** imply significance at the 0.1, 0.05, and 0.01 significance levels respectively.

d. The lag numbers (between 1-12) upon which the Q statistics are significantly different from zero at the 90% level of confidence.

Small Firm Effect

As I described earlier, the prices of smaller REITs might react more slowly to new information, compared to larger REITs. As a result, there would be significant and positive cross-autocovariances between the returns on smaller REITs and those on larger REITs. Consistent with my hypothesis, the cross-autocorrelation coefficient matrix is found to be asymmetric–the returns on the portfolios of smaller REITs lag behind the returns on the portfolios of medium and larger REITs. The sluggishness in smaller REIT returns also leads to positive autocorrelations in the returns on the small REIT portfolios.

Cross-Autocorrelation between Smaller REIT Returns and Larger REIT Returns. The slower response of smaller REIT prices to new information relative to larger REIT prices can cause significant and positive cross-autocovariances between the returns on smaller REITs and the returns on larger REITs. This is exactly what I find.

Table 4.12 summarizes the cross-autocorrelation coefficients of returns between size-sorted REIT portfolios. Since higher-order cross-autocorrelation coefficients are in general insignificant, I report only the first-order cross-autocorrelation coefficients. For the definitions of these portfolios, please refer to Section 4.3.

The diagonal elements of Table 4.12 are the first-order autocorrelation coefficients and the off-diagonal elements are the first-order cross-autocorrelation coefficients. For instance, the entry on the first column and first row, 0.130, is the first-order autocorrelation coefficient for the returns on the equally-weighted portfolio of all small REITs. The entry on the first column and second row, 0.247, is the first-order cross-autocorrelation coefficient between the returns on the equally-weighted portfolio of all small REITs and the one-month lagged returns on the equally-weighted portfolio of all medium-size REITs.

It is interesting to note the asymmetry in these autocorrelation and cross-autocorrelation matrices. Except for the value-weighted hybrid REIT portfolios, all entries below the diagonal are positive and greater than those above the diagonal. This clearly indicates that the one-month lagged returns on medium and larger REITs are good predictors of the returns on smaller REITs. That is, the higher the returns on medium and larger REITs in one month, the higher the expected returns on smaller REITs in the following month. Due to the asymmetry in the autocorrelation and cross-autocorrelation matrices, however, the reverse is not true.

For instance, the first-order cross-autocorrelation coefficient between the returns on the equally-weighted portfolio of all larger REITs in the previous month with the returns on the equally-weighted portfolio of all smaller REITs in the current month is 21.43%, statistically greater than zero at the 0.01 significance level. In other words, the one-month lagged return on larger REITs alone can account for about 5% of the return variations in smaller REITs. At the same time, the first-order cross-autocorrelation coefficient between the return on the equally-weighted portfolio of all smaller REITs in the previous month and the return on the equally-weighted portfolio of all larger REITs in the current month is insignificant at -3.47%. These findings clearly indicate that smaller REITs underreact to shocks, compared to larger

REITs. The results are consistent with the findings of Lo and MacKinlay [51] on the asymmetry in the autocorrelation and cross-autocorrelation matrices of size-sorted general stock portfolios.

Positive autocorrelations may be caused by infrequent trading of smaller REITs. Smaller REITs are traded much less frequently than larger REITs. The problem of non-synchronous trading arises because the prices of the securities with different trading frequencies are mistakenly assumed to be sampled simultaneously. This problem leads not only to autocorrelation in smaller REIT returns, but also to cross-autocorrelation between smaller REIT returns and the lagged returns on larger REITs. Typically, news first affects those REITs that trade more frequently, and later the influence spreads to the returns of the thinly-traded REITs.

In order to examine the impact of non-synchronous trading on the significant and positive cross-autocorrelation coefficients, I use a relation formulated by Lo and MacKinlay [51, p. 17]. According to Lo and MacKinlay, the cross-autocorrelation coefficient between the returns on two portfolios can be expressed as

$$Corr[R^o_{L,t-k}(q), R^o_{S,t}(q)] = \frac{\frac{(1-p_L)(1-p_S)}{(1-p_L p_S}\big)\big(\frac{1-p_S^q}{1-p_S}\big)^2 p_S^{kq-q+1}}{\sqrt{q - 2p_L \frac{1-p_L^q}{1-p_L^2}}\sqrt{q - 2p_S \frac{1-p_S^q}{1-p_S^2}}} \tag{4.48}$$

where $R^o_{L,t}$ and $R^o_{S,t}$ are the observed returns on portfolios of large and small REITs respectively, p_L and p_S are non-trading probabilities for portfolios of large and small REITs, and q is the holding periods in number of trading days. For monthly returns, I assume $q = 22$.

Table 4.13 summarizes ten combinations of P_L and P_S that would give a monthly cross-autocorrelation coefficient of 0.2143 between the returns on the equally-weighted portfolio of all smaller REITs and the one-month lagged returns on the equally-weighted portfolio of all larger REITs. In the most pessimistic case, in which $P_L = 0.85$ or a non-trading duration of 5.67 days for larger REITs, the probability of non-trading for the equally-weighted portfolio of smaller REITs is 0.87. In other words, smaller REITs must have an expected non-trading duration of 6.46 days[19] to account for all the first-order positive cross-autocorrelations between the smaller REIT returns and the one-month lagged larger REIT returns. Although I have no solid evidence on how thin the markets are for smaller REITs, it seems plausible that smaller REITs listed in the NASDAQ are traded less than once a week. In other words, it is possible that non-synchronous trading in smaller REITs causes the positive cross-autocorrelations between the returns on smaller REITs and the returns on larger REITs.

[19]The expected nontrading duration is calculated based upon the following relationship:

$$E(\tilde{d}) = \frac{p_i}{1 - p_i}, \qquad (4.49)$$

where p_i is the probability of non-trading.

Table 4.12: Autocorrelation and Cross-Autocorrelation Coefficients of the Monthly Returns on Size-Sorted REIT Portfolios

	EWAS[b]	EWAM[b]	EWAL[b]	VWAS[b]	VWAM[b]	VWAL[b]
EWAS1[a]	0.1300*	0.0242	-.0347			
EWAM1	0.2469**	0.0997	0.0335			
EWAL1	0.2143**	0.1174	0.0044			
VWAS1				0.0891	0.0494	0.0256
VWAM1				0.1646**	0.0690	0.0428
VWAL1				0.1879**	0.1136	0.0401
	EWES	EWEM	EWEL	VWES	VWEM	VWEL
EWES1	-0.0127	-0.0510	-0.0631			
EWEM1	0.1798**	-0.0242	0.0771			
EWEL1	0.2461**	0.1221	0.0326			
VWES1				-0.0501	-0.0375	-0.0674
VWEM1				0.1426*	-0.0296	0.0838
VWEL1				0.2338**	0.1041	0.0208
	EWHS	EWHM	EWHL	VWHS	VWHM	VWHL
EWHS1	0.0529	0.0535	-0.0109			
EWHM1	0.0938	-0.1215	-0.0829			
EWHL1	0.0718	0.0212	-0.0109			
VWHS1				-0.0489	0.0343	0.0110
VWHM1				-0.0330	-0.1250	-0.0631
VWHL1				0.0242	0.0839	-0.0035
	EWMS	EWMM	EWML	VWMS	VWMM	VWML
EWMS1	0.1072	0.0438	-0.0128			
EWMM1	0.2059**	0.0695	0.0072			
EWML1	0.1700**	0.0688	-0.0304			
VWMS1				0.0769	0.0346	0.0581
VWMM1				0.1244	-0.0261	-0.0214
VWML1				0.1178	0.0509	0.0037

Notes: a. One-month lagged returns on size-sorted REIT portfolios.

b. EWA, EWE, EWH, and EWM denote the equally-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively; VWA, VWE, VWH, and VWM denote the value-weighted portfolios of all REITs, equity REITs, hybrid REITs, and mortgage REITs respectively. S, M, and L refer to portfolios of small, medium, and large REITs respectively. Please refer to Section 4.3 for descriptions of these portfolios.

c. * and ** imply that I can reject the null hypothesis that autocorrelation and cross-autocorrelation coefficients are zero at the 95% level and 99% percent level (two-tailed) of confidence respectively.

Table 4.13: Nontrading Probabilities and Expected Non-Trading Days Necessary to Generate a Cross-Autocorrelation Coefficient between the Lagged Return on the Equally-Weighted Portfolio of Large REITs $R_{EWAL,t-1}$ and the Return on the Equally-Weighted Portfolio of Small REITs $R_{EWAS,t}$ that is 0.2143.

Combinations	P_{EWAL}	$E(\tilde{d})$	P_{EWAS}	$E(\tilde{d})$
1	0	0	0.810	4.269
2	0.100	0.111	0.813	4.334
3	0.200	0.250	0.815	4.417
4	0.300	0.429	0.819	4.522
5	0.400	0.667	0.823	4.656
6	0.500	1.000	0.829	4.831
7	0.600	1.500	0.835	5.072
8	0.700	2.333	0.857	5.427
9	0.800	4.000	0.857	6.003
10	0.850	5.667	0.866	6.457

Note: $P_{EW\dot{A}}$ and $E(\tilde{d})$ are the probability of non-trading and expected non-trading days respectively.

Small REIT Effect and Autocorrelations in Portfolio Returns. The tendency for the price of smaller REITs to respond slowly to new information may also cause positive autocorrelation coefficients in REIT portfolio returns. Positive autocorrelation in returns arises because it takes a long time for investors of smaller REITs to react and adjust to new information. Consequently, the prices of smaller REITs tend to move in the same direction when experiencing shocks. If this is true, I should expect positive autocorrelations only in the returns on smaller REITs. The positive autocorrelation coefficients for smaller REITs should also be greater than those for larger REITs.

In general, the results are consistent with my hypothesis. Tables 4.14, 4.15, and 4.16 summarize autocorrelation coefficients of returns up to 12 lags for the large, medium, and small REIT portfolios respectively. It appears that the level of positive autocorrelations in REIT portfolio returns is negatively correlated with the size of the REITs included in these portfolios.

For instance, at 12 lags, none of the Q statistics for the large REIT portfolios are significantly different from zero even at the 0.1 significance level. In other words, I fail to reject the null hypothesis that all autocorrelation coefficients are zero for all eight large REIT portfolios. On the other hand, the twelfth-order Q statistics for six out of the eight small REIT portfolios are statistically significant. The effect of REIT size on autocorrelations is evident even in the small REIT portfolios. Among the small REIT portfolios, all the equally-weighted small REIT portfolios have significant Q statistics. Only two of the four value-weighted REIT portfolios, those that assign more weights to larger REITs, have significant Q statistics.

REIT size also affects the levels of the first and twelfth autocorrelation coefficients. The first-order autocorrelation coefficients for most of the small REIT portfolios are higher than those for the large REIT portfolios. The first-order autocorrelation coefficient for the returns on the equally-weighted portfolio of all small REITs is significantly greater than zero–a finding consistent with the small firm effect hypothesis.

The twelve-month lagged returns are relatively poor predictors of current returns for portfolios of larger REITs, compared to their ability to predict for portfolios of smaller and medium REITs. For the large REIT portfolios, only mortgage REIT portfolios and REIT industry portfolios have twelfth-order autocorrelation coefficients that are significantly different from zero. In contrast, seven out of the eight portfolios of smaller and medium REITs have significant and positive twelfth-order autocorrelation coefficients.

Table 4.14: Autocorrelation Coefficients of the Returns on Portfolios of Large REITs

January 1970-December 1989

LAGS	EWAL[a]	EWEL[a]	EWHL[a]	EWML[a]	VWAL[a]	VWEL[a]	VWHL[a]	VWML[a]
1	0.004	0.033	-0.005	-0.031	0.040	0.021	0.000	0.000
2	-0.076	-0.167	-0.052	-0.023	-0.094	-0.106	-0.041	-0.067
3	0.007	0.051	0.073	-0.037	-0.022	-0.012	0.056	-0.025
4	0.018	-0.008	0.039	0.048	0.035	0.038	0.052	0.030
5	0.046	0.059	0.000	0.049	0.075	0.120	-0.011	0.068
6	0.039	-0.011	0.015	0.041	0.055	-0.040	-0.003	0.090
7	-0.059	0.032	-0.006	-0.101	-0.062	-0.051	0.019	-0.064
8	-0.004	-0.005	0.089	0.027	-0.009	-0.037	0.056	0.022
9	-0.064	-0.007	0.065	-0.079	-0.057	-0.017	0.042	-0.070
10	0.004	0.055	0.036	0.001	-0.026	0.007	0.047	-0.015
11	0.063	0.068	-0.047	0.041	-0.031	0.022	-0.068	-0.046
12	0.146**	0.076	0.094	0.174**	0.146**	0.112	0.106	0.160**
$Q_{L=12}$	10.715	12.045	8.231	14.688	12.756	11.398	7.497	14.167
SIG Q[c]	Non	2&3	None	None	None	None	None	None

Notes:

a. EWAL, EWEL, EWHL, and EWML denote the equally-weighted portfolios of all large REITs, large equity REITs, large hybrid REITs, and large mortgage REITs respectively; VWAL, VWEL, VWHL, and VWML denote the value-weighted portfolios of all large REITs, large equity REITs, large hybrid REITs, and large mortgage REITs respectively.

b. ** indicates that autocorrelation coefficients are significantly different from zero at the 95% significance level.

c. The lag numbers (between 1-12) upon which the Q statistics are significantly different from zero at the 90% level of confidence.

Table 4.15: Autocorrelation Coefficients of the Returns on Portfolios of Medium REITs

January 1970-December 1989

Lag	EWAM[a]	EWEM[a]	EWHM[a]	EWMM[a]	VWAM[a]	VWEM[a]	VWHM[a]	VWMM[a]
1	0.100	-0.028	-0.089	0.069	0.069	-0.035	-0.065	-0.026
2	0.069	0.007	0.024	0.082	-0.023	-0.016	-0.091	0.011
3	-0.003	0.006	0.125	-0.014	0.037	0.031	0.089	-0.035
4	-0.014	0.002	-0.150**	-0.005	-0.021	-0.045	-0.104	0.032
5	0.044	-0.006	0.135**	0.039	0.042	0.027	0.130**	0.024
6	0.066	0.050	0.012	-0.026	0.040	0.035	-0.013	-0.067
7	-0.065	-0.031	-0.033	-0.079	-0.069	-0.037	-0.099	-0.054
8	0.073	-0.036	-0.030	0.115	0.015	-0.064	-0.025	0.100
9	-0.040	0.063	-0.139**	0.025	-0.025	0.099	-0.068	-0.073
10	0.007	-0.007	0.128**	0.029	0.014	-0.012	0.077	0.012
11	0.136**	0.110	-0.158**	0.136**	0.045	0.061	-0.090	0.102
12	0.209***	0.179***	0.157**	0.156**	0.161**	0.172***	0.112	0.135**
$Q_{L=12}$	23.8**	13.7	37.9**	19.3	11.1	13.9	22.4**	13.8
SIG Q[c]	12	None	4-12	12	None	None	5-12	None

Notes:

a. EWAM, EWEM, EWHM, and EWMM denote the equally-weighted portfolios of all medium REITs, medium equity REITs, medium hybrid REITs, and medium mortgage REITs respectively; VWAM, VWEM, VWHM, and VWMM denote the value-weighted portfolios of all medium REITs, medium equity REITs, medium hybrid REITs, and medium mortgage REITs respectively.

b. *, **, and *** indicate significance at the 90%, 95% and 99% levels of confidence respectively.

c. The lag numbers (between 1-12) upon which the Q statistics are significantly different from zero at the 90% level of confidence.

Table 4.16: Autocorrelation Coefficients of the Returns on Portfolios of Small REITs

January 1970-December 1989

LAGS	EWAS	EWES	EWHS	EWMS	VWAS	VWES	VWHS	VWMS
1	0.130**	-0.001	0.053	0.105	0.089	-0.025	-0.049	0.073
2	0.0120	-0.026	-0.117	0.052	-0.018	-0.033	-0.097	0.041
3	-0.040	-0.05	-0.015	-0.029	-0.054	-0.03	0.081	-0.092
4	0.047	0.030	-0.05	0.046	0.054	0.05	-0.029	0.087
5	0.039	-0.02	0.096	-0.011	0.097	0.084	0 118	0.015
6	0.053	0.125	0.059	0.007	0.066	0.103	-0.005	0.048
7	-0.062	-0.082	-0.062	-0.009	-0.052	-0.101	0.011	-0.053
8	0.011	0.025	0.015	-0.002	0.031	0.053	-0.008	0.04
9	-0.014	-0.101	0.005	0.039	-0.037	-0.061	0.03	0.041
10	0.035	0.091	-0.088	0.08	0.025	0.07	0.007	0.016
11	0.144**	0.095	0.128	0.116	0.095	0.017	0.003	0.152**
12	0.300***	0.176***	0.180***	0.254***	0.191***	0.101	0.129**	0.164**
$Q_{L=12}$	35.7**	21.6**	19.7*	25.9**	19.8*	13.7	10.7	20.5*
SIG Q [c]	1 & 12	12	12	1& 12	12	None	None	12

Notes:

a. EWAS, EWES, EWHS, and EWMS denote the equally-weighted portfolios of all small REITs, small equity REITs, small hybrid REITs, and small mortgage REITs respectively; VWAS, VWES, VWHS, and VWMS denote the value-weighted portfolios of all small REITs, small equity REITs, small hybrid REITs, and small mortgage REITs respectively.

b. *, **, and *** indicate significance at the 90%, 95% and 99% levels of confidence respectively.

c. The lag numbers (between 1-12) upon which the Q statistics are significantly different from zero at the 90% level of confidence.

Predicting REIT Returns with Lagged Common Factors. The slower response in the prices of smaller REITs relative to that of larger REITs may also lead to positive cross-autocorrelations between the common factors and the returns on the smaller REITs. If the positive cross-autocorrelations indeed exist, it would be possible to use lagged common factors to predict smaller REIT returns. A possible set of common factors includes the returns on the equally-weighted CRSP portfolio, the returns on the one-month Treasury bills, and the returns on the ten-year Treasury bonds–a relationship outlined in equation (4.25). Since the higher-order autocorrelation function for the equally-weighted CRSP Index drops off rapidly,[20] I focus mainly on first-order autocorrelations.

Tables 4.17 and 4.18 report the results from regressing the returns of the eight large and the eight small REIT portfolios on the lagged common factors respectively. The percentage of return variations explained by the three lagged return generating factors is generally small, ranging from 0% to 8%. Furthermore, to my surprise, the predicting power of the lagged factors is the same for the small REIT portfolios as for the large REIT portfolios. There is little evidence that smaller REIT returns are more predictable, using the lagged return-generating factors, than larger REIT returns.

[20] Due to limited space, the autocorrelation coefficients for the return-generating factors are not reported here.

Table 4.17: Predicting the Returns on Large REITs with Lagged Return Generating Factors

January 1970-December 1989

$$\tilde{R}_{j,t} = \alpha_j + \beta_1 \tilde{R}_{EWC,t-1} + \beta_2 \tilde{R}_{TB3M,t-1} + \beta_3 \tilde{R}_{TB10Y,t-1} + \tilde{\epsilon}_{j,t}$$

REIT Portfolios	α	β_1	β_2	β_3	Ad.R^2
Equally-Weighted Portfolios of					
All REITs	0.01	-0.00	-0.01	0.07**	0.05
	(1.18)	(-0.42)	(-0.87)	(3.85)	
Equity REITs	0.13	0.00	-0.12	0.06**	0.05
	(1.54)	(0.91)	(-0.86)	(3.70)	
Hybrid REITs	0.10	-0.01	-0.14	0.07**	0.05
	(1.10)	(-0.63)	(-0.96)	(2.97)	
Mortgage REITs	0.06	-0.01	-0.07	0.08**	0.04
	(0.53)	((-0.72)	(-0.43)	(3.62)	
Value-Weighted Portfolios of					
All REITs	0.12	-0.00	-0.11	0.08**	0.08
	(1.49)	(-0.46)	(-0.79)	(4.54)	
Equity REITs	0.14	0.11	-0.20	0.18	0.00
	(0.90)	(1.15)	(-0.96)	(1.18)	
Hybrid REITs	0.35*	-0.01	-0.42	0.07**	0.04
	(1.90)	(-1.54)	(-1.55)	(3.03)*	
Mortgage REITs	0.15	-0.11	-0.23	0.11	0.00
	(0.99)	(-1.29)	(-1.04)	(1.31)	

Notes: a. $\tilde{R}_{j,t}$ is the return on the REIT portfolios. $\tilde{R}_{EWC,t-1}$, $\tilde{R}_{TB3M,t-1}$, and $\tilde{R}_{TB10Y,t-1}$ denote the lagged monthly returns on the equally-weighted CRSP Index, the three-month Treasury bills, and the ten-year Treasury bonds at month t-1 respectively. The equation is estimated using White's [92] heteroscedasticity-consistent estimators.

b. * and ** indicate that parameters are significantly different from zero at the 95% and 99% levels of confidence respectively.

c. Substituting the returns on the equally-weighted CRSP index with the returns on either the value-weighted CRSP index, the S&P Index, or the small stock index gives very similar results.

Table 4.18: Predicting the Returns on Small REITs with Lagged Return Generating Factors

January 1970-December 1989

$$\tilde{R}_{j,t} = \alpha_j + \beta_1 \tilde{R}_{EWC,t-1} + \beta_2 \tilde{R}_{TB3M,t-1} + \beta_3 \tilde{R}_{TB10Y,t-1} + \tilde{\epsilon}_{j,t}$$

REIT Portfolios	α	β_1	β_2	β_3	Ad.R^2
Equally-Weighted Portfolios of					
All REITs	0.09	0.01	-0.08	0.06**	0.05
	(1.56)	(1.17)	(-0.82)	(3.42)	
Equity REITs	0.11	0.01	-0.06	0.06**	0.06
	(1.84)	(1.37)	(-0.59)	(3.87)	
Hybrid REITs	0.09	0.01	-0.04	0.04	0.01
	(1.06)	(0.93)	(-0.32)	(1.79)	
Mortgage REITs	0.09	0.01	-0.14	0.07**	0.04
	(1.22)	(0.72)	(-1.09)	(3.16)	
Value-Weighted Portfolios of					
All REITs	0.14**	0.00	-0.07	0.07**	0.07
	(2.34)	(0.48)	(-0.72)	(3.93)	
Equity REITs	0.10*	0.01	-0.00	0.06**	0.07
	(1.90)	(1.47)	(-0.23)	(3.81)	
Hybrid REITs	0.14	-0.01	-0.10	0.06**	0.02
	(1.86)	(-0.55)	(-0.89)	(2.69)	
Mortgage REITs	0.14	0.08	-0.34	0.44	0.00
	(0.60)	(0.44)	(-1.27)	(1.71)	

Notes: a. $\tilde{R}_{j,t}$ is the return on the REIT portfolios. $\tilde{R}_{EWC,t-1}$, $\tilde{R}_{TB3M,t-1}$, and $\tilde{R}_{TB10Y,t-1}$ denote the lagged monthly returns on the equally-weighted CRSP Index, the three-month Treasury bills, and the ten-year Treasury bonds at month *t-1* respectively. The equation is estimated using White's [92] heteroscedasticity-consistent estimators.

b. * and ** indicate that parameters are significantly different from zero at the 95% and 99% levels of confidence respectively.

c. Substituting the returns on the equally-weighted CRSP index with the returns on either the value-weighted CRSP index, the S&P Index, or the small stock index gives very similar results.

Overreaction and Cross-Autocovariance: Evidence from a Simple Contrarian Strategy

If REIT investors overreact to new information, I should expect positive profits from some simple contrarian strategies. Table 4.19 reports the expected profits and the sources of these profits for twelve different contrarian strategies. These strategies are constructed based upon the 1–12 month lagged performance of 25 survivor REITs. I assume zero transaction costs in the calculation of contrarian profits. The assumption of zero-transaction costs may be appropriate for two reasons. First, the amount of the transaction is small because implementing the contrarian strategy involves only marginal revision of the positions in different REITs after the portfolio is formed. Second, many large institutional investors have very low transaction costs.

These findings suggest that it is possible to make a positive profit from these contrarian strategies. For instance, using one or two-month lagged returns, I can construct a simple contrarian strategy and lock into positive and significant arbitrage profits. With an average total investment of $311 per month,[21] the expected arbitrage profit from the contrarian portfolio I have constructed based upon one-month lagged returns is $12.26, significantly greater than zero at all conventional significance levels.

In contrast to the findings of Lo and MacKinlay [51], most of the expected returns are generated from the autocovariances in individual REIT returns,

[21] The average total investment is the sum of short and long positions, which is a measure of risk exposure. The net investment of the arbitrage portfolio is zero, however.

Table 4.19: Contrarian Profits from a Sample of 25 Survivor REITs
June 1973-November 1989

Lag k	$E[\phi(k)]^a$ (z)	$\hat{C}_k^a$ (z)	%	$\hat{O}_k^a$ (z)	%	$\sigma_\mu^{2\ a}$	%
1	12.26**	2.43	19.82	10.04	81.89	0.23	-1.88
	(3.238)	(0.530)		(1.326)			
2	7.49*	-0.81	-10.82	8.53	113.90	0.23	-0.031
	(2.224)	(-0.265)		(1.981)			
3	0.64	-1.34	-209.38	2.21	344.84	0.23	-35.94
	(0.279)	(-0.426)		(0.536)			
4	-0.31	3.29	–	-3.37	–	0.23	–
	(-0.137)	(0.998)		(-0.779)			
5	-2.28	0.94	–	-2.97	–	0.23	–
	(-0.994)	(0.211)		(-0.558)			
6	2.07	0.80	38.65	1.49	71.98	0.23	-11.11
	(0.835)	(0.446)		(0.612)			
7	-1.69	-1.39	–	-0.04	–	0.23	–
	(-0.332)	(-0.414)		(-0.010)			
8	1.21	0.18	14.88	1.25	103.31	0.23	-19.01
	(0.483)	(0.083)		(0.355)			
9	-4.77	-2.51	–	-1.90	–	0.23	–
	(-0.585)	(-0.644)		(-0.308)			
10	-1.63	0.80	–	-2.15	–	0.23	–
	(-0.815)	(0.376)		(-0.827)			
11	0.58	2.73	470.69	-1.94	-334.43	0.23	-39.66
	(0.170)	(0.648)		(-0.311)			
12	-3.78	7.51 *	–	-10.90*	–	0.23	–
	(-1.910)	(2.086)		(-2.434)			

Notes:

a. $E[\phi(k)]$ is the total expected profit. $\hat{C}_k$, $\hat{O}_k$, and σ_μ^2 denote the expected profits contributed by the cross-autocovariance, the autocovariance, and the cross-sectional variance of the mean returns respectively. Expected profits and their components are multiplied by 10,000. Please refer to equation (4.30) for more details.

b. – Not computed when the expected profits are negative.

c. * and ** indicate significance at the 0.05 and 0.01 significance levels.

d. The average total investment is around $31.1 * 10^{-3}$, with standard deviations about $15.7 * 10^{-3}$.

not the cross-autocovariances between the returns on different REITs. For instance, the autocovariances in individual REIT returns contribute 82% of the expected profits, compared to about 20% from the cross-autocovariances of individual REIT returns.

These small cross-autocorrelations may be explained by the homogeneity of the survivor REIT sample. Most of the survivor REITs are large. They are traded frequently on either the NYSE or the ASE. [22] Since the cross-autocorrelations arise mainly from the differences in trading frequencies, the homogeneity of the survivor sample may thus result in small cross-autocorrelations.

Furthermore, neither the first-order autocorrelation nor the first-order cross-autocorrelation of the REIT returns are statistically significant. This is reflected by the insignificant overreaction element and the cross-autocovariance element in expected profits. In other words, I fail to reject the random walk hypothesis in favor of either the market overreaction hypothesis or the cross-autocovariance hypothesis for the survivor sample.

This finding is robust for all REIT stocks. The survivor REITs are more frequently traded than the average REITs. Therefore, their prices are more likely to overreact to shocks than are the prices for ordinary REITs. It is unlikely that the prices of other REIT stocks would overreact if the prices of these survivor REITs did not.

The significant sum and insignificant components raise the possibility of a negative correlation between the two components. Because they co-vary

[22]Twenty out of the 25 survivor REITs included in this sample are listed on either the NYSE or the ASE.

Table 4.20: Correlation Coefficients Between $\tilde{C}_k$ *and* $\tilde{O}_k$

Lag	Correlation Coefficients
1	-0.928**
2	-0.851**
3	-0.778**

Note: ** indicates significance at the 0.01 significance level.

negatively, the variance of their sum is less than the sum of their variances. Table 4.20 summarizes the correlation coefficients between $\tilde{C}_k$ *and* $\tilde{O}_k$. It is obvious that the two components are indeed negatively correlated.

In summary, there is no evidence of significant overreaction in the REIT market. The cross-autocorrelation does not appear to be significant either. However, this may be a result of the homogeneity of the survivor sample. The expected profits from the contrarian strategies are found to be positive and statistically significant. However, the economic significance of these contrarian profits can be determined only when I introduce more realistic assumptions on transaction costs.

Fads

Market inefficiency may also arise because REIT prices deviate persistently from their fundamental values over a long period of time. If this is true, the returns on REIT stocks should exhibit significant long-term mean reversion.

Table 4.21 reports the slopes and adjusted R^2s from the first-order autoregressive functions for five different holding period returns on an equally-weighted portfolio of 25 survivor REITs. Because of the limit imposed by the number of observations,[23] I compute the first-order autocorrelation coefficients for holding period returns up to five years. Holding period returns are calculated as the compounded monthly returns over the selected holding periods. White's heteroscedasticity-consistent variance-covariance matrices are used in estimation, to assure that the estimators will be robust to heteroscedasticity. They can be used to draw conventional inferences.

The test results suggest that REIT prices exhibit a tendency of long-term mean reversion. For instance, the βs for the four-year and five-year holding-period returns are negative and significant at all conventional significance levels. The first five-year holding period returns can explain up to 46% of the variance of the returns in the subsequent five-year holding period. However, REIT returns exhibit no mean reversion in holding periods that are three years or shorter. In contrast, the one-year holding-period returns for REITs are positively correlated.

It is interesting to note that, as the length of the holding period increases, β approaches -0.5, the limit for the β coefficient when REIT prices follow a pure stationary process. For instance, the β coefficient is -0.412 for the five-year holding period. If the price process for REITs is the sum of a random walk process and a stationary process, my findings suggest that the latter

[23]The loss in degrees of freedom equals 2 times the number of cases in each holding period. For instance, for a five-year holding period, the loss in degrees of freedom is 120 observations.

may dominate the former by a significant margin for long holding-period returns.[24]

It is difficult to interpret the seemingly obvious long-term mean reversion, however. There are two problems. The first is an econometric problem. Many econometricians, such as Richardson and Stock [69], have demonstrated that poor performance of the asymptotic theory in a finite sample can contribute to mean reversion. In particular, since the small sample distribution of White's t-statistics has a fatter left tail than the standard normal distribution, the use of the asymptotic distribution may lead to excessive rejection of the random walk hypothesis [39, p. 1432]. In my tests, this argument may be irrelevant since the asymptotic t-statistics (-5.49 and -11.07) are sufficiently smaller than the critical t value (-1.96) in both the four-year and the five-year holding periods. It is implausible that the long-term mean reversion is merely a result of the bias associated with asymptotic distribution.

Second, it is not clear whether the mean-reversion in REIT returns is the result of a long-term transitory component in REIT prices or of the booms and busts in the REIT history. The REIT market is characterized by drastic booms and busts. For instance, the boom in the early 1970s sent the share prices of REITs up through the roof and total REIT assets rose by more than 2,000% during the 1968-1973 period [33, pp. 18–22]. The boom was immediately followed by a bust–the average REIT industry price index lost

[24]As the length of the holding period increases, the random walk process pushes the β to zero while the stationary process pushes it to -0.5. That the e $\beta = -0.412$ for the five-year holding period returns certainly demonstrates the strength of the stationary process relative to the random walk process.

more than 68% of its value between the beginning of 1973 and the end of 1975 [63, p. 10] and more than half of the existing REITs went bankrupt between 1973 and 1976. This pattern of overvaluation and undervaluation was repeated in the 1980s. These booms and busts can certainly result in ex post negative first-order autocorrelation of long holding period returns, as I saw in my test results. But the booms and busts in the REIT industry are not necessarily predictable, ex ante: the mean reversion in the REIT prices might just be historical coincidence. Since I knew that REITs have experienced several booms and busts before I conducted my test, my finding of the long-term mean reversion in REIT returns may be biased because of non-random sample selection. Thus, the ex post mean-reversion does not necessarily imply that REIT returns are predictable, ex ante. Consequently, I do not have sufficient evidence to reject the random walk hypothesis in favor of the fad hypothesis.

Table 4.21: Slope Coefficients from the First-Order Autoregressive Functions

$$\tilde{R}_{t,t+\tau} = \alpha + \beta \tilde{R}_{t-\tau,t} + \tilde{\delta}_t^a$$

Holding Periods (years)	β (t statistics)	R^2
1	0.20** (2.93)	0.03
2	0.14 (1.68)	0.01
3	-0.10 (-1.77)	0.01
4	-0.25** (-5.49)	0.15
5	-0.41** (-11.07)	0.46

Notes:
a. $\tilde{R}_{t,t+\tau}$ and $\tilde{R}_{t-\tau,t}$ denote the holding-period returns for periods t to $t+\tau$ and $t-\tau$ to t. The equation is estimated using White's [92] heteroscedasticity-consistent estimators. The parameters estimated are therefore robust to heteroscedasticity.
b. ** indicates significance at the 0.01 significance level.

4.5 Summary and Conclusion

This chapter addresses two specific questions regarding the random walk hypothesis as applied to REIT stock prices. First, is the random walk hypothesis a good approximation for the REIT price process? Second, if REIT prices do not follow a random walk, what are the appropriate alternatives that best characterize the REIT price process? The random walk hypothesis has been tested jointly with the assumption of constant expected returns. Possible type I errors from variable expected returns and from the choice of holding period have also been investigated. Finally, I have examined four alternative price processes that may cause market prices to deviate from the rational valuation.

The random walk hypothesis is rejected for the January 1970–December 1989 period. The rejection is not attributed to variable expected returns, heteroscedasticity, and the choice of holding period. Inefficiency in the REIT market arises mainly because of the January effect and the underreaction of small REIT investors.

The findings in this chapter indicate that the January effect exists in the REIT market. The expected returns on REITs are found to be higher in January than in any other month. The positive and significant autocorrelated January returns contribute significantly to the twelfth-order autocorrelation in the returns on all eight REIT portfolios. However, the January effect is not unique to REITs. The abnormal January returns in REITs disappear after I remove the influence of the stock and bond markets. In other words, the January effect in the REIT market is a result of the January effect in the stock and bond markets.

Considerable evidence suggests that the significant autocorrelations are primarily associated with smaller REITs because the prices of smaller REITs respond sluggishly to new information. This sluggishness also leads to cross-autocovariances between the returns on smaller REITs and those on larger REITs. In other words, the first-order cross-autocorrelation matrix is asymmetric: the returns on the small REIT portfolios lag behind the returns on the medium and the large REIT portfolios. However, the reverse is not true. To my surprise, the lagged common factors can predict the returns on smaller REITs no better than the returns on larger REITs.

My findings do not support the short-term market overreaction hypothesis. Although the expected profits from the contrarian strategy that exploits short-term autocovariances and cross-autocovariances are statistically significant, the contribution from either component alone is not significant. In other words, there is no evidence that market overreaction exists in the REIT market. The positive arbitrage profits exist mainly because of the negative correlation between the profits from the autocovariance component and those from the cross-autocovariance component. Although the finding of positive and significant expected profit is inconsistent with the random walk hypothesis, I do not have sufficient evidence to reject the random walk hypothesis, since the alternative assumption on transaction costs may lead to different outcomes.

Finally, the returns on an equally-weighted portfolio of 25 survivor REITs exhibit long-term (four- and five-year) mean reversion. This is demonstrated by the negatively and significantly first-order autocorrelated four-year and five-year holding-period returns. A transitory but slowly decaying component may contribute to this long-term mean reversion in REIT prices. On the other hand, the booms and busts in the REIT history may also result in this long-term mean reversion. At this point, it is still unclear what contributes to this apparent long-term mean reversion.

In summary, I have detected sufficient evidence to question the joint hypothesis that REIT prices follow a random walk process and that the expected return is constant. Market inefficiency arises mainly because of the January effect and because of the "underreaction" that investors in smaller REITs may have to new information. Short-term market overreaction does not appear to be a significant source of market inefficiency. Long-term mean reversion of REIT returns is also detected, but its interpretation remains unclear.

The findings from this chapter have raised serious doubts about the relevance of the random walk hypothesis to the REIT market. At the same time, readers should realize that this study represents the first major effort to address this very important issue. Some puzzles, such as the structure of the autocorrelation functions after the removal of the stock and bond effects, remain unresolved. Testing the random walk hypothesis with different sample frequencies such as weekly returns and with variable expected returns will also be fertile grounds for future research. I hope that my findings will stimulate more academic interest in the important hypothesis of the efficient REIT market.

Appendix A

The Small Stock Factor and The Jensen Index

The effect of excluding the smaller stocks in the S&P portfolio when generating REIT performance estimates can be analyzed through a modified two-factor model for the Jensen Index.

If the CAPM holds, the expected rate of return for portfolio j is

$$E(\tilde{r}_j) - r_f = AM\sigma_{j,m}, \qquad \forall\, j = 1,\ \ldots,\ n. \tag{A.1}$$

where

A is the risk aversion factor,

$\sigma_{j,m}$ is the covariance between the return on portfolio j and the return on the market portfolio,

n is the number of assets or portfolios in the universe, and

M is the aggregate market value of all assets.

Assume that the universe of all assets consists of only two types of securities: large company stocks and small company stocks. In other words, $M = M_{sp} + M_{ss}$, where M_{sp} is the aggregate market value of the large company stocks as represented by the market value of the S&P portfolio, and M_{ss} is the aggregate market value of the small company stocks as represented by the small stock (SS) portfolio. Equation (A.1) can be rewritten as

$$E(\tilde{r}_j) - r_f = AM_{sp}\sigma_{j,sp} + AM_{ss}\sigma_{j,ss}, \forall\ j = 1,\ ...,\ n. \tag{A.2}$$

where

$\sigma_{j,sp}$ is the covariance between the return on portfolio j and the return on the S&P portfolio, and

$\sigma_{j,ss}$ is the covariance between the return on portfolio j and the return on the SS portfolio.

Since (A.2) holds for all securities and portfolios, applying (A.2) to the S&P portfolio and the SS portfolio gives:

$$E(\tilde{r}_{sp}) - r_f = AM_{sp}\sigma_{sp}^2 + AM_{ss}\sigma_{sp,ss}, \tag{A.3}$$

$$E(\tilde{r}_{ss}) - r_f = AM_{sp}\sigma_{ss,sp} + AM_{ss}\sigma_{ss}^2, \tag{A.4}$$

Using (A.3) and (A.4) and rewriting (A.2) gives the expression for the expected return on REIT portfolio j:

$$E(\tilde{r}_j) - r_f = \beta_{j,sp}[E(\tilde{r}_{sp}) - r_f] + \beta_{j,ss}[E(\tilde{r}_{ss}) - r_f] \tag{A.5}$$

where

$\beta_{j,sp} = \frac{\sigma_j(\rho_{j,sp} - \rho_{j,ss}\rho_{sp,ss})}{\sigma_{sp}(1-\rho_{sp,ss}^2}$ is the S&P market risk for REIT portfolio j, and

$\beta_{j,ss} = \frac{\sigma_j(\rho_{j,ss} - \rho_{j,sp}\rho_{sp,ss})}{\sigma_{ss}(1-\rho_{sp,ss}^2}$ is the small stock market risk for REIT portfolio j.

In the case that the expected return on the small stock portfolio is independent of the expected return on the S&P portfolio, that is, $\rho_{sp,ss} = 0$, the expressions for the β coefficients can be reduced to

$$\beta_{j,sp} = \frac{\sigma_j\rho_{j,sp}}{\sigma_{sp}}, \quad and$$

$$\beta_{j,ss} = \frac{\sigma_j\rho_{j,ss}}{\sigma_{ss}}.$$

Assume that (A.5) holds month by month. (A.5) can be generalized as

$$E(\tilde{r}_{j,t}) - r_{f,t} = \beta_{j,sp}[E(\tilde{r}_{sp,t}) - r_{f,t}] + \beta_{j,ss}[E(\tilde{r}_{ss,t}) - r_{f,t}] \tag{A.6}$$

Assume that returns on REIT portfolio j are generated by a two-factor "market model," or

$$\tilde{r}_{j,t} = E(\tilde{r}_{j,t}) + b_{j,sp}\tilde{\pi}_{sp,t} + b_{j,ss}\tilde{\pi}_{ss,t} + \tilde{e}_{j,t}, \forall\ j = 1,\ ...,\ n, \tag{A.7}$$

where $b_{j,sp} \approx \beta_{j,sp}$ and $b_{j,ss} \approx \beta_{j,ss}$ [22], $\tilde{\pi}_{sp,t},\ and\ \tilde{\pi}_{ss,t}$ are unobservable "S&P market factors" and "SS market factor" respectively, $\tilde{\pi}_{sp,t},\ \tilde{\pi}_{ss,t},\ and\ \tilde{e}_{j,t}$ are assumed to be independently and normally distributed random variables with the following properties:

$$E(\tilde{\pi}_{sp,t}) = 0 \tag{A.8}$$

$$E(\tilde{\pi}_{ss,t}) = 0 \tag{A.9}$$

$$E(\tilde{e}_{j,t}) = 0 \qquad \forall\ j = 1,\ ...,\ n \tag{A.10}$$

$$Cov(\tilde{\pi}_{sp,t}, \tilde{\pi}_{ss,t}) = 0 \tag{A.11}$$

$$Cov(\tilde{\pi}_{sp,t}, \tilde{e}_{j,t}) = 0 \qquad \forall\ j = 1,\ ...,\ n \tag{A.12}$$

$$Cov(\tilde{\pi}_{ss,t}, \tilde{e}_{j,t}) = 0 \qquad \forall\ j = 1,\ ...,\ n \tag{A.13}$$

$$Cov(\tilde{e}_{j,t}, \tilde{e}_{i,t}) = \begin{cases} 0, & j \neq i, \\ & j = 1,\ ...,n, \\ \sigma^2(\tilde{e}_j), & j = i. \end{cases} \tag{A.14}$$

The market model can also apply to the S&P portfolio and the SS portfolio. Because $Cov(\tilde{\pi}_{sp,t}, \tilde{\pi}_{ss,t}) = 0$, we have:

$$\tilde{r}_{sp,t} = E(\tilde{r}_{sp,t}) + \tilde{\pi}_{sp,t} \tag{A.15}$$

$$\tilde{r}_{ss,t} = E(\tilde{r}_{ss,t}) + \tilde{\pi}_{ss,t} \tag{A.16}$$

Substituting for $E(\tilde{r}_{sp,t})\ and\ E(\tilde{r}_{ss,t})$ in (A.6) from (A.15) and (A.16) respectively, adding $b_{j,sp}\tilde{\pi}_{sp,t} + b_{j,ss}\tilde{\pi}_{ss,t} + \tilde{e}_{j,t}$ to both sides of (A.6), and combining terms gives:

$$\tilde{r}_{j,t} - r_{f,t} = \beta_{j,S\&P}(\tilde{r}_{S\&P,t} - r_{f,t}) + \beta_{j,ss}(\tilde{r}_{ss,t} - r_{f,t}) + \tilde{e}_{j,t} \qquad \text{(A.17)}$$

By relaxing the constraint that forces the regression to pass through the origin, we derive equation (2.2), the two-factor model for the Jensen Index of performance:

$$\tilde{r}_{j,t} - r_{f,t} = \alpha_j + \beta_{j,S\&P}(\tilde{r}_{S\&P,t} - r_{f,t}) + \beta_{j,ss}(\tilde{r}_{ss,t} - r_{f,t}) + \tilde{\epsilon}_{j,t} \qquad (2.2)$$

where $\tilde{\epsilon}_{j,t}$ is the new random and serially independent error term with $E(\tilde{\epsilon}_{j,t}) = 0$.

The interpretation of the Jensen Indexes from the two-factor model is the same as the interpretation in equation (2.1). However, as long as the $\beta_{j,ss} \neq 0$, *and* $(\tilde{r}_{ss,t} - r_{f,t}) \neq 0$, the Jensen Indexes estimated based on the two-factor model will be different from those estimated based on (2.1). If $\beta_{j,ss} = 0$, equation (2.2) reduces to (2.1).

Appendix B

Sample Description

B.1 Equity REITs

Name of REITS	*Places Listed*	*Ticker Symbols*	*Data Range*
American Health Properties Inc	NYSE	AHE	03/87-12/89
B.B. Real Estate Inv. Corp.	ASE	BBR	09/80-12/89
Boddie-Noell Restaurant Pty	ASE	BNP	06/87-12/89
Bradley Real Estate Trust	Nasdaq	BRT	07/85-09/89
Burnham Pacific Properties	ASE	BPP	07/87-12/89
California REIT	NYSE	CT	01/81-12/89
Cedar Income Fund 1, Ltd	Nasdaq	CEDR	02/87-11/89
Central Realty Investors, Inc	Nasdaq	CMRT	02/73-12/84
Chicago Dock and Canal Trust	Nasdaq	DOCKS	12/86-11/89
CleveTrust Realty Investors *	Nasdaq	CTRIS	02/73-11/89
Connecticut General Mty& Rlty	NYSE	CGM	07/70-07/81
Dial REIT Inc	Nasdaq	DEAL	02/87-11/89
Duke Realty Investments, Inc	NYSE	DRE	04/86-07/88
EastGroup Properties *	ASE	EGP	02/73-12/89
Eastover Corp.*	Nasdaq	EAST	05/73-02/83
			01/84-11/89

EQK Realty Investment Trust	NYSE	EKR	04/85-12/89
Federal Realty Inv. Trust	NYSE	FRT	07/75-12/89
First Fidelity Inv. Trust	Nasdaq	FFITS	02/73-10/78
Florida Gulf Realty Trust	Nasdaq	FGLF	07/73-85/11
General Growth Properties	NYSE	GGP	04/73-08/85
General Real Estate Shares	Nasdaq	GREL	02/73-06/74
			01/76-11/89
Golden Corral Realty Corp	Nasdaq	GCRA	12/84-11/89
Health Care REIT, Inc	ASE	HCN	03/84-12/89
HMG Property Investors, Inc*	ASE	HMG	10/72-12/89
Hollywood Park Realty Enter.*	Nasdaq	HTRFZ	02/73-11/89
Hotel Investors Trust *	NYSE	HOT	06/72-12/89
HRE Properties *	NYSE	HRE	06/70-12/89
ICM Realty	ASE	ICM	02/85-12/89
International Income Pty, Inc	ASE	IIP	07/84-12/89
IRT Property Company	NYSE	IRT	01/70-08/73
Kavanau Real Estate Trust	ASE	KAV	01/70-04/76
Koger Properties Inc	ASE	KOG	01/80-12/89
Linpro Specified Pty Trust	ASE	LPO	08/86-12/89
Meditrust	Nasdaq	MT	12/85-05/87
MSA Realty Corp.	ASE	SSS	11/84-12/89
New Plan Realty Trust	NYSE	NPR	04/79-12/89
Nooney Realty Trust	Nasdaq	NRTI	12/85-11/89
One Liberty Properties	ASE	OLP	11/86-12/89
Pennsylvania REIT*	ASE	PEI	07/70-12/89
Pittsburgh W. Virginia Rail.*	ASE	PW	01/70-12/89
Property Capital Trust*	ASE	PCL	10/72-12/89
Property Trust of American *	Nasdaq	PTR	03/73-03/89
Prudential Realty Corporation	NYSE	PRT	11/85-12/89
REIT of America	ASE	REI	01/70-09/83
Santa Anita Realty Enter.,Inc	NYSE	SAR	06/81-12/89
Saul B.F. REIT	NYSE	BFS	08/73-07/88
Sierra Real Est. Ety Trust'83	Nasdaq	SETBS	07/85-11/89
Sierra Real Est. Ety Trust'84	Nasdaq	SETC	07/85-11/89
Sierra Capital Realty Trust IV	Nasdaq	SETD	06/86-09/88
Sierra Capital Rlty Trust VII	ASE	SZG	09/88-12/89

Storage Equities, Inc	NYSE	SEQ	11/82-12/89
Summit Properties	Nasdaq	SMMTS	02/73-05/79
Terrydale Realty Trust	Nasdaq	TRYLS	06/73-12/81
Trammell Crow Real Estate Inv.	NYSE	TCR	12/85-12/89
Turner Equity Investors	ASE	TEQ	08/85-11/88
United Dominion Realty Trust	Nasdaq	ODRE	04/86-07/88
Universal Hlth Rlty Inc. Trust	NYSE	UHT	02/87-12/89
USP Real Estate Inv. Trust	Nasdaq	URT	06/78-07/88
Washington REIT *	ASE	WRE	06/71-12/89
Weingarten Realty, Inc	NYSE	WRI	09/85-12/89
Wespac Investors Trust	Nasdaq	WESP	06/77-12/82
Wespac Investors Trust II	Nasdaq	WPTR	02/84-10/87
Wetterau Properties Inc	Nasdaq	WTPR	07/87-11/89
Wisconsin REIT*	Nasdaq	WREI	02/73-11/89

* indicates that the REIT is used in the survivors-only sample.

B.2 Hybrid REITs

Name of REITS	*Places Listed*	*Ticker Symbols*	*Data Range*
American Hotels& Realty Corp	NYSE	AHR	04/83-12/89
Angeles Mortgage Inv. Trust	ASE	ANM	02/88-12/89
Arlington Realty Investors	Nasdaq	RYMN	02/73-01/88
Asset Investors Corp.	NYSE	AIC	01/87-12/89
Citizens Growth Properties	Nasdaq	CITG	02/73-06/74
			01/78-11/89
Commonwealth Realty Trust	Nasdaq	CRTY	05/74-02/88
Federated Development Co.	NYSE	FDM	07/66-02/74
1st Union Real Est. Ety& Mtg *	NYSE	FUR	06/70-12/89
Florida Investment Trust	Nasdaq	FITSS	09/73-08/75
Harris Teeter Properties, Inc	ASE	HPT	09/86-11/87
Health& Rehabilitation Pty	NYSE	HRP	01/87-12/89
HealthVest	ASE	HVT	06/86-12/89
JMB Realty Trust	Nasdaq	JMBR	01/81-11/89
Landsing Insti. Pty Trust V	Nasdaq	LANV	06/85-10/88
Landsing Insti. Pty Trust VI	Nasdaq	LANV	07/85-10/88
M&T Mortgage Investors	Nasdaq	MTMIS	02/73-08/83
Merry Land & Inv. Co., Inc	Nasdaq	MERY	09/81-11/89
MGI Properties *	NYSE	MGI	04/72-12/89
Miller, Henry S. Realty Trust	Nasdaq	HSMTS	02/73-11/82
Monetary Realty Trust	Nasdaq	MRTR	02/73-09/74
Monmouth REIT	Nasdaq	MNRT	02/73-11/89
Mony Real Estate Investors*	NYSE	MYM	11/70-12/89
REIT of California	Nasdaq	RCT	10/84-07/87
Virginia REIT	Nasdaq	VARES	02/73-01/81
Western Inv. Real Est. Trust	ASE	WIR	07/84-12/89

* indicates that the REIT is used in the survivors-only sample.

B.3 Mortgage REITs

Name of REITS	*Places Listed*	*Ticker Symbols*	*Data Range*
American Fletcher Mtg Inv.	ASE	AFM	12/70-11/77
American Realty Trust	NYSE	ARB	01/70-12/89
American Southwest Mtg Inv.	ASE	ASR	09/87-12/89
Associated Mortgage Investors	ASE	AMY	04/70-09/73
BRT Realty Trust *	ASE	BRT	06/73-12/89
BT Mortgage Investors	NYSE	BTM	04/71-05/82
Capital Mortgage Investments	Nasdaq	CMU	09/73-08/77
Cenvill Investors, Inc *	NYSE	CVI	04/73-12/89
Cenvill Development Corp	ASE	CVL	12/87-12/89
Chase Manhattan Mtg& Rlty Tr	NYSE	CMR	09/70-03/78
CI Mortgage Group	Nasdaq	CI	04/71-06/77
Columbia Real Estate Inv. Inc	ASE	CIV	03/86-12/89
Continental Illinois Realty	NYSE	CIR	11/70-06/79
Continental Illinois Mtg Inv.	NYSE	CMI	01/70-06/75
Copley Properties, Inc	ASE	COP	08/85-12/89
Countrywide Mortgage Inv. Inc	NYSE	CWM	10/85-12/89
Cousins Property Inc *	NYSE	COUS	02/73-11/89
CRI Insured Mtg Inv. II, Inc	NYSE	CII	07/86-10/89
Del-Val Financial Corp.	ASE	DVL	08/82-12/89
Emerald Mortgage Inv. Corp.	NYSE	EIC	08/88-12/89
Equitable Life Mtg& Rlty Inv	NYSE	MMT	02/71-12/82
Fidelity Mortgage Investors	NYSE	FID	12/70-12/74
Fraser Mortgage Investors	Nasdaq	FRAS	02/73-01/86
Great American Mortgage Inv	Nasdaq	GAMI	04/72-02/75
Grubb& Ellis Rlty Income Tr	Nasdaq	GRIT	06/85-11/89
Guild Mortgage Inv, Inc	ASE	GUM	07/86-05/88
IDS Realty Trust	NYSE	IDR	06/73-11/76
Independence Mortgage Trust	Nasdaq	IMTGS	02/73-11/74
Justice Mortgage Investors	Nasdaq	JMI	01/74-04/77
L&N Housing Corporation	NYSE	LHC	05/82-12/89
Lincoln N.C. Realty Fund Inc	ASE	LRF	01/86-11/89
Lomas& Nettleton Mtg Inv*	NYSE	LOM	05/72-12/89

MassMutual Mtg& Rlty Inv.	NYSE	MML	02/71-05/85
Mellon Participating Mtg Tr	Nasdaq	MPMT	04/85-11/89
Mortgage& Realty Trust*	NYSE	MRT	06/71-12/89
Mortgage Inv Plus, Inc	ASE	MIP	08/85-12/89
Murray Mortgage Investors	Nasdaq	MMTGS	08/73-05/84
North American Mortgage Inv	ASE	NAM	01/70-04/81
Northwestern Financial Corp.	Nasdaq	NWFN	02/73-11/85
N.W. Mutual Life Mtg& Rlty	NYSE	NML	08/71-10/82
Old Stone Mortgage Rlty Trust	Nasdaq	OSMRS	02/73-04/77
Presidential Rlty Corp. A*	ASE	PDL	01/70-12/89
Presidential Rlty Corp. B*	ASE	PDL	01/70-12/89
RAC Mortgage Inv. Corp.	ASE	RMR	03/88-12/89
Rainier Realty Investors	Nasdaq	RRETS	06/85-06/87
Realty Refund Trust *	NYSE	RRF	12/72-12/89
Realty South Investors	ASE	RSI	09/85-12/89
Residential Mortgage Inv. Inc	ASE	RMI	07/86-12/89
Resort Income Investors Inc	ASE	RII	11/88-12/89
Resources Pension Share 1	Nasdaq	RPSAS	01/83-11/88
Resources Pension Share 2	Nasdaq	RPSBS	01/84-11/88
Rockefeller Center Properties	NYSE	RCP	10/85-12/89
Rymac Mtg Investment Corp.	ASE	RM	10/88-12/89
Strategic Mortgage Inv,Inc	NYSE	STM	01/85-10/89
Sutro Mortgage Inv Trust	ASE	SUT	01/70-10/79
TIS Mortgage Investment Co.	NYSE	TIS	09/88-12/89
Travelers Real Estate Inv Tr	Nasdaq	TRATS	06/84-02/89
Travelers Realty Income Inv	Nasdaq	TRIIS	05/85-02/89
VMS Hotel Investment Trust	ASE	VHT	02/86-12/89
VMS Short Term Income Trust	ASE	VST	01/85-12/89
VMS Strategic Land Trust	Nasdaq	VLANS	06/87-11/89
Wachovia Realty Investments	NYSE	WRI	02/71-02/82
Wedgestone Rlty Inv Trust	ASE	WDG	11/85-12/89
Wells Fargo Mtg& Eqty Trust *	NYSE	WFM	05/72-11/89

* indicates that the REIT is used in the survivors-only sample.

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