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Real Estate Market Efficiency: Issues and Evidence

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Abstract

This paper provides a review of the studies that have examined the efficiency of the real estate market. Existing evidence suggests that real estate market segments (i.e., housing, income-property, and land markets) experience different degrees of efficiency. Short-run returns to housing (and real house price changes) are generally found to be positively autocorrelated. In addition, initial evidence suggests that long-run returns to housing may be mean-reverting. Consistent with the housing market, land price movements appear to be serially dependent. Income property markets are reported to be more efficient than the housing market but less efficient than corporate security markets. Most researchers report, however, that when trading rules are examined, transaction costs typically prohibit investors from exploiting the predictable price movements in any of the market segments. Finally, many of the studies report that their findings are preliminary and indicate the need for additional work. (*JEL* G14, *JREL* 410)

Real estate assets represent a substantial portion of the nation's wealth.[1] Changes in real estate values, anticipated or unanticipated, can dramatically influence both national and local economies. The assets of many companies (e.g., financial institutions, insurance companies, and manufacturing firms) include considerable amounts of real estate-related securities or directly-held real estate. Moreover, the largest portion of an individual's investment portfolio is often the leveraged-equity position in his or her home.[2] Consequently, understanding the degree of efficiency within the various segments of the real estate market is important to investors (corporate and individual), lending institutions, homeowners, and policymakers.

Historically, the real estate market has been casually claimed to be highly inefficient—an assertion commonly supported in the past by anecdotal evidence.[3] It is well known, however, that many of the models applied to analyze the market are predicated on the efficient markets paradigm. Still, until recently, rigorous testing of the efficient markets hypothesis (EMH) was largely confined to corporate security markets. The paucity of studies on the efficiency of the real estate market in the past can be generally attributed to a lack of adequate data. However, early studies may have been limited in part because, as Gau (1987) states, "[M]any researchers and most participants in real estate markets would consider the idea of an efficient real estate market to be a paradox—a statement that is seemingly contradictory and opposed to common sense" (p. 2).

Today, examining the efficiency of the real estate market stands as a demanding and important line of research. In addition to the issue of general economic welfare, understanding

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the relative efficiencies of real estate market segments is important to the development of economic theory and its application to the real estate market. It is fundamental to advancing areas such as valuation theory, investment theory, and urban economics.

The purpose of this paper is to provide a synthesis of the literature that examines the efficiency of the real estate market. Section 1 discusses the fundamental definitions of the EMH and, in particular, the importance of the martingale model. Papers by Samuelson (1965, 1973), Fama (1970, 1991), and LeRoy (1989) constitute the basis of this discussion. In Section 2 the unique characteristics of the real estate market are identified. Differences between financial assets and real estate assets, and the implications of these differences on the efficiency of the real estate market, are discussed. Empirical studies that *directly* test and report results on the efficiency of different segments of the real estate market are reviewed in Section 3. Approximately sixty papers are identified that meet this criterion.[4] It is important to note that a large body of related studies that examine both historical real estate asset returns and return volatility (or risk) have been well documented and are not reviewed here.[5] In addition, empirical studies that rely heavily on the efficient markets assumption, but do not directly test the assumption, have not been included.[6] Finally, Section 4 provides a summary of the findings and some concluding suggestions for future research.

1. An overview of the efficient markets hypothesis

The concept of efficiency is central to understanding both the positive and normative economics of a market. Economists commonly describe efficiency as the allocation of resources such that no reallocation can occur that increases the utility of some without decreasing the utility of others. A new allocation of goods or services in an economy is said to be "Pareto-preferred" if all economic agents are at least as well off or better off than under the prior allocation.[7] Thus, efficiency is a relative, not absolute, concept.

The financial economics literature identifies three distinct but interrelated types of efficiencies: informational, allocational, and operational. The focus of this study is on *informational* efficiency.[8] (Unless otherwise noted, the terms *efficient* and *efficiency* refer to informational efficiencies from this point forward.) An efficient market, as described by Fama (1970), implies that all market prices fully and instantaneously reflect all relevant information. Grossman and Stiglitz (1980) show that for markets to be fully efficient there must be no costs associated with obtaining information or executing trades. Consistent with Jensen (1978) and LeRoy (1989), Fama (1991) presents a more practical definition. Fama suggests that in an efficient market "prices reflect information to the point where the marginal benefits of acting on information (the profits to be made) do not exceed the marginal costs" (p. 1575).

If prices reflect all information, then asset markets will allocate scarce resources and funds to their most productive use. In such a market, prices serve as an accurate signal for the current allocation of scarce capital. Funds flow to the most productive investments—those yielding the highest marginal risk-adjusted return. Hence, Fama (1970) argues that the informational efficiency of financial markets is necessary to achieve allocational efficiency.[9]

The theory of efficient markets is an application of the zero-profits theorem that has been well established in economics. It posits that if market participants compete for information, then current asset prices will rapidly adjust, through trading, to new information and leave no room for persistent profits on the basis of the information. Arbitrage activity and rational expectations represent the primary investment concepts necessary to support the EMH—they insure that new relevant information is quickly embedded into current prices.[10] If new information arrives randomly, then the current price of an asset is an unbiased predictor of the future value of that asset.

1.1. The martingale model and the efficient markets hypothesis

The EMH is often formally defined and tested using the martingale model—an application of the fair-game model. A stochastic process, x_t, is termed a martingale with respect to the sequence of information sets, Φ_t, if

$$E_t(x_{t+1} | \Phi_t) = x_t, \tag{1}$$

where E_t denotes the expectations operator conditional on the information set Φ_t available at time t. This indicates that the best forecast of x_{t+1} is x_t, given the relevant information set, Φ_t (note that x_t is assumed to be in Φ_t). If $E_t(x_{t+1} | \Phi_t) > x_t$ holds then (1) becomes a submartingale. (For convenience, the notation $E_t(*)$ is used hereafter to denote $E_t(* | \Phi_t)$.)

A stochastic process, y_t, is considered a fair game if

$$E_t(y_{t+1}) = 0 \tag{2}$$

where $E_t(y_{t+1}) = E_t(x_{t+1}) - x_t$. Thus, x_t is a martingale if and only if $y_{t+1} = x_{t+1} \pm x_t$ is a fair game. Returns on assets are considered a fair game if the present value of a series of prices (plus any dividends) is a martingale.[11] For interested readers, a more detailed mathematical exposition of the martingale model that includes reinvested dividends has been provided in the Appendix of this paper.

Samuelson (1965) proved that a sequence of asset prices, P_t, is a martingale with respect to a sequence of information sets, Φ_t, if investors are assumed to 1) be risk-neutral, 2) have common and constant-time preferences, and 3) have common expectations probabilities. The martingale characterization of efficiency implies that the market is in equilibrium and that investors cannot consistently earn above-normal returns on investments based of any information set, Φ_t. Samuelson's work is regarded as perhaps the most important contribution to the study of the EMH because it "put the theory of efficient capital markets on a firm footing for the first time" (LeRoy, 1989, p. 1590).

1.2. Different forms of efficiency and Fama's contribution

Fama (1970) defines three forms of efficiency: strong-form, semistrong-form, and weak-form, where each form is based on a different notion of exactly what type of information is contained in the relevant information set, Φ_t. *Strong-form efficiency* states that investors cannot consistently earn above-normal risk-adjusted returns using any or all information, whether private or public. This, of course, is highly restrictive, suggesting that even insider information is reflected in current prices. Grossman and Stiglitz (1980) have shown that such efficiency is impossible since costless information is both a sufficient and necessary condition in order for prices to fully reflect all available information. When information is costly, as in both financial and real estate markets, prices cannot reflect all information since those who incur costs gathering it would not be fully compensated. However, weaker forms of efficiency are not precluded by the existence of costly information. Investors acquiring costly information in such environments could be fairly compensated with returns commensurate with the cost of the information acquired.[12]

The information subset relevant for *semistrong-form* efficiency consists of all available public information. This includes newly released information such as government economic statistics, investment advisory data, or information in newspapers or news services. For *weak-form efficiency* the information set is further partitioned to include only publicly available data on past prices and returns. Hence, by definition, weak-form efficient markets

indicate that investors cannot construct investment strategies based on past price or return information that consistently yield above-normal risk-adjusted returns. Weak-form efficiency is a necessary condition for both strong- and semistrong-form efficiencies.

Fama further suggests that a submartingale model with respect to prices, $E_t(P_{t+1}) > P_t$, may describe an efficient market, such that

$$E_t(r_{t+1}) > 0, \tag{3}$$

where r_{t+t} denotes asset returns in period $t + 1$. Fama notes that if

$$\epsilon_{t+1} = r_{t+1} - E_t(r_{t+1}) \tag{4}$$

and

$$E(\epsilon_{t+1}) = E[r_{t+1} - E_t(r_{t+1})] = 0, \tag{5}$$

then no trading rule can outperform the buy-and-hold strategy if all available information, Φ_t, is used by the market in pricing assets.[13] Equation 5 assumes, of course, that the market is rational and that returns are risk-adjusted (or that intertemporal changes in risk are random).

Conventional weak-form tests of efficiency evaluate the stochastic characteristics of the relevant return series and typically take the form of 1) tests of autocorrelation, 2) runs tests, or 3) trading strategies. Findings of autocorrelated returns indicate that historical returns may be used to predict future returns. It should be noted, however, that serial dependence of one-period returns is not inconsistent with the fair-game model—the conditional expected return can depend on the observed return in t. Empirical tests of efficiency therefore require either independence in the successive return estimates or an examination of trading rules. To fully reject the hypothesis of weak-form efficiency requires the identification of trading strategies, which account for transaction costs, that can exploit any serial dependence and consistently earn above-normal returns. More recently tests of efficiency that use other economic data to predict market prices movements have also been applied.

Tests of semistrong-form efficiency most often take the form of event studies. These studies evaluate if new relevant information is immediately and fully capitalized in contemporaneous asset prices. Finally, tests of strong-form efficiency examine the ability of "informed" investors, acting on private information, to consistently earn excess returns.

Unfortunately, the EMH is not by itself testable. Any test of market efficiency is a joint test with some market equilibrium model. While conducting tests of the EMH, constructed actual returns and expected equilibrium return models are typically employed. If a component of either the *ex post* return or the expected return model is misspecified, the test may yield spurious results. Thus, the equilibrium model is implicitly tested, as well as the EMH. Because of this, definitive measures of the degree of efficiency of a market are likely to remain impossible. Still, we concur with the view of Fama (1991); tests of the EMH should be judged on how they improve our ability to describe the time-series and cross-sectional behavior of prices and returns.

1.3. Current status of the efficient markets hypothesis

The empirical results on the EMH of security markets are mixed. Early empirical studies of 1960s and 1970s provide strong support for the hypothesis. Recent studies employing new empirical models, however, question the validity of the earlier findings and provide

evidence that markets may not be efficient.[14] Motivated by developing empirical models free from the jointness problem of the CAPM, LeRoy and Porter (1981) and Shiller (1979, 1981a, 1981b) developed so-called variance-bounds tests.[15] They report that data from financial markets violated the variance-bounds relationships—a strong piece of evidence against the EMH. In addition, a consistently reported finding is that long-run returns to securities exhibit mean-reverting tendencies (see Cutler, Poterba, and Summers, 1990; and Poterba and Summers, 1988; among others).

A major theme in the current literature on the EMH of security markets is that investors' sentiments (i.e., market psychology or fads) play an important role in the pricing of assets. Many researchers suggest that recent alternative behavioral models to rationality, as developed in cognitive psychology, should be incorporated into the financial models and analyses in order to obtain more realistic results (see Arrow, 1982; DeBondt and Thaler, 1985, 1987; Shiller, 1984, 1986, 1990; Shefrin and Statman, 1985.

Some researchers, however, defend the rationality principle (which underlies the martingale model) and argue that the present value relationship is not called into question by the new evidence. These researchers have formulated three approaches. The first approach attributes the new findings to "rational bubbles" (Blanchard and Watson, 1982). The second approach modifies the EMH by suggesting that investors would immediately discount the value of the firm below the fundamental or intrinsic value in the face of uncertainty and that the prices would adjust gradually to their equilibrium level as uncertainty surrounding the firm is resolved (Brown *et al.*, 1988, 1989). The third approach argues that risk may be shifting over time and therefore the findings of excess volatility based on a constant discount rate are not incompatible with EMH and rationality (Merton, 1987; Cochrane, 1991; Fama, 1991).

As the above discussion demonstrates, the current status of the EMH can be summarized as full of controversy and awaiting for a theory capable of explaining the new evidence while providing a consistent framework for the early results. The fact that there is disagreement on the evidence of the efficiency of markets and on whether rationality should still be the dominating paradigm of financial models fuels the need for further studies to better understand how markets operate.

2. Real estate market efficiency

In real estate markets, information efficiency implies that the distribution of market prices accurately reflects the spectrum of characteristics and risks associated with each asset. In other words, any errors associated with pricing real estate assets are random. As in financial markets, if the real estate market is efficient, the distribution of prices is useful for directing investment (or consumption) decisions: firms and individuals will choose to invest in (or consume) optimal amounts of real estate, under a given regulatory environment.[16]

Grossman and Stiglitz (1976), in reference to capital markets, have suggested that in the efficient market it is the activity of informed individuals that serves to set prices for the entire market. The market prices aggregate information so that all participants (both informed and uninformed) become informed by observing prices. If real estate properties wtihin a market are viewed as substitutes, then "the result of this process, which is the competitive process, is an arraying of all the sites in a hierarchy of land values" (Ratcliff, 1949, p. 366). Individual property value movements are not purely idiosyncratic. Under this condition, it is plausible that the activity of informed individuals in the real estate market influences the prices of substitute properties. While it is recognized that real estate market participants are not price-takers, findings of market efficiency strengthen the notion that informed individuals substantially influence market prices.[17]

As mentioned previously, the real estate market has been historically perceived to be highly inefficient—investors have claimed to be able to consistently earn abnormal returns. Empirical work reporting above-normal returns to real estate is often cited as evidence of real estate market inefficiency. For example, Wendt and Wong (1965), Coyne, Goulet, and Piconni (1980), Kaplan (1985), as well as others, indicate that returns on nonsecuritized real estate investments have consistently outperformed alternative asset groups, such as stocks and bonds, on both a risk-adjusted and unadjusted basis. In addition, Bruggeman, Chen, and Thibodeau (1984), Miles and McCue (1984), and Hartzell, Hekman, and Miles (1987) report that returns on risk-adjusted commingled real estate funds dominate stock and bond returns. In contrast, Ibbotson and Siegel (1984) indicate returns, unadjusted for risk, on direct real estate investments fall between those of stocks and bonds, while Glascock (1991) finds no evidence of excess returns in a sample of REITs analyzed for the period 1977–1986.

Real estate market inefficiency has been asserted to be a consequence of substantial transaction and information costs. These costs result from a market distinguished by highly heterogeneous products cleared through a negotiated, rather than an auction, pricing process. It is difficult, therefore, for investors to identify and take advantage of opportunities which would serve to correct market prices. However, the existence of transaction and information costs is not sufficient to preclude market efficiency (Fama, 1970).

Other real estate market imperfections such as barriers to entry, indivisible assets, and limited liquidity have also been suggested as potential sources of market inefficiency.[18] It is important, though, to distinguish between perfect markets and efficient markets. Of the two concepts, market efficiency is much less restrictive. For example, it does not require markets to be frictionless, assets to be infinitely divisible, or assets to be mobile. It simply requires that market imperfections be fully and rationally reflected in the market price. Given this, there is reason to suspect that real estate markets may be efficient. This is the position Gau (1987) takes in his presidential address to the American Real Estate and Urban Economics Association.

There is some disagreement, however, about the influence that some imperfections may have on the efficiency of the real estate market. For example, Clapp (1988) takes the position that space is heterogeneous, and therefore indivisibilities should matter. Clapp argues that relocation costs and limited spatial information would lead to thin markets (i.e., few buyers and sellers) and inefficiencies.[19]

While real estate market characteristics are not consistent with the characteristics of a perfect market, the weaker conditions required for market efficiency allow for tests of the EMH to be applied. It is important to note, however, that real estate market imperfections may affect the specification of the market equilibrium model. This suggests that tests of real estate market efficiency may be strongly affected by the joint-test condition.

3. Tests of real estate market efficiency

The efficiencies of the following three segments of the real estate market are examined in this section: 1) housing, 2) income-property, and 3) urban and rural land. The single-family housing market, where the largest number of efficiency tests have been conducted, is initially discussed. Subsequent tests involving the income-property market and the land markets are then reviewed. In addition, a limited number of studies have looked at the efficiency of the market for securitized real estate assets. Because a full examination of the securitized market (debt and equity) requires an analysis of how well securitized returns reflect their underlying assets, this segment is considered beyond the scope of this review. However, a short comment, listing the most relevant studies, has been provided at the end of this section for interested readers.

3.1. The market for single-family housing

Studies of the housing market, which implicitly assume that the market is efficient, have been conducted for many years; however, formal tests of the efficiency of the housing market appear in the research literature within only the last ten years. Among the first tests of the EMH were studies by Hamilton and Schwab (1985) and Linneman (1986). Their studies relied primarily on cross-sectional data from the mid-1970s. As time-series transaction data became more readily available, tests typically applied to examine the efficiency of capital markets have been adapted to the housing market (e.g., tests of autocorrelation, runs tests, trading rules, and event studies). More recently, tests which explicitly include the unique spatial characteristics of real estate markets have been integrated into the analyses.

When compared to other real estate market segments, empirical tests of the efficiency of the single-family housing market are marked by an additional difficulty. Unlike other real estate assets, single-family housing is viewed as both an investment and a consumption good. If housing consumption preferences are time-varying, tests of the EMH may be incorrectly applied. It is widely recognized, however, that many home buyers consider housing to be a major investment and price it with respect to its investment characteristics. In doing so, buyers consider both the expected implicit rental stream and the expected future value of the home. While the dynamics of this process are poorly understood, these buyers form "subjective" estimates of the value. The price is formed as the present value of the expected after-tax "cash flows." Application of investment-motivated housing models are widely applied in the literature.[20]

An overview of the studies that *directly* test the efficiency of the single-family housing market is provided below. Section 3.1.1 discusses conventional tests of weak-form efficiency. These studies look at the ability to predict real house price changes (and returns) using historical price information. Recent studies that further examine the predictability of house price trends using other forecasting variables and studies citing evidence of speculative house price "bubbles" and are discussed in Section 3.1.2. Finally, Section 3.1.3 focuses on tests of semistrong-form efficiency. Table 1 provides a chronological listing of these studies.

3.1.1. Return predictability: conventional tests of weak-form efficiency. One of the first analyses of the efficiency of the housing market is a related study by Hamilton and Schwab (1985). They examine whether households use all available information in forming their expectations of future house price changes. Hamilton and Schwab report that during the period from 1974 to 1976 households systematically failed to incorporate past appreciation information in forming their expectations of future house price appreciation, $E_t(P_{t+1}) - P_t$. They indicate that households do not use all available information in forming future price expectations; thus, they reject a rational expectations hypothesis.

Guntermann and Smith (1987) extend the Hamilton and Schwab study by including data from 1968 to 1982. They argue that the results of Hamilton and Schwab are not robust when the tests are extended to include a longer time period. Using FHA-based house price data for 57 metropolitan areas, Guntermann and Smith analyze the patterns of autocorrelation in the unanticipated aggregate annual returns to housing.[21] They report no relationship in the unanticipated returns for lags of one-to-three years and a weak negative relationship in returns for lags of four-to-ten years. A trading rule, based on ranked decile groupings of annual returns for the metropolitan areas, did not outperform a buy-and-hold strategy after transactions costs were considered. Hence, Guntermann and Smith do not reject the hypothesis of a weak-form efficient housing market.

While Guntermann and Smith's approach is elegant and their findings interesting, the applicability of their study is limited. They employ a market portfolio approach to test for

Table 1. Efficient market studies of the single-family housing market (listed in chronological order).

Study	Test Market (Period)	Data Source Index or Model Type	Major Findings
Hamilton and Schwab, 1985, "Expected Appreciation in Urban Housing Markets," *Journal of Urban Economics*.	U.S. (49 MSAs), (1974–1976)	Annual Housing Survey. Cross-section model using the average sale price of existing homes insured under the FHA 203(b) program.	Reports that households failed to accurately incorporate past house appreciation into their expectations of future house appreciation.
Case, 1986, "The Market for Single-Family Homes in the Boston Area," *New England Economic Review.*	Boston, MA, (1978–1985)	Local official records (1,514 obs.). Quarterly repeat-sales index.	Finds evidence of a dramatic speculative house price "bubble" at the end of the study period.
Linneman, 1986, "An Empirical Test of the Efficiency of the Housing Market," *Journal of Urban Economics*.	Philadelphia, PA, (1975–1978)	Annual Housing Survey (3,862 obs.). Cross-section model.	While public information about housing units sold revealed relevant information that could be used to achieve above normal appreciation, the abnormal returns did not exceed the transaction costs; hence, a profitable trading rule could not be constructed.
Guntermann and Smith, 1987, "Efficiency of the Market for Residential Real Estate," *Land Economics*.	U.S. (57 MSAs), (1967–1982)	FHA Section 203(b) transaction data. Average annual price per square foot for each market.	Finds no relationship of returns for lags of one to three years, and a weak four- to ten-year relationship. A profitable trading rule could not be constructed when transaction costs were considered.
Krashinsky and Milne, 1987, "Housing Prices in Metropolitan Toronto," *Regional Science and Urban Economics*.	Toronto, Ontario, (1970–1984)	MLS data. Average prices for homes sold listed with the multiple listing service.	Changes in real house prices are found to be correlated with past real house prices, time on the market, and past inflation rates. Expected real house prices are argued to follow an adaptive expectations process.
Rayburn, Devaney, and Evans, 1987, "A Test of Weak-Form Efficiency in Residential Real Estate Returns," *AREUEA Journal*.	Memphis, TN, (1970–1984)	Local official records (122,000 obs.). Monthly submarket indices constructed using mean price per square foot.	Seven of the ten submarkets exhibited substantial autocorrelation; however, a profitable trading rule could not be constructed for any of the submarkets when transaction costs were considered.
Skantz and Strickland, 1987, "House Prices and a Flood Event: An Empirical Investigation of Market Efficiency," *Journal of Real Estate Research*.	Houston, TX, (1977–1981)	SREA Market Data Center (183 obs.). Monthly time-series for two subdivisions.	The findings indicate that house prices did not decline immediately after a flood event; this information was already embedded in market prices. However, when flood insurance premiums increased, prices declined.

Table 1. (Continued).

Study	Test Market (Period)	Data Source Index or Model Type	Major Findings
Green, Marx, and Essayyad, 1988, "The Effect of Inter-Regional Efficiency on Appraising Single-Family Homes." *The Real Estate Appraiser and Analyst.*	U.S. (73 MSAs), (1966–1973)	FHA Section 203(b) transaction data on existing homes.	Single-family housing markets in the North Central and Northeast states are argued to be more efficient than in the West or South.
Case and Shiller, 1989, "The Efficiency of the Market for Single-Family Homes," *The American Economic Review.*	Atlanta, GA: Chicago, IL; Dallas, TX; and San Francisco, CA, (1970–1986)	SREA Market Data Center (approx. 10,000 obs. per market). Quarterly repeat-sales index.	Reports significant first-order autocorrelation of after-tax excess returns to housing. Assuming no transaction costs, a trading rule was constructed to consistently exploit the autocorrelation in returns.
Mankiw and Weil, 1989, "The Baby Boom, The Baby Bust, and The Housing Market," *Regional Science and Urban Economics.*	U.S., (1947–1987)	Census records, fixed reproducible wealth; and the residential investment deflator relative to the GNP deflator.	Forecastable increases in the demand for housing are reported not to be anticipated by the housing market.
Case and Shiller, 1990, "Forecasting Prices and Excess Returns in the Housing Market," *The AREUEA Journal.*	See Case and Shiller (1989)	See Case and Shiller (1989)	Findings indicate that the ratio of construction costs to price, changes in population, and changes in real per capita income can be used to consistently predict subsequent house price changes.
Gatzlaff, 1990, "The Efficiency of the Single-Family Housing Market: An Empirical Study," Unpublished Ph.D. Thesis.	See Case and Shiller (1989)	See Case and Shiller (1989)	Previous findings of significant autocorrelation in excess returns to housing are not substantially altered by specifying time-varying marginal tax rates or volatility; however, they are highly influenced by inflation expectations.
Turnbull, Sirmans, and Benjamin, 1990, "Do Corporations Sell Houses for Less? A Test of Housing Market Efficiency," *Applied Economics.*	Baton Rouge, LA, (1984–1987)	Transaction data from local realtors (342 obs.).	Findings indicate that houses sold by corporate owners do not sell at a discount. The authors report that "housing markets are sufficiently efficient to maintain the 'single price' hypothesis for identical housing."
Guntermann and Norrbin, 1991, "Empirical Tests of Real Estate Market Efficiency," *Journal of Real Estate Finance and Economics.*	Lubbock, TX, (1970–1981)	MLS and transaction data maintained by local appraisers (9,340 obs.). Quarterly index using the mean price per square foot.	Evidence that markets rapidly adjust toward market equilibrium is reported. Moderate adjustment delays are explained by the existence of large transaction and search costs in the housing market.

Table 1. (Continued).

Study	Test Market (Period)	Data Source Index or Model Type	Major Findings
Hosios and Pesando, 1991, "Measuring Prices in Resale Housing Markets in Canada: Evidence and Implications," *Journal of Housing Economics.*	Toronto, Canada, (1974–1989)	Local official records compiled by Teela Market Surveys (52,581 obs.). Quarterly repeat-sales index.	Substantial persistence in the movement of real house prices is reported. In addition, house price movements are found to have a significant seasonal component.
Tirtiroğlu, 1991, "Information Processing by Markets and Market Efficiency, Unpublished Ph.D. Thesis.	Connecticut (19 towns), (1982–1988)	Local official records. AV index construction method.	Finds that movements in house values in one town are correlated with lagged movements in prices in a neighboring town.
Gyourko and Voith, 1992, "Local Market and National Components in House Price Appreciation," *Journal of Urban Economics.*	U.S. (56 MSAs), (1971–1989)	WEFA Group. Time-series cross-section data on the median price of existing home sales.	Reports persistence in price trends.
Meese and Wallace, 1992, "Testing the Present Value Relation for Housing Prices: Should I Leave My House in San Francisco?" Working Paper.	Alameda and San Francisco Counties, (1970–1988)	Selling prices from the California Market Data Cooperative (111,747 and 36,197 obs.). Rent index from local newspaper listings, nonparametric house price index.	Reports persistent errors between the modeled short-run present value prices of housing and the actual prices. However, long-run results are found to be consistent with the housing price present value expectations. The authors suggest that the findings are consistent with a market characterized by high transaction costs.
Tirtiroğlu, 1992, "Efficiency in Housing Markets: Temporal and Spatial Dimensions," *Journal of Housing Economics.*	See Tirtiroğlu (1991)	See Tirtiroğlu (1991)	See Tirtiroğlu (1991)
Kim and Suh, 1993, "Speculation and Price Bubbles in Korean and Japanese Real Estate Markets," *Journal of Real Estate Finance and Economics.*	Korean Housing Market, (1974–1989)	House price index compiled by the Korean Housing Bank	Evidence suggests that the relative price of housing is predictable.
Clapp, Dolde, and Tirtiroğlu, 1994, "Imperfect Information and Investor Inferences from Housing Price Dynamics," Working Paper.	San Francisco, Boston, Connecticut, and the U.S. (periods vary)	Quarterly indices obtained from previous studies.	House price changes are reported to be influenced by lagged price changes in neighboring market areas, but not in nonneighboring localities.

Table 1. (Continued).

Study	Test Market (Period)	Data Source Index or Model Type	Major Findings
Clapp and Giaccotto, 1994, "The Influence of Economic Variables on Local House Price Dynamics," *Journal of Urban Economics*.	Connecticut (4 towns), (1982–1988)	Local official records, AV index construction method.	Predictable changes in local (un)employment, population, and income are found to predict changes in local market house prices.
Clapp and Tirtiroğlu, 1994, "Positive Feedback Trading and Diffusion of Asset Price Changes: Evidence from Housing Transactions," *Journal of Economic Behavior and Organization*.	See Tirtiroğlu (1991)	See Tirtiroğlu (1991)	House price changes are found to be diffuse across markets. The pricing process is argued to be consistent with biases in human judgment and decision-making.
Tirtiroğlu and Clapp, 1994, "Spatial Barriers and Information Processing in Housing Markets: An Empirical Investigation of Effects of Connecticut River on Housing Returns," Working Paper.	Connecticut towns located along the Connecticut River, (1982–1990)	Local official records. AV index construction method.	Evidence indicates that spatial barriers (i.e., the Connecticut River) reduces the diffusion of information.
Gatzlaff, 1995, "Excess Returns, Inflation and the Efficiency of the Housing Market," *The AREUEA Journal*.	See Gatzlaff (1990)	See Gatzlaff (1990)	Findings indicate that while autocorrelated after-tax excess returns are substantially diminished when tests are restricted to allow for autocorrelated unanticipated inflation, some serial dependency remains.

house price efficiency *across* 57 U.S. metropolitan markets, rather than *within* an individual market.[22] This makes their study distinct from the others cited in this section. Even if their findings had indicated that the housing market was inefficient, it would be difficult for homeowners or investors to exploit the market failure. Investors would need to be able to hold city-indexed portfolios of housing, subject to homestead property taxes, in multiple cities. Alternatively, highly mobile homeowners could earn abnormal returns by identifying and trading houses that replicate the returns in multiple cities. It appears that it would be highly unlikely for investment groups, development firms, or individual homeowners to exploit such market inefficiencies.

In contrast, many studies have constructed house price indices for individual metropolitan markets and examined whether past changes in real house prices could be used to forecast future changes. Alternatively, some studies have estimated and examined returns to housing. These studies implicitly assume that buyers can either hold a market portfolio of housing, or can identify an individual house that replicates the market index.

Tests of autocorrelation in short-run returns to housing have been the focus of studies by Rayburn, Devaney, and Evans (1987); Green, Marx, and Esayyad (1988); Case and Shiller (1989); Gatzlaff (1990); Guntermann and Norrbin (1991); Hosios and Pesando (1991); and Gatzlaff (1995). While the test methods and the markets studied may differ, the findings are quite consistent—intertemporal short-run changes in real house prices, and returns to housing, are generally found to be positively correlated. However, most argue that housing market transaction costs are substantial and, if included, a trading rule cannot be developed that consistently yields above-normal returns.

Rayburn, Devaney, and Evans (1987), (RDE), test the efficinecy of ten residential submarkets in Memphis, Tennessee. Using 140,000 residential transactions, a monthly index of the mean selling price per square foot was constructed from 1970 to 1984 for each of the ten submarkets. Using log transformations of the time series and taking the first differences, tests of autocorrelation at various lags were performed. A limited time pattern of returns was revealed in seven of the ten submarkets.[23] RDE applied Alexander's filter rule and report that a buy-and-hold strategy could not be outperformed for the period sampled, assuming transactions costs as low as two percent. Therefore, the weak-form efficiency hypothesis could not be rejected.[24]

Green, Marx, and Essayyad (1988), (GME), report findings similar to RDE using annual FHA Section 203(b) data from 1966 through 1973 for 73 U.S. metropolitan areas. However, the findings of RDE and GME are based solely on the changes in real house prices—the dividend stream (implicit rent) to housing is not included in their housing return model. Furthermore, these studies are not based on constant-quality house price indices, and the spatial characteristics associated with the transactions are not explicitly explored.

Case and Shiller (1989) extend previous works by addressing a number of their limitations. Using actual transaction data, homes selling more than once were identified and repeat-sales indices constructed for four major metropolitan markets—Atlanta, Chicago, Dallas, and San Francisco. Case and Shiller argue that the use of repeat-sales indices is an improvement over other methods, controlling for possible systematic characteristic changes in the sample over time. Tests of autocorrelation were performed on the annual changes in real house prices and on the estimated after-tax excess housing returns. Returns to housing explicitly include an estimate of the implicit rents to housing over the time period (city-specific rental indices from the U.S. Bureau of Labor Statistics were used to estimate implicit rents for each market). Case and Shiller find that while real changes in house prices are positively correlated, they are not highly predictable. This finding is generally consistent with previous works. However, they report substantial and significant positive autocorrelation in after-tax excess returns lagged one-quarter, with the estimated coefficient on the lagged returns ranging from 0.33 to 0.71.

Case and Shiller indicate that it is possible to construct a trading rule that yields abnormal returns to home buyers who are unconstrained as to time of purchase.[25] Hence, they reject the notion of a weak-form efficient housing market. Case and Shiller suggest that the most likely reason for the apparent inefficiencies is that "predictable" real interest rates were not priced by the housing market during the study period. Given the evidence of the market's apparent rapid response to other much less obvious factors affecting house prices, it seems possible that expected real interst rates were adaptively priced during the study period, as suggested by Gatzlaff (1995).

Using a methodology similar to Case and Shiller (1989), Hosios and Pesando (1991) report similar results of first-order autocorrelation for the Toronto single-family housing market. Hosios and Pesando estimate coefficients on quarterly-lagged annual changes in real house prices to be about 0.37 and significant at a five percent level. In addition, they report evidence of a strong seasonal component in the intertemporal pattern of house prices and speculate that it may be related to northern climatic factors. These findings are consistent with the earlier findings of Krashinsky and Milne (1987), who suggest the Toronto housing market follows an adaptive pricing process. However, neither Hosios and Pesando nor Krashinsky and Milne employ trading strategies in their analyses.

Adopting the repeat-sales indices constructed by Case and Shiller, Gatzlaff (1990, 1995) examines whether their results are sensitive to alternative specifications of what a "fair" or equilibrium expected return is for single-family housing. Gatzlaff (1990) extends previous works by explicitly examining the possible impact that time-varying marginal tax rates and return volatility have on the serial dependence of after-tax excess returns. He reports the impacts to be negligible. In addition, the study restricts the efficiency test to allow for serially correlated unanticipated inflation. Gatzlaff (1995) indicates that when after-tax excess returns are adjusted to allow for autocorrelated inflationary shocks, the serial dependencies in the after-tax excess returns reported by Case and Shiller for each market are substantially diminished. He suggests that findings of highly autocorrelated after-tax excess housing returns reported by Case and Shiller are largely dependent upon the implicit assumption that treasury bills were rationally priced during the volatile inflationary period of the late 1970s and early 1980s.

Guntermann and Norrbin (1991) also look at the role of inflation in influencing the pattern of returns to housing. They employ a DYMIMIC model to explicitly control for expected inflation and examine twenty census tract areas in Lubbock, Texas from 1970 to 1981. In most of the census tracts, significant two- or three-quarter lagged correlations of real house price changes are reported. They interpret this as a relatively rapid adjustment process, given the substantial transaction and search costs in the market.

More recently, studies by Clap and Tirtiroğlu (1994), Clapp, Dolde, and Tirtiroğlu (1994), Tirtiroğlu and Clapp (1994), and Tirtiroğlu (1991, 1992) extend existing work by incorporating the spatial dimension of the real property markets into the tests of the EMH. Building upon the methodology used by Case and Shiller (1990) and estimating townwide price indices following Clapp (1990) and Clapp, Giaccotto, and Tirtiroğlu (1991), these studies show that there is spatial diffusion and inertia in house prices within the Connecticut metropolitan housing markets. Clapp and Tirtiroğlu (1994) attribute the diffusion of house prices to biases in human decison-making and judgment.

Finally, examining the pattern of long-run returns to housing represents a fertile area for future study. While house price movements are typically measured with substantial noise, evidence of positive serial correlation in short-run returns to housing combined with negative serial correlation in long-run returns provides considerable evidence of speculative pricing "bubbles" in the housing market. Negative serial correlation in long-run house returns suggests that house prices are, at times, out of equilibrium and follow a long-run mean-reversion process—consistent with a weak-form inefficient market.

The initial findings on the pattern of returns examined over longer horizons, although quite preliminary, is mixed. Guntermann and Smith (1987), for example, report significant negative serial correlation in lags of four-to-ten years in real returns to housing. In addition, Case and Shiller (1990) present evidence of moderate negative serial correlation in real house prices changes lagged two and three years using a "stacked regression" procedure. These findings are consistent with the long-run return patterns observed for other assets presented by Cutler, Poterba, and Summers (1990). Meese and Wallace (1993) also examine long-run returns. They use a house price present value model to took at the San Francisco housing market. While they report findings that are consistent with market inefficiencies in the short-run, they find the housing market to be consistent with long-run market efficiency when adjustments are made to allow for changes in tax rates and borrowing costs.

3.1.2. Return predictability: other forecasting variables and speculative "bubbles." At times, persistent price increases in regional markets appear to suggest speculative house price bubbles. In the 1980s, markets in the northeast and California experienced substantial and persistent price increases while markets in Texas declined. Case (1986) notes large reoccurring price increases in the Boston market; Gyourko and Voith (1990) indicate evidence of a "California effect," and Kim and Suh (1993) report the existence of price bubbles in the Korean housing market. Findings from these studies suggest the occurrence of trends in house prices which lack fundamental economic rationale.

Studies by Mankiw and Weil (1989), Case and Shiller (1990), and Clapp and Giacotto (1994) examine the relationship of house price trends to demographic and economic trends. In a landmark study that has attracted considerable attention in both the academic and popular press, Mankiw and Weil (1989) forecast real house prices in 2007 to decline 47 percent from 1987 levels. They suggest that real house price movements over the long-run can be largely attributed to increases in demand. They argue that the dramatic increases in real house prices in the 1970s were largely the product of increased demand brought on by the baby-boom generation and that the "fluctuations in (real house) prices caused by fluctuations in market demand do not appear to be foreseen by the market (p. 254). They conclude that the housing market probably should not be characterized as an efficient asset market in which prices reflect available information on future demand.[26]

Studies by Case and Shiller (1990) and Clapp and Giaccotto (1994) correlate house prices to currently available public economic information (e.g., construction costs, income growth, tax rates, (un)employment rates, etc.). These studies report evidence that macroeconomic variables can be used to forecast house prices, and conclude that housing markets are not consistent with the EMH.

Case and Shiller (1990) report evidence that the ratio of construction costs to house prices and real per capita income growth in one year are positively related to both excess returns and real house price changes over the subsequent year. In addition, they report that increases in the age of the population also positively affect returns to housing, consistent with Mankiw and Weil (1989). Clapp and Giaccotto, focusing on the Hartford metropolitan housing market also report strong evidence that both inflation and unemployment are highly correlated with subsequent house price movements.

3.1.3. Tests of semistrong-form efficiency. A study by Linneman (1986) represents the first formal test of semistrong-form efficiency. Using a sample of 3,776 owner-occupied residential properties in Philadelphia, owner's contemporaneous assessments of values in 1975 were regressed on nearly fifty detailed structural and neighborhood characteristics considered to be "current public information." The study examines whether undervalued houses (those with negative residuals) in 1975 increase in value over a three-year holding period

at a greater rate than other homes in the sample. The findings indicate abnormal increases to the subsequent values of the undervalued properties. However, when transaction costs are considered, assumed to be twelve percent, an insignificant number of properties are judged to be profitable arbitrage candidates. Thus, the hypothesis of a semistrong-form efficient market is not rejected.[27]

However, the property values used are the owners' contemporaneous assessments of market value. If they are assumed to be normally distributed across the "true" market value and the variance is constant between periods, it is likely that the residuals would have mean reverting tendencies. That is, properties with negative (positive) residuals would subsequently redistribute themselves toward the mean when reassessed by the owners. Consistent with Linneman's findings, undervalued properties would appear to yield excessive returns, and overvalued properties would yield less than normal (average) returns.

Only a very small number of studies conduct conventional tests of semistrong-form efficiency of the housing market (i.e., the market's reaction to new public information and events). However, studies that employ cross-sectional or time-series hedonic regression analysis find that the market is generally responsive to new information (e.g., Evans and Rayburn, 1991; Voith, 1991; Delaney and Smith, 1989; and Ford and Gilligan, 1988).[28] While many have examined the reaction of implicit house prices associated with changes in the economic, legal, or physical environment, few report how *quickly* prices respond to new information. Skantz and Strickland (1987) provide one such analysis. They examine the reaction of house prices to a major flood event and indicate that no drop in house prices occurred immediately after a flood, due to the availability of low-cost flood insurance. However, subsequent increased insurance rates were followed by immediate and significant house price declines. The results, they report, are consistent with a semistrong-form efficient market.

Measuring the speed of the housing market in pricing new information relative to other markets remains an area requiring additional work. Furthermore, research offers no insights as to how new information enters the market and is priced by individuals. For example, how do the offer and reservation prices of uninformed market participants change relative to informed buyers and sellers, and by what mechanism?

Finally, Turnbull, Sirmans, and Benjamin (1990) apply a cross-sectional model to examine if homes sold by corporations sold at a discount relative to other homes sold. They argue that selling price differences between constant-quality homes owned by corporations (relocating employees) and those owned by individuals should not exist in an efficient market. Consistent with the notion of market efficiency, they do not reject the hypothesis that corporation-sold homes and individual-sold homes sell for equivalent prices.

3.2. The market for income-producing property (nonsecuritized)

Nine studies which test the EMH of directly-held income-producing properties are identified in this section. As in the case of single-family housing, a majority of the studies employ conventional weak-form tests of efficiency by analyzing the time-patterns of returns. The initial findings suggest that the income-producing property market is more efficient than the housing market and less efficient than the capital market. However, these findings are quite preliminary. Most of the studies are largely restricted by a lack of adequate transaction-based data and precise income information. A listing of the studies is provided in Table 2.

A study by Greer (1974) represents the first formal test of the efficiency of the income-property market. Greer examines whether market "insiders" (i.e., real estate agents) were able to earn significantly higher returns than the market. He uses transaction data from 135 apartment sales recorded from January of 1968 through April of 1973. Greer's study

Table 2. Efficient market studies of the income-property market (listed in chronological order).

Study	Test Market (Period)	Data Source Index or Model Type	Major Findings
Greer, 1974, "Risk, Return, and Efficiency in the Market for Real Property," Unpublished Ph.D. Thesis.	Denver, CO, Apartment Market, (1968–1973)	Local transaction data (135 obs.).	Tests show that investors with inside information were not able to earn significantly higher risk-adjusted returns than those predicted by a market model.
Gau, 1984, "Weak Form Tests of the Efficiency of Real Estate Investment Markets," *Financial Review.*	Apartment and office submarkets in Vancouver, B.C., (1971–1980)	Local transaction data (120 obs.). Price per square foot, gross income multiplier, and price per suite indices constructed using one transaction per month.	This study reports a general absence of significant autocorrelation in returns.
Brown, (1985), "The Information Content of Property Valuations," *Journal of Valuation.*	Retail, office, and industrial properties in the UK, (1979–1982)	Returns generated using valuation and cashflow data on a monthly basis.	This study reports a lack of serial dependence in monthly, quarterly, and semi-annual returns. The hypothesis that the serial correlation coefficients were all significantly different from zero was rejected for all lags and holding periods tested.
Gau, 1985, "Public Information and Abnormal Returns to Real Estate Investment," *AREUEA Journal.*	Vancouver, B.C., Apartment market, (1971–1980)	See Gau (1984)	Findings indicate that investors were unable to earn abnormal risk-adjusted returns on the basis of new government tax policy information or interest rate movements.
Isakson and McInish, 1988, "The Efficiency of the Market for Multi-Family Housing," Unpublished Manuscript.	18 U.S. cities, Apartment markets, (1978–1983)	IREM income and expense data. Annual returns are calculated as the ratio of annual net operating income per square foot to current investment per square foot for each city.	Findings are consistent with a weak-form efficient hypothesis for lags of one year, but not consistent for lags of two or three years.
McIntosh and Henderson, 1989, "The Efficiency of the Office Properties Market," *Journal of Real Estate Finance and Economics.*	Office submarkets in Dallas-Ft. Worth, TX, (1979–1985)	Local transaction data (73 obs.). Price per square foot of rental area, gross income multiplier, and net income multiplier indices constructed using one transaction per month.	Serial correlation tests of price and return measures indicate a lack of significant autocorrelation.

Table 2. (Continued).

Study	Test Market (Period)	Data Source Index or Model Type	Major Findings
Evans, 1990, "A Transfer Function Analysis of Real Estate Capitalization Rates," *Journal of Real Estate Research*.	U.S. income property markets, (1975–1988)	American Council of Life Insurance Companies' capitalization rates for commitments on multifamily and non-residential properties.	The analysis indicates a one-quarter lag in the relationship between the stock and real estate markets, suggesting that the real estate market is slow to adjust to changes in the business cycle.
Dokko, Edelstein, Pomer, and Urdang, 1991, "Determinants of the Rate of Return for Nonresidential Real Estate: Inflation Expectations and Market Adjustment Lags," *AREUEA Journal*.	U.S. income property markets, (1975–1984)	Properties selected from six large commingled Real Estate Funds for Pension Trusts (102 obs.).	When parcel location and land use are added as explanatory variables, the coefficient of the lagged rate of return are not significantly positive. Evidence suggests that the effects of a given economic shock dissipate quickly.
Londerville, 1992, "Commercial Real Estate Market Efficiency," Working Paper.	Vancouver, B.C., Apartment market, (1971–1985)	Local official records (809 obs.). Risk adjusted Sharpe indices are calculated for portfolios as well as the total group of properties.	Tests indicate no difference in Sharpe indices constructed for individual portfolios versus the full group of properties; hence, consistent excess returns are not achievable.

is unique in that it represents a test of strong-form efficiency. He is unable to reject the hypothesis that returns to insiders are consistent with the expected market returns.

Gau (1984) examines the weak-form efficiency of both the apartment and commercial property markets located in Vancouver, British Columbia, by constructing a monthly price index for a submarket. Unfortunately, the study is limited by the small number of property transactions available. For example, standardized return indices for the income properties were constructed using a single, but different, property transaction each month. Despite its limitations, this study represents an important contribution to the area. It is generally acknowledged to be the first formal test of real estate market efficiency to be published.

Evaluating the autocorrelation functions, Gau reports serial correlation estimates to be less than two standard errors from the hypothesized value of zero. These findings are considered consistent with a weak-form efficient market hypothesis. Subsequent studies conducting additional tests of weak-form efficiency generally report findings consistent with Gau.

Brown (1985), for example, finds little evidence of serial correlation for constructed monthly, quarterly, and semiannual returns of various lags for a set of commercial properties in the UK. In addition, Isakson and McInish (1988) state that the presence of weak-form efficiency is generally supported for lags of one year; however, the hypothesis is rejected for lags of two or three years. Finally, McIntosh and Henderson (1989), using procedures similar to Gau, test the efficiency of office properties located in the Dallas-Ft. Worth metropolitan area and report results consistent with a weak-form efficient market.

In the most recent study of the weak-form efficiency of the income property market, Londerville (1992) extends the works of Gau (1984, 1985). This study uses a sample of transaction data to calculate apartment property returns in Vancouver between 1971 and 1985. Improving on previous works, Londerville applies the Sharpe index as a technique for adjusting returns to control for risk. A Sharpe index for portfolios with different size estimation errors is calculated and a test of statistical difference among the indices is performed. In addition, the adjusted returns are used to test whether a trading rule can be used to earn abnormal risk-adjusted returns. Londerville finds no significant statistical difference among the Sharpe indices; hence, the hypothesis of an efficient apartment market is not rejected.

In contrast to the previous studies listed, Evans (1990) reports results that are interpreted as inconsistent with an efficient markets hypothesis. He uses quarterly data from the American Council of Life Insurance of appraisal-based capitalization rates and finds that investors seem slow to adjust to changes in the business cycle and monetary conditions relative to stock market investors. He indicates a one-quarter lag in the relationship between the two markets. However, trading rules are not applied to examine whether this market condition can be exploited.

Tests of semistrong-form efficiency in the commercial real estate market have been severely restricted by the availability of adequate transaction data. In an extension of his work mentioned above, Gau (1985) examines the semistrong-form efficiency of the Vancouver apartment market. He reports that the market reacted quickly to changes in government tax policy and interest rate movements. Gau suggests that the general findings are consistent with the notion of a semistrong-form efficient market. Consistent with Gau, Dokko, *et al.* (1991) also report that the effects of economic events dissipate quickly and do not appear to affect real returns after location and property use differences are considered.

3.3. The market for urban and rural land

A number of studies that consider the intertemporal patterns of land price movements are summarized in Table 3. Early studies by Adams, Milgram, Green, and Mansfield (1968)

Table 3. Efficient market studies of urban and rural land markets (listed in chronological order).

Study	Test Market (Period)	Data Source Index or Model Type	Major Findings
Adams *et al.*, 1968, "Undeveloped Land Prices During Urbanization: A Micro-Empirical Study Over Time," *Review of Economics and Statistics.*	Philadelphia, PA, Urban Land Market, (1945–1962)	Local transaction data (1111 obs.). Analysis of cross-section observations pooled over time.	Authors indicate that land development trends were anticipated and rationally priced by the market.
Davies, 1977, "An Examination of the Market for Urban Single-Family Detached Lots," *Journal of Regional Science.*	London, Ontario, Urban Land Market, (1966–1973)	The Teela Digest. The montly median sale price of lots sold.	Evidence suggests that builders form expectations about future prices and costs primarily on the basis of the rate of change in the profitability of building and selling houses four months prior to the current period. The adoption of restrictive land use policies triggered an immediate and sustained increase in prices due to increased costs and uncertainty.
Burt, 1986, "Econometric Modeling of the Capitalization Formula for Farmland Prices," *American Journal of Agricultural Economics.*	Illinois Farmland, (1960–1983)	Illinois value series for high-quality grainland and data from the University of Illinois farm record program.	Suggests that farmland values are determined primarily by land rents and that values are not driven by speculative forces.
Carey, 1990, "Feeding the Fad: The Federal Land Banks, Land Market Efficiency, and the Farm Credit Crisis," Unpublished Ph.D. Thesis.	U.S. Farmland and Illinois Grain Farms, (1910–1988 and 1959–1985)	Agricultural Finance Databook; and National Financial Summary of Farm Market Developments and Agriculture Resources: Agricultural Land Values, Market Situation and Outlook Report.	This study reports large deviations in agricultural land values from market fundamentals. These deviations are attributed to market psychology and failures of the Farm Credit System.
Scott, 1990, "The Efficiency of the Office Properties Market," *Journal of Real Estate Finance and Economics.*	U.S. Farmland, (1912–1984)	USDA farmland value and income series. Average value per acre and income per acre indices are used.	Results somewhat support the notion that land prices reflect market fundamentals; however, recent price movements suggest the opposite.
Falk, 1991, "Formally Testing the Present Value Model of Farmland Prices," *American Journal of Agricultural Economics.*	Iowa Farmland, (1921–1986)	USDA farm value series (1921–1949); Iowa State University Extension Service's land value series (1950–1986).	Findings indicate that the changes in the excess returns to Iowa farmland are predictable.
Tegene and Kuchler, 1991, "A Description of Farmland Investor Expectations," *Journal of Real Estate Finance and Economics.*	Midwest Farmland, (1921–1989)	USDA. The nominal value per acre and rent per acre series are deflated by the personal consumption expenditure component of the gross national product.	The results suggest that the market follows an adaptive expectations pricing process.
Falk, 1992, "Predictable Excess Returns in Real Estate Markets: A Study of Iowa Farmland Values," Working Paper.	See Falk (1991)	See Falk (1991)	The results suggest that there exist simple profitable trading strategies available to investors in the Iowa farmland market.

and Davies (1977) examine the market information set and mechanisms which are considered in pricing land. Adams, *et al.* conduct an analysis to determine the relationship between macroeconomic variables and land assets values. They indicate that land market prices reflect changes in interest rate, construction activity, and holding cost expectations. Davies (1977) argues that developers construct their expectations of future selling prices and costs primarily on the basis of the rate of change in the profitability of building and selling houses four months prior to the current period, at the time of a commitment to the construction process. He reports evidence that suggests that the adoption of restrictive land use policies triggered immediate increases in prices due to restrictive supplies. In addition, Burt (1986) argues that farmland values are determined primarily by movements in land rents and are not driven by speculative forces. Thus, early studies suggest that both urban and rural land markets may be efficient.

Studies by Scott (1990) and Carey (1990) evaluate whether historical farmland prices have been consistent with historical market fundamentals. Scott (1990) applies a series of regression, volatility, and means tests to determine how well land prices reflect the market fundamentals. Consistent with Adams, *et al.*, Scott (1990) indicates that farm land prices generally reflect market fundamentals and there appears to be no systematic errors in valuing land assets. In contrast, Carey (1990), in examining the causes of the farm credit crisis in his doctoral dissertation, argues that deviations from fundamental land prices are the major cause of loss of equity and bankruptcy for the farmers. He uses a methodology originally developed by Campbell and Shiller (1987) to test the efficiency of the Illinois rural land market. Carey suggests that price inefficiency in the farmland market is one of the main reasons for the farm credit crisis.

Falk (1991) tests the present value relationship for farm land data by employing the volatility tests initially developed by Shiller (1979) and LeRoy and Porter (1981). His data come from the Iowa farmland market. Falk argues that his findings indicate excess volatility in the sample farmland market and a fad in farmland prices. Consistent with both Falk (1991) and Carey (1990), Tegene and Kuchler (1991) report evidence that rural land market participants' price expectations are best described by an adaptive expectations process. They report that land prices are slow to adjust to new policies and information. Finally, Falk (1992) reports that excess returns to Iowa farmland are predictable and that there appear to be profitable trading rules available to investors.

3.4. The market for real estate related securities

A limited number of studies have examined the efficiency of real estate-related securities. However, the market for REITs, RELPs, whole mortgages, mortgage-backed securities, and other real estate-related securities is generally argued to be quite different from that of direclty-held property markets. Hence, a full description and review of the market for real estate-related investments is considered to be beyond the scope of this study. For interested readers, the major studies have been listed in Table 4 and a brief summary of the findings provided below.

Studies of securitized real estate assets have focused largely on the market for REITs. These studies generally report findings that are inconsistent with the EMH. Bharat and Gupta (1992), and Liu and Mei (1992) indicate that excess returns to REITs are predictable. Extending previous work, Mei and Liu (1993) argue that trading strategies can be constructed to exploit the predictability in REIT returns. In addition, Darrat and Glascock (1989) and Scott (1990) suggest that REIT prices do not reflect contemporaneous market fundamentals. In a follow-up study Darrat and Glascock (1993) indicate that the real estate market fully and quickly prices new relevant economic information; however, they find a

Table 4. Efficient market studies of real estate-related securities markets.

Panel A: Real Estate Securities Market

Study	Test Market (Period)	Data Source Index or Model Type	Major Findings
Locke, 1986, "Real Estate Market Efficiency," *Land Development Studies*.	British and Australian Real Estate-Related Securities, (1980s)	British and Australian property indices.	Tests of autocorrelation and runs tests are found to be consistent with the EMH. In addition, the majority of the returns were found to be lognormally distributed.
Darrat and Glascock, 1989, "Real Estate Returns, Money and Fiscal Deficits: Is the Real Estate Market Efficient?" *Journal of Real Estate Finance and Economics*.	U.S. real estate-related securities, (1965–1986)	CRSP tapes, University of Chicago.	Report evidence of a significant relationship between lagged monetary policy and real estate returns; however, trading rules were not explored to determine if consistent abnormal profits were achievable.
Colwell and Park, 1990, "Seasonality and Size Effects: The Case of Real-Estate-Related Investment," *Journal of Real Estate Finance and Economics*.	28 equity REITs and 33 mortgage REITs (1964–1986)	CRSP tapes, University of Chicago.	Evidence of size-related seasonality in real estate-related investments.
Scott, 1990, "Do Prices Reflect Market Fundamentals in Real Estate?" *Journal of Real Estate Finance and Economics*.	The market for REITs, (early 1970s–1986, periods vary)	CRSP tapes, University of Chicago.	Regression tests and mean tests indicate prices do not always track market fundamentals, and in many cases volatility is greater than *ex post* market fundamentals.
McIntosh, Liang, and Tompkins, 1991, "An Examination of the Small-Firm Effect within the REIT Industry," *Journal of Real Estate Research*.	The market for REITs, (1974–1988)	CRSP tapes, University of Chicago. The National Association of Real Estate Investment Trusts.	Report evidence that REIT investors could have earned abnormal returns by acquiring the securities of smaller REITs, even when the possible causes of the small-firm effect as described in the financial efficient markets literature were considered.
Bharati and Gupta, 1992, "Asset Allocation and Predictability of Real Estate Returns," *Journal of Real Estate Research*.	The market for REITs (1973–1990)	CRSP tapes, University of Chicago.	Results suggest that trading rules may be able to outperform buy-and-hold strategies even when considering transactions costs.
Liu and Mei, 1992, "The Predictability of Returns on Equity REITs and Their Co-Movement with Other Assets," *Journal of Real Estate Finance and Economics*.	Equally-weighted equity REIT return series using all available REITs on the CRSP tapes, (1971–1989)	CRSP tapes, University of Chicago.	Evidence indicates that expected excess returns to REITs are more predictable for equity REITs than for small cap stocks, value-weighted stocks, and bonds. In addition, risk premia appear to vary over time.

Table 4. (Continued).

Study	Test Market (Period)	Data Source Index or Model Type	Major Findings
Darrat and Glascock, 1993, "On the Real Estate Market Efficiency," *Journal of Real Estate Finance and Economics.*	U.S. real estate-related securities, (1965–1989)	CRSP tapes, University of Chicago. VAR model.	Report that changes in industrial production, risk premia, interest rate term structure, and the monetary base were quickly and fully capitalized by the real estate market. However, evidence of a significant lagged relationship between fiscal policy and real estate returns existed. Trading rules were not explored to determine if consistent abnormal profits were achievable.
Mei and Liu, 1993, "The Predictability of Real Estate Returns and Market Timing," Working Paper.	Returns constructed using equity REITs and real estate-related firms, (1971–1989)	CRSP tapes, University of Chicago.	Reports that an *ex ante* trading strategy can be constructed to earn excessive risk-adjusted returns, relative to the overall stock market, for the period studied.

Panel B: The Mortgage and Mortgage-Backed Securities Markets

Study	Test Market (Period)	Data Source Index or Model Type	Major Findings
Klaman, 1961, *The Postwar Residential Mortgage Market.*	Primary mortgage market, (1946–1956)	Quarterly data on conventional mortgage contract rates from major insurance companies.	Report a consistent four-quarter lag in the movements of mortgage interest rate changes behind those of changes in bond yields. In addition, substantial regional differences in yields are reported.
Guttentag and Beck, 1970, *New Series on Home Mortgage Yields Since 1951.*	Primary mortgage market, (1954–1960)	Monthly data on FHA, VA, and conventional residential loans from large insurance companies.	Estimated that changes in mortgage yields lagged changes in bond yields by approximately four to seven months.
Hilliard and Haney, 1982, "The Evolutionary Relationship Between Bond Markets and Mortgage Markets: A Cross-Spectral Analysis," *Housing Finance Review.*	Primary mortgage market, (1951–1962) and (1963–1972)	NBER series constructed by Guttentag and Beck (1970) and the FHLBB series. Conducted cross-spectral analysis.	Estimated that mortgage yields lagged long-term government bond yields by approximately three months during the 1950s and one month in the 1960s.
Edmister and Merriken, 1988, "Pricing Efficiency in the Mortgage Market," *AREUEA Journal.*	Primary mortgage market, (May 1981 to Oct. 1982)	Daily yields computed from mortgage terms quoted by lenders in New Jersey and New York.	Mortgage contracts were generally found to be efficiently priced relative to the bond market. However, some mortgages were observed to be smoothed with an autoregressive lag lasting up to thirteen weeks.

Table 4. (Continued).

Study	Test Market (Period)	Data Source Index or Model Type	Major Findings
Haney, 1988, "Sticky Mortgage Rates: Some Empirical Evidence," *Journal of Real Estate Research.*	Primary mortgage market, (1973–1981)	Effective mortgage rates reported by the Federal Home Loan Bank Board and Salomon Brothers' yield series for GNMA securiteis. Conducted cross-spectral analysis.	Reports that the secondary mortgage market appears to be fully integrated with the capital market. However, changes in the primary mortgage market are estimated to lag changes in the bond market by three weeks.
Roth, 1988, "Volatile Mortgage Rates—A New Fact of Life?" *Economic Review.*	Primary mortgage market, (1972–1987)	Monthly mortgage rates from the FHLMC Primary Mortgage Market Survey.	Reports that correlations between monthly changes in the 10-year Treasury rate and in the FHLMC mortgage rate have dramatically increased from 1972 to 1987 due to the growth of the secondary mortgage market.
Reichenstein, 1989, "Martingales and Efficient Forecasts of Effective Mortgage Rates," *Journal of Real Estate Finance and Economics.*	U.S. mortgage and mortgage-backed securities markets, (1972:1–1979:3) and (1979:4–1987:4)	Effective rates on new commitments for 30-year, conventional fixed-rate mortgages and bond-equivalent yields on GNMA securities from the FHLBB and the Federal Reserve System.	Findings reject the efficiency of no-change forecasts of the 30-year conventional rate and GNMA rate for the period 1972 to 1979. The results support the efficiency of one- through three-quarter-ahead no-change predictions from 1979 to 1987.
Quigley and Van Order, 1990, "Efficiency in the Mortgage Market: The Borrowers Perspective," *AREUEA Journal.*	Primary mortgage market, (1976–1989)	Mortgage history data on 30-year, fixed-rate mortgages from the FHLMC.	While borrowers were generally found to exercise their prepayment options consistent with a contingent-claims model, they were slow to exercise the option.
Ma and Goebel, 1991, "On the Seasonalities of Mortgage-Backed Security Prices," *Journal of Real Estate Research.*	Mortgage-backed securities market, (1980–1988)	Daily prices from Data Resources Incorporated.	Significant negative Monday returns are found to occur during "bear-market" periods. In addition, the returns of GNMA pass-through securities are found to be abnormally high on days prior to a holiday.
Haney, 1992, "Primary Mortgage Market Integration into the Capital Markets," Working Paper.	Primary mortgage market, (1971–1992)	See Haney (1988).	Mortgage rates on single-family mortgages persistently lagged bond market rates well into the 1980s. However, rate movements in mortgage market are now found to be contemporaneous with rate movements in the capital market.

significant lagged relationship between real estate returns and fiscal policy moves. Finally, Colwell and Park (1990) and McIntosh, Liang, and Tompkins (1991) find EMH anomalies in examining size-related seasonality and size-related returns to REITs. It is important to note, however, that with the exception of the study by Mei and Liu, trading strategies are not examined in any of the studies cited.

Empirical studies of the pricing efficiency of mortgages by Klaman (1961), Guttentag and Beck (1970), Hilliard and Haney (1982), Haney (1988), Roth (1988), and Haney (1992) examine the correlation of lags between mortgage yields and bond yields. Together these studies provide strong evidence that, because of the secondary market, the primary mortgage market has become dramatically more efficient over the last forty years. Changes in the yields of mortgages, which reportedly lagged changes in bond yields by nearly 12 months in the 1950s and varied across U.S. regions, are now contemporaneous to bond market movements. Conducting conventional tests of autocorrelation and return predictability Edmister and Merriken (1988) report results generally consistent with the EMH, while Reichenstein (1989) reports mixed results and Ma and Goebel (1991) find significant day-of-the-week and holiday return patterns. Again, it is important to note that the ability to construct profitable trading rules is not examined by the studies cited.

4. Concluding remarks

4.1. A synthesis

Serious study of the efficiency of real estate markets has occurred primarily within the last ten years. In comparison, studies of the efficiency of corporate security markets have been the subject of considerable controversy and debate for over thirty years. It would be presumptuous to say that any definitive, or final, conclusions on the efficiency of real estate markets have been reached at this time. The results of the studies reviewed should be viewed as initial, especially when the complexity of modeling real estate markets is considered. In fact, as Fama (1991) argues with respect to securities markets, the joint-test conditions make any definitive conclusions of the efficiency of real estate markets difficult.

The unique characteristics of the real estate market make it a challenge to model expected equilibrium prices. As noted previously, real estate markets have substantial transactions costs, significant barriers to entry, indivisible and durable assets with limited liquidity, and costly information. In addition, market participants are not generally viewed as price-takers. Prices are typically established through a privately negotiated process, rather than an auction process. Actual transaction price information as well as information on the dividend (income flow) is difficult to obtain. Implicit rents to owner-occupied housing, for example, are unobservable. Given these obstacles, it seems reasonable to assume that tests of efficiency using market equilibrium models yield only rough estimates of the market's relative efficiency at this time.

This, however, does not make recent tests of efficiency meaningless—quite the contrary. It highlights the need for additional work to better understand the market. Important aspects of the market and its pricing mechanism have been revealed by recent studies. For example, existing studies show that real estate prices often respond rapidly to new information. In contrast, the studies also indicate that real price changes and real returns may be largely predictable. In addition, existing evidence suggests that real estate market segments may experience different degrees of efficiency.

To date, tests of the efficiency of the housing market have focused primarily on the examination of the patterns of short-run real house price changes and real returns. Intertemporal changes in short-run real prices (and real returns) are consistently found to be positively

correlated. Transaction costs, however, are considered to be substantial and are generally found to preclude the construction of trading rules that exploit the market. The study by Case and Shiller (1989) is a notable exception.

In addition to predictable short-run price movements, initial evidence suggests that long-run real house price changes (and returns to housing) may be mean-reverting. These findings are consistent with others found in studies of the return patterns of other asset groups (e.g., Cutler, Poterba, and Summers, 1990; DeBondt and Thaler, 1985, 1987, 1990) and are argued to be evidence of fads. Furthermore, considerable evidence of speculative price bubbles and the ability to predict real house price trends using publicly available demographic and economic information have been reported. More recent studies have extended the tests of efficiency to explicitly include the unique spatial component of the real estate market. These studies report evidence of spatially-related correlations in housing market prices and suggest that the correlations are the result of biases in human judgment and decision-making.

Existing studies report that income property markets are more efficient than housing markets but less efficient than corporate security markets. Unfortunately, the number of studies conducted is quite limited, and of those completed, most are considerably restricted by a lack of adequate data. Findings in this segment of the real estate market are considered to be very preliminary.

A small number of studies were identified that examine the efficiency of land markets (urban and rural). The earlier works indicate that urban land markets are responsive to new economic information and policy changes. More recent studies have focused on the rural land market and their findings are somewhat mixed. Most, however, report persistent deviations in land market prices from market fundamentals and argue that the market follows an adaptive expectations process. Still, existing evidence on the efficiency of land markets is quite limited.

While the existing results offer some early evidence on the efficiency of real estate markets, the evidence is mixed and incomplete. In fact, the discussion above probably raises more questions than it answers; hence, there is considerable need for additional work to better understand the pricing mechanisms and factors at work in each of the real estate market segments.

4.2. Some suggestions for future research

Compared to the securities market, our current understanding of the efficiency of the real estate market is rudimentary. The possible directions for future research are infinite. While studies of the housing market have found some interest, studies of other real estate segments have lagged. Certainly, additional studies addressing the efficiency of income-property markets and land markets are greatly needed. However, studies of housing market efficiency are far from being exhausted. Therefore, with some reluctance, the need for the following three types of research is emphasized:

1. Studies that develop efficient and reliable techniques to estimate price changes and returns in real estate assets for national, regional, metropolitan, and local markets
2. Studies that test alternative market equilibrium models and the sensitivity of previous EMH test results to changes in the model specifications
3. Studies that test conditions of intra-market, inter-market, and full market efficiency

Finding reliable and commonly accessible real estate data has traditionally been an obstacle to conducting rigorous empirical study of the real estate market. While recent technology advances have made data more accessible, it is crucial that efforts be made to construct reliable, consistent, and commonly accessible databases. Specifically, studies that advance efforts to measure the movements of constant-quality property values, rents (explicit and implicit), taxes, and expenses need to be explored. The recent burst of studies examining the construction of house price indices is very positive. Similar interests in estimating income-property price indices and dividend series for different segments of the real estate market would be beneficial.

Significant advancements in understanding the pricing mechanisms of the real estate market require relaxing some of the stylized conditions of the traditional tests of the EMH. It is possible that important new results could be demonstrated if tests of efficiency were designed to relax some of the test assumptions violated by the real estate market. Some progress in this direction has been made in recent work by Liu, Grissom, and Hartzell (1990). In addition, Clapp and Tirtiroğlu (1994), Tirtiroğlu and Clapp (1994), and Tirtiroğlu (1991, 1992) relax the assumption of spatial homogeneity in testing the EMH, and tests allowing for time-varying risk premia to real estate are introduced by Gatzlaff (1990). Finally, tests that explicitly consider the notion that real estate market participants are not price-takers could potentially reveal important insights into the market pricing process.

Future work should attempt to integrate efficient market studies of the real estate market with other markets. Few studies provide models that jointly test the efficiency of financial and real estate markets. To date, most studies of real estate market efficiency concentrate on tests of individual markets types, segments, and geographical areas. With the exception of Guntermann and Smith (1987) and Clapp, Dolde, and Tirtiroğlu (1994), and Tirtiroğlu (1992), few studies have been conducted that analyze price movements across market areas. Studies have not generally examined the possible influence that real estate market prices in one area may have on adjacent markets either within or across market areas.[29] In addition, the correlation of prices and returns between different segments of the real estate market has not been explored.

Finally, alternative tests of market efficiency are needed. As Dokko and Edelstein (1992) suggest,

> Future analyses of market efficiency must contain explicit models of micro real estate valuation. The analyses need to create a framework of equilibrium or market adjustment dynamics toward equilibrium, including an explicit mechanism by which information is translated into transactions (p. 207).

Studies that apply present value applications may be valuable in examining real estate markets, and while explicit applications of such models may be difficult, variations of the applications are not impossible. Efficiency tests using the variance-bounds tests in financial markets have proven to be very valuable as mentioned in Section 4. The application of such models could prove quite useful in tests of real estate markets. Studies by Falk (1991), Geltner (1992), and Meese and Wallace (1992) represent recent examples of where present-value models have been applied to the analysis of real estate markets.

Appendix

To show the martingale behavior of prices, let

$$r_t = \frac{[P_t - P_{t-1} + d_t]}{P_{t-1}} \tag{6}$$

be the rate of return on an asset from $(t - 1)$ to t, where d_t denotes the appropriate dividend for the period. Suppose that

$$E_t(r_{t+1}) - k = 0 \tag{7}$$

is a fair game, where k is a constant. (It is assumed that all variables have finite, but necessarily constant, means and variances.) Substituting (6) into (7) yields

$$E_t\left(\frac{[P_{t+1} - P_t + d_{t+1}]}{P_t}\right) = k. \tag{8}$$

Then,

$$P_t = (1 + k)^{-1}E_t(P_{t+1} + d_{t+1}). \tag{9}$$

The price of an asset follows (9) if markets are efficient. Equation 8 indicates that prices without the inclusion of dividends do not imply a martingale. Thus, if dividends are time-varying and not included in the model of equilibrium prices, tests of the EMH may be spurious. LeRoy proves that a series of prices plus cumulated *reinvested* dividends, discounted back to the present, behaves as a martingale. A series composed only of prices is not generally a martingale. LeRoy warns that "the practice in the efficient capital markets literature is to speak of asset prices as following a martingale; in such cases *price* should be understood to include reinvested dividends" (p. 1590). Thus, (9) is an approximation to martingale. To remain consistent with convention practice, P_t has been referred to as a martingale in this paper.

Samuelson's proof showed that if asset returns follow the fair-game model of (7), then asset prices equal the expected present value of future stream of dividends. This can be easily shown. Expressing P_{t+1} from (9) as

$$P_{t+1} = (1 + k)^{-1}E_{t+1}(P_{t+2} + d_{t+2}), \tag{10}$$

and substituting (10) back into (9) generates

$$P_t = E_t[(1 + k)^{-1}E_{t+1}(P_{t+2} + d_{t+2}) + d_{t+1}](1 + k)^{-1}. \tag{11}$$

By iterative expectations, it can be shown that after n iterations

$$P_t = \left[\sum_{i=0}^{n} (1 + k)^{-i}E_t(d_{t+i})\right] + [(1 + k)^{-n}E_t(P_{t+n})]. \tag{12}$$

It is assumed that $[(1 + k)^{-n}E_t(P_{t+n})]$ converges to zero for sufficiently large n. Note that this convergence condition is commonly termed the transversality condition. If the term in question does not converge to zero, a speculative bubble will arise.[30]

At the limit

$$P_t = \left[\sum_{i=0}^{n} (1 + k)^{-i}E_t(d_{t+i})\right], \tag{13}$$

which is the standard present value model.

Samuelson was very critical of the financial analyses industry. Financial analysts were advocating that asset prices would fluctuate around the discounted expected cash flows (i.e., equation 13). Therefore, they were suggesting that it was possible to make profits from the difference between the price and the discounted expected cash flows. What Samuelson showed indicates that the price would be equal to the discounted expected cash flows. Samuelson asserted that "there is no way of making an expected profit by extrapolating past changes in the futures price, by chart or any other esoteric devices of magic or mathematics. The market quotation. . . already contains in itself all that can be known about the future contingencies as much as is humanly possible (or inhumanly possible within the axiom of the model)" (Samuelson, 1965, p. 44).

Notes

1. In 1990 real estate assets were estimated to represent approximately 63 percent of all U.S. tangible assets (U.S. Bureau of Economic Analysis, *Survey of Current Business*, January 1992).
2. A U.S. Census Bureau study reported that homeownership was claimed by 65 percent of all U.S. households and accounted for 41.9% of the median household's total net wealth. The median home equity reported by homeowners was $43,078. In addition, other real estate accounted for 12.2% of the median household's total net wealth (Eller 1994).
3. Jaffe and Sirmans (1984), in discussing real estate investment decisions, offer evidence that the real estate market is perceived to be inefficient. However, they indicate that scholarly work on the issue is limited.
4. While our intent is to present a complete and objective discussion of the topic, it is possible that with the growing research attention given to this area, some studies may have been inadvertently omitted. If this is the case, we offer our apologies to the authors.
5. For example, overviews of this literature are provided by Sirmans and Sirmans (1987) and Sirmans and Fisher (1992).
6. These include, among others, empirical tests of option-pricing, portfolio analysis, and hedonic studies that attempt to identify the significance of the effect of one or more factors.
7. This concept of efficiency is attributed to Vilfredo Pareto, a nineteenth-century Italian economist and sociologist.
8. Studies that examine the allocational and operational efficiencies of real estate markets are not included in this review. For examples of that literature, see Henderson (1986), Mills (1987), Fujita and Kashiwadani (1989), Fujita (1991), and Yinger (1992).
9. It is important to note that the finance literature describes allocational efficiency on an after-tax (corporate) basis. Pareto-efficiency of investment requires that risk-adjusted marginal returns be equated before-tax. It maintains that the substitution effect resulting from taxes may create allocational inefficiencies.
10. Arrow (1982) notes some reasons why the arbitrage process may not be so influential.
11. Application of the martingale may also provide evidence that supports the theory that valuations are present value.
12. Cornell and Roll (1981) argue that the average investor who uses costly security analysis data will outperform investors who use less information, but their net returns will be identical.
13. To avoid a tautology, the appropriate information set in (4) can be defined as the information set *used* by the market, $\Phi_{t,m}$, in determining $E_t(r_{t+1})$, while (5) includes *all relevant* information, Φ_t.
14. See LeRoy (1989), Shiller (1990a), Fama (1991), and Tirtiroğlu (1991) for a review of these mixed results.
15. Various variance-bounds relationships are examined in LeRoy (1989) and Gilles and LeRoy (1991).
16. This condition assumes that real estate capital is fluid and mobile. In addition, it assumes that externalities and congestible assets are priced, and future conditions are rationally anticipated.
17. Mills (1988) reports evidence that social returns to housing and nonhousing have converged gradually during the postwar period. He speculates that the most plausible cause has been a "steadily improving sophistication of capital market participants and of computerized decision-making techniques and data availability" (p. 83).
18. Discussions of real estate market imperfections are provided in Roulac (1976, 1978), Draper and Findlay (1982), Gau (1984, 1987), Linneman (1986), and Clapp (1988).
19. Clapp (1988) argues that there would be gaps in the real estate market. His work suggests how one might use statistical tools to identify such gaps to earn above-normal returns.
20. Among other places, examples of investment-motivated housing models appear in the tenure choice literature, such as Hendershott and Shilling (1982).
21. It is well known the FHA-based price data have some deficiencies. First, the maximum mortgage limit truncates the data base. Thus, there may be systematic moves in the index brought about by periodic statutory changes to the limit (Greenlees, 1982). Second, homes within the sample that experience abnormal returns may subsequently move out of the sample.

22. In using this approach they note that significant autocorrelation of actual returns is not inconsistent with market efficiency. *Ex post* actual returns may exhibit significant serial correlation over some time intervals even though unexpected returns would not. They point out that serial correlation of raw returns over long time intervals would be expected even in an efficient market due to such factors as changes in inflation rates and changes in tax rates.
23. As noted previously, the use of first differences of an individual logged index to construct returns may induce spurious correlations.
24. The EMH was rejected for some submarkets during the period from 1970 to 1975. Possible reasons for this anomaly were not explored.
25. They consider only first-time home buyers and homeowners who want to trade up and therefore argue that transaction costs can be ignored. In addition, they assume all costs associated with waiting to purchase are zero.
26. A number of responses to Mankiw and Weil are contained in a 1992 special issue of *Regional Science and Urban Economics*.
27. The use of subjective value estimates as a proxy for market value may be biased. Because housing assets are heterogeneous, the assumption that all homeowners equally value different housing characteristics is restrictive. Linneman examines this bias and argues that it is insignificant. Yet, he concedes that the use of actual transaction price data would strengthen the study. In addition, the estimates are contaminated with the owners' private information.
28. Skantz and Strickland (1989) cite a number of studies that provide additional evidence suggesting that real estate prices rapidly respond to new relevant information.
29. For spatial autocorrelation and modeling see Cliff and Ord (1975a, 1975b, 1981), Haining (1985, 1987), and Miron (1984), among others.
30. See Ingersoll, (1987, Chapter 10) for a detailed explanation and examples of bubbles.

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