What Can We Learn About the Sensitivity of Investment to Stock Prices with a Better Measure of Tobin's *q*?

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Abstract

This paper examines the responsiveness of investment to *q* (i.e., the ratio of a firm's market value to the replacement cost of its assets) using data on a unique type of firm: Real Estate Investment Trusts (REITs). For REITs, we have high quality estimates of the net asset value of the firm that we use to create relatively accurate measures of Tobin's *q*. In addition, REITs have institutional features that mitigate some of the complications faced by previous studies. We have three main results. First, there is little evidence of a statistical link between REIT investment and a traditional accounting-based measure of *q*. Second, REIT investment is highly sensitive to estimates of *q* that are based on analysts' appraisals of asset value. A REIT whose NAV-based *q* ratio rises from 1.0 to 1.1 will increase its assets by 4.3 percent in the next year. Third, the difference between the appraisal-based measure of *q* and the traditional accounting based measure typically increases with the age of the firm's assets and varies across types of properties. These results suggest that measurement error in *q* can lead to appreciable downward biases in investment sensitivities, even in an industry that seems to meet many of the assumptions in Tobin's original paper, but that Tobin's investment model performs well with a better measure of *q*.

I. Introduction

Traditional *q*-theory models describe the optimal level of investment subject to adjustment costs. Despite providing a simple and elegant prediction that investment should depend on the market value of an investment project relative to the cost of undertaking the project, as discussed below, empirical support for this prediction has been difficult to find and the estimated sensitivity of investment to *q* has appeared quite small.

In this paper, we consider Real Estate Investment Trusts (REITs). REITs provide a natural place to examine how investment responds to stock market value because several institutional features mitigate some of the complications facing other studies. For example, since REITs do very little advertising or research and development, we sidestep the issues associated with valuing intangible assets for measuring investment incentives. Furthermore, REITs have relatively little market power.[1] Finally, REITs may face fewer adjustment costs than other firms because most of their assets are not firm-specific; instead, other potential owners would have a similar value for their assets. With a competitive market for buildings, mostly tangible assets, and relatively low adjustment costs, we would expect that Tobin's original model of investment and *q* should hold reasonably well for REITs, and possibly better than for industrial firms.

At the same time, REITs also have some disadvantages related to the measurement of the replacement cost of their assets. Most studies of Tobin's *q* use the book value of assets as a

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[1] REITs owned just 7 percent of all commercial real estate as of 9/20/2002 (National Association of Real Estate Investment Trusts, Lend Lease/PricewaterhouseCoopers) and have a relatively small penetration in most major markets and property types. Even for regional malls, the property sector with the largest REIT penetration, REITs own just over 42 percent of the malls in the US, and that ownership is divided among more than a dozen REITs (source: Merrill Lynch, 10/29/2001). Other property sectors such as apartments, offices, and strip centers have REIT market penetrations that are no more than 8 percent.

proxy for the replacement cost of a firm's assets. Yet, the book value of assets often does not equal the replacement cost of assets. During peak times of demand, existing equipment may have a market value that exceeds its book value, while at other times equipment might fall appreciably when, for example, manufacturers offer a new generation product or demand falls. For example, consider the airline industry. Today, the market value of aircraft is well below the book value of aircraft because demand for air travel has fallen substantially; however, just four years ago, aircraft had a very high value and airplane manufacturers were unable to meet the then-current demand. In addition, inflation affects how well historical book values approximate current market values for assets. For real estate, building values can rise or fall appreciably due to changes in supply or demand in particular markets and for specific property types.

With REITs, we circumvent this problem by using an alternative measure of the replacement cost of assets based on analyst estimates of the market value of a REIT's buildings rather than the book value of a REIT's assets. This strategy is feasible for REITs because, by law, most of their assets must be real estate, which is relatively easy for outside analysts to appraise – at least compared to the assets of other corporations. These analyst appraisals help us generate an estimate of Tobin's *q* that is arguably more accurate than the measures based on the book value of assets that researchers have used for industrial firms.[2]

[2] Of course, one would like to generate such a measure for other industrial firms, but it is considerably more difficult. In a few cases, analysts attempt to do a comparable analysis by estimating the value of oil and gas companies based on the amount of their proven reserves multiplied by current oil and gas prices. Some pharmaceutical analysts will estimate the value of corporate assets based on the value of a drug portfolio. This type of analysis is often used to assess management's performance by comparing the market value of a firm to the break-up value of a firm if its divisions were sold separately, an analysis that is in the same spirit as Tobin's original model.

We have three principal findings. First, despite the fact that REITs hold mostly tangible assets and the real estate industry is quite competitive and closer to having constant returns to scale than other industries, we do not find a statistical link between REIT investment and traditional accounting-based measures of *q*.

Second, in stark contrast, we find a strong and statistically significant relationship between REIT investment and our appraisal-based measure of *q*. Using our appraisal-based measure of *q*, we estimate that a REIT that starts the year with a *q* of 1.1 will be 4.3 percent larger after one year than if it starts the year with a *q* of 1.0. Our estimated elasticity is roughly five times larger than the elasticities typically found in empirical investment studies.[3] The responsiveness of investment to *q* is consistent with neoclassical investment theory but contradicts the view that stock market valuations are not central in explaining investment, possibly because managers view stock prices as having a non-fundamental component (see, *e.g.*, Morck, Shleifer, and Vishny (1990) and Blanchard, Rhee, and Summers (1993)).

Third, we examine the sources of 'measurement error' in the traditional measure of *q*, which we define as the difference between the appraisal-based measure of *q* and the traditional measure of *q* accounting data. This measurement error depends on the vintage of a REIT's properties with REITs that have older buildings typically having more measurement error. It also varies by property sector (e.g., apartment buildings versus shopping malls) for the REIT. In addition, this measurement error varies systematically over time.

While the magnitude of the coefficients are certainly specific to the real estate industry, these results suggest that even in an industry where the assumptions of Tobin's original *q*-theory

[3] See, *e.g.*, Bond and Cummins (2000) and the cites given in section III on previous estimates.

are most likely to hold, measurement error in Tobin's q can still substantially bias downward estimates of the coefficient on q. In addition, these results can also be more directly applied to non-real estate corporations than might at first be obvious because real estate represents a material portion of the assets for the typical firm. Federal Reserve Flow of Funds data show that real estate (separate from equipment) represented more than 25 percent of the assets of non-financial corporations as of the 4th quarter of 2002. Historically, real estate has been even more important for corporate balance sheets: In 1992 and 1982, real estate represented more than 30 percent and 40 percent of total corporate assets, respectively.[4] Goolsbee and Maydew (2002) show that two manufacturing firms, General Electric and General Motors, are in the top seven (non-real estate) firms with the largest real estate holdings in 2002. The historical importance of real estate assets for corporate balance sheets could play a significant role in creating measurement error for studies of investment and Tobin's q using data from these years.

The paper is organized as follows. Section II provides background information on REITs. Section III reviews previous tests of the q-theory of investment. The data are summarized in Section IV. Section V discusses our empirical methodology and the measurement of q. Section VI presents our empirical results on investment and q while section VII provides evidence on the sources of measurement error. Section VIII concludes with an agenda for future research.

[4] Goolsbee and Maydew (2002) note that a recent tax policy change can allow many corporations to generate significant tax savings by spinning-off their real estate holdings into REITs. Their argument is based on the claim that corporations own a substantial amount of real estate whose book value is below its market value.

II. Background on REITs

With certain key tax-related exceptions, REITs are similar to other corporations. Like other firms, REITs often initiate operations by raising capital from external markets and investing the capital in operating assets. To qualify as a REIT, among other things, a firm must meet certain asset and income tests that set minimum levels of real estate activity to prevent REITs from using their tax-advantaged status to move into other business areas. REITs must earn at least 75 percent of their income from real estate related investments and 95 percent of their income from these sources as well as dividends, interest and gains from securities sales. In addition, at least 75 percent of their assets must be invested in real estate, mortgages, REIT shares, government securities, or cash. While older REITs were often passive investors, several changes in tax rules in the late 1980s allowed REITs to actively manage their assets during the 1990s. Although some REITs invest in real estate mortgages, we restrict our focus to equity REITs, which primarily invest in rental properties. The relatively straightforward nature of REITs' assets (compared to industrial firms) leads many analysts to value REITs by appraising their properties. We use one set of these appraisals in our empirical work.

In addition to the asset and income tests, tax law requires REITs to pay out a minimum percentage of their taxable income as dividends each year. For most of our sample period, this percentage was 95 percent; however, tax changes in 2000 reduced the minimum percentage to 90 percent. This distribution requirement is based on taxable income rather than financial reporting income. Despite this requirement, REITs have some discretionary cash flow because operating cash flow typically exceeds taxable income, especially since depreciation allowances reduce taxable income but not cash flow. In general, however, the distribution requirement limits REITs' ability to finance investment with internally generated funds, so they uniformly rely more heavily on secondary equity issues than do regular corporations. Thus, while many studies of investment focus on the differences in the behavior of firms with and without internally generated funds, REITs offer less cross-sectional variation in dependence on external funds.

The benefit of qualifying as a REIT is avoiding the double taxation of equity-financed investment. Unlike regular corporations, REITs receive an annual tax deduction for dividends paid out to shareholders. REITs often distribute all of their taxable income to shareholders each year, which eliminates the corporate tax altogether. The lack of double taxation changes the tax incentives for investment decisions. As discussed by Summers (1981), Poterba and Summers (1983), and Cummins, Hassett and Hubbard (1994), tax policy affects the construction of q as a measure of the incentive for a firm to invest. Since REITs are exempt from the corporate tax, the corporate tax does not affect their q.

III. Stock Prices and Investment

This section reviews the theory and empirical evidence on how stock prices affect investment. Our comparative advantage is using better data so we do not provide an exhaustive review of the previous econometric methodology. Many studies of investment start with the insight of Tobin's (1969) q model of investment that a firm will want to invest if the market value of a project exceeds its replacement value. The ratio of the market value to the replacement value is called q. If the output market is perfectly competitive and the production technology has constant returns to scale, Hayashi (1982) shows that Tobin's original hypothesis implies that the firm will invest if the market value of the firm exceeds the replacement value of the firm. The difference between these two statements is that the former applies to marginal q

but the latter refers to average *q*. These conditions eliminate economic profits on inframarginal investments so that the firm's marginal project has the same value as its average project.

For empirical work on investment, the theory must be adjusted so that the capital stock does not immediately move to its optimal level where the firm faces no marginal incentive to invest. That is, the simplest view of *q* theory is that it provides a condition for the equilibrium capital stock but does not describe the dynamics of the investment process. To implement *q* theory empirically, adjustment costs have been added to the theory.[5] With adjustment costs, the benefits of investment as measured by *q* are traded off against the non-linear costs of investing.

For empirical work, *q* theory has the implication that *q* is a sufficient statistic for the value of investing. That is, *q* fully captures the firm's incentive to invest so the theory predicts a univariate relationship between investment and *q*. The functional form of this relationship depends on the form of adjustment costs. However, the regression equation does not need other variables. Despite the simple relationship predicted by theory, as discussed in more detail below, the poor econometric performance of this univariate relationship has led researchers to augment *q* regressions with other variables, most commonly with cash flow.

In general, early attempts to test *q* theory in both aggregate and firm-level data found little support for the theory (see, *e.g.*, Summers, 1981). The theory failed on several counts. First, the estimated responsiveness of investment to *q* was low and often not statistically

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[5] Among the contributions on the role of adjustment costs in models of investment, see Lucas and Prescott (1971) and Mussa (1977). The functional form of the adjustment costs affects the predicted relationship between investment and *q*. A common functional form choice is quadratic adjustment costs because it implies a linear specification between investment and *q* and the parameter estimates can be interpreted as measures of the cost of adjustment. Unfortunately, as discussed by Erickson and Whited (2000), the linear specification of investment and *q* is consistent with a broader class of adjustment cost functions than just quadratic adjustment costs. Thus, using the parameters as estimates of adjustment costs requires a specific functional form choice.

different from zero; based on common functional form assumptions about adjustment costs, the point estimates suggested unrealistically high adjustment costs. Second, the simple regressions did not explain much of the variation in investment data. Third, adding other variables to the regression improved the explanatory power of the regression, which refutes the argument that q is a sufficient statistic for investment incentives.

The dismal early results did not deter further empirical work because, in part, the simple elegance of q theory seems inherently logical. Broadly speaking, researchers blamed the empirical failure of q theory on measurement error. This measurement error takes many different forms. For example, accounting data only allows for a proxy of the true replacement cost of the firm. Accounting data provide historical cost information on previous investment, typically not adjusted for inflation. These historical data reflect accounting depreciation which is a noisy proxy for true economic depreciation. In addition, while the stock market valuation of common equity is relatively straightforward, the market value of the firm includes the market value of debt and preferred equity which are more difficult to measure.

Also, the theory is stated in terms of the manager's perception of the value of the firm and its ideas but the empirical implementation uses the stock market valuation of the firm. Blanchard, Rhee, and Summers (1993) point out that the manager's valuation could differ from the market's valuation, especially if the stock market has fads or inefficiencies. Thus, the standard empirical exercises are based on the joint hypothesis of market efficiency and q theory.

Q-theory calls for marginal q but the initial measures captured, at best, average q. If marginal q diverges from average q for any of the reasons described by Hayashi, such as imperfect competition, then the proxies fail to capture the incentive to invest. This form of measurement error led researchers to estimate the marginal value of additional capital.

Previous research has used many strategies to deal with measurement error. Assuming that the measurement error is serially uncorrelated, lagged values of q can be used as instruments for current values of q (see Blundell, Bond, Devereux, and Schiantarelli, 1992); unfortunately, many reasons for measurement error in q persist over time which complicates such attempts. Cummins, Hassett, and Hubbard (1994) argue that tax reforms create surprise innovations in tax-adjusted q. Another approach to moving toward marginal q instead of average q is to predict marginal profits based on variables known by the managers (see, Abel and Blanchard, 1986, and Gilchrist and Himmelberg, 1995). This strategy may help explain why investment is sensitive to cash flow even after controlling for q, if cash flow contains information about marginal profits that is not captured by the standard measures of q. Gilchrist and Himmelberg find that incorporating cash flow into the measure of 'fundamental' q outperforms standard measures of q, but cash flow still affects investment for firms that may face financial constraints. Finally, analysts' forecasts of earnings could provide information about future profitability. Cummins, Hassett, and Oliner (1998) and Bond and Cummins (2000) incorporate these forecasts into measures of q and estimate a responsiveness of investment to q that is roughly a factor of ten larger than estimates using traditional measures (*e.g.*, Bond and Cummins find that the coefficient on q increases from 0.0014 to 0.13).

Erickson and Whited (2000) attack the measurement error problem in a different way by creating measurement-error consistent generalized method of moments estimators, using the higher moments of the distributions to impose restrictions on the data. With these estimators, they find that q suffers from substantial measurement error but the consistent estimators imply that q theory has good explanatory power. Their estimates suggest a much stronger sensitivity of investment to stock price changes than in previous work (*e.g.*, the estimated coefficient on q

increases from 0.014 to 0.044), but the elasticities are still relatively modest in economic terms. Furthermore, they argue that the importance of cash flow found in some previous research is an artifact of the measurement error.

A second line of empirical research on investment is whether *q* theory holds for some firms but not others. Financing constraints may explain the weak relationship between *q* and investment (see Fazzari, Hubbard, and Petersen, 1988, hereafter FHP). FHP argue that if financing constraints affect investment, then *q* will be less important and cash flow variables will be more important for explaining the investment of financially-constrained firms than they are for explaining the behavior of unconstrained firms. This insight spawned a large literature (summarized by Hubbard, 1998) on how to identify constrained firms and whether such regressions shed light on the role of financing constraints for corporate investment.[6] Since all REITs must pay relatively high dividends and thus go to the financial markets to finance almost all new investment, we have no cross-sectional variation in the extent of equity-dependence with which to examine the results of the financing constraints literature.

Our approach to the measurement error is strikingly simple. First, we concentrate on real estate firms – a competitive industry for which the constant returns to scale assumption seems more reasonable. Second, the nature of the industry allows us to obtain data on appraisals of the replacement cost of each firm's assets. Instead of relying on accounting data that uses historical measures of cost, we have fair market value estimates of the replacement cost.

[6] Kaplan and Zingales (1997) question the validity of the FHP approach and challenge the FHP results; see also the rejoinder by FHP (2000) and Baker, Stein, and Wurgler (2001).

IV. Data

Our sample period begins in 1992, which corresponds with the beginning of a 5-year period of strong growth in the REIT industry, and ends in 2002. The number of equity REITs grew from 89 in 1992 to 149 in 2002 and their equity market capitalization grew from $11 billion in 1992 to $151 billion in 2002, with a consequent gain in liquidity and trading volume.[7]

The key variable for our analysis is an alternative measure of Tobin's *q* that is based on private appraisals--estimates of the market value of each REIT's assets. We rely on Net Asset Value (NAV) estimates from Green Street Advisors, Inc to construct this alternative measure of *q*, referred to as NAV-*q* below. In estimating NAV, Green Street assesses the value of the major properties of a REIT and subtracts the liabilities of the REIT. Green Street's goal is to compare the market value of the REIT's common stock with the market value of the underlying assets (after adjusting for other ownership claims). They use these estimates to advise clients (often large institutional investors) on selecting REITs as investments. While Green Street provides NAV estimates for 40 percent of equity REITs in 2001, the firms they cover represent 75 percent of REIT value.[8]

Several factors motivate using the Green Street NAV estimates. Industry observers and participants almost uniformly agree that Green Street produces the most careful and accurate estimates in the REIT industry. It is the only analyst firm to have a consistent set of estimates prior to 1996. Green Street focuses exclusively on real estate firms and each of its analysts follows only a few firms. These analysts specialize by type of property and compute NAV by

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[7] Industry statistics are from the National Association of Real Estate Investment Trust (www.nareit.org).

[8] Gentry, Jones, and Mayer (2003) show that Green Street NAV data have significant value in predicting risk-adjusted REIT returns.

determining the fair market value of each property owned by a REIT, often visiting larger properties. Finally, Green Street performs no investment banking functions for REITs, so it is immune from the potential conflicts of interest that may impact the research of banks that underwrite securities.

Over this sample period, the mean (median) share-price-to-NAV ratio is 1.04 (1.01). While the central tendency of this ratio is close to one, there is substantial variation both over time and within time periods. Figure 1 plots the 25th percentile, median, and 75th percentile price/NAV ratio by month for 1992-2002. The time series plot reveals a strong industry-wide component to the price/NAV ratio with the median value exceeding 1.20 for all of 1997 but being below 0.9 for most of 2000. Clayton and MacKinnon (2000) argue that this industry-wide component represents a form of investor sentiment for REITs. The spread between the 25th and 75th percentile of the monthly distribution has narrowed over time.

In addition to the NAV estimates from Green Street, we obtain accounting data from SNL Securities, Inc. and data on share prices from the University of Chicago's Center for Research in Security Prices (CRSP). We use the accounting data to measure investment activity, the book value of debt and preferred equity, and cash flow. The SNL data also provide industry-specific information that are not available from broad-based accounting databases, such as Compustat, including the number of operating partnership units in the ownership structure and the net investment in real estate.[9] All variables are measured on an annual basis.

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[9] One complication that we face is that many REITs operate as UPREITs, or umbrella partnership REITs (see Sinai and Gyourko, 2002, for details regarding the UPREIT structure). UPREITs have a separate class of stakeholders who own partnership units that are freely convertible one-for-one into REIT common shares. These partnership units arise when investors contribute appreciated properties to the umbrella partnership in exchange for partnership units, deferring any unrealized capital gains taxes on the properties. The partnership units are essentially equivalent to REIT shares, so we include equity in the

Our sample includes 91 REITs and real estate companies covered by Green Street between 1992-2002. Overall, after matching with SNL data and restricting the sample to US equity REITs, we obtain information on 83 REITs and 481 firm-years with non-missing data.

V. Empirical Specification and Measurement of *q*

Standard investment theory implies the following regression equation:

$$\frac{I_{it}}{K_{it-1}} = \alpha + \beta q_{it-1} + \varepsilon_{it} \quad (1)$$

where I/K is the rate of investment during the period (the ratio of investment during year *t* to the end of year *t* - 1 capital stock), *q* is a measure of firm-specific Tobin's *q* at the beginning of the period, α is a constant, β is the sensitivity of investment to *q*, and ϵ is the error term. The empirical model often includes year-effects, firm-effects, or both.

Previous investment research measures *q* as:

$$q_{it} = \frac{E_{it} + D_{it} + PE_{it}}{BVA_{it}} \quad (2)$$

where *E* is the market value of common equity, *D* is the book value of debt which is a proxy for the market value of debt (some authors have attempted to adjust the book value of debt so that it better reflects the market value), PE is the book value of preferred equity (again taken as a proxy

form of the partnership units when computing the market value of equity. These partnership units are reported as a minority interest on the balance sheet and typically dominate that category of financing.

for the market value), and *BVA* is the book value of the firm's assets. The book value of assets represents the replacement cost of the firm's assets.

As discussed above, using historical accounting data as a proxy for the replacement value induces measurement error in q. We compare the traditional measure of q to an alternative NAV-based q, which we compute by using estimates of the net asset value for the REIT in the denominator for q.[10] To obtain the gross value of assets so that the numerator and denominator of our measure of q are consistent, we add the book value of debt, preferred equity, and other liabilities (as a proxy for the market value of these variables) to the aggregate value of the REIT's NAV to get an estimate of the replacement cost of the REIT's assets. This NAV-based q assumes that REITs can buy more properties or sell its existing buildings at the current price of its buildings. The ability to sell buildings at the appraised value seems natural (provided the appraisals are fair). For positive investment, the REITs could purchase buildings from existing building owners or from real estate developers. Neither our measure of NAV q nor traditional accounting-based measures of q capture the incentives of real estate developers to build new buildings.

Following previous studies of investment, we augment equation (1) with cash flow variables. As discussed in Section III, a common interpretation of the estimated coefficient on the cash flow variable is that it reflects the importance of financing constraints. However,

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[10] We do not adjust our measure of q for taxes. The lack of a corporate-level tax on REITs implies that any tax adjustment must use the appropriate shareholder tax rate. The standard tax adjustments for q reflect how the tax system affects the cost of acquiring new assets. Based on the results in Gentry, Kemsley and Mayer (2003), one could argue for adjusting the market value of REIT equity relative to the net asset value due to the capitalization of future shareholder taxes into share prices. Specifically, Gentry, Kemsley and Mayer find that, conditional on a REIT's NAV, the market value of its equity increases with the amount of tax basis that remains in its assets. This tax capitalization effect could affect our measured q but would not be relevant for the REIT's marginal incentive to invest. Our results are invariant to whether or not we make such a correction. Results with a tax-adjusted q are available upon request.

Gilchrist and Himmelberg (1995) note that this interpretation is not valid if q is measured poorly and cash flow provides incremental information about future profitability (see Abel and Eberly, 2002 for a theoretical model in which cash flow serves as an indicator of future investment opportunities). The Gilchrist and Himmelberg argument suggests that if measurement error drives the estimated coefficients on cash flow, then better measures of q should reduce the importance of the cash flow variables. We focus on this hypothesis in comparing specifications that use traditional and NAV-based measures of q.

The dividend distribution requirement for REITs complicates the measurement of cash flow, but also provides an additional opportunity to explore why cash flow is often associated with investment. Typically, cash flow is measured as operating cash flows for the firm before dividends since dividends are a discretionary use of funds. REITs do not have complete discretion over dividends because tax rules require a minimum dividend. In our empirical specifications, we use two alternative cash flow measures. For comparison with previous research, we use the standard operating cash flow measure before dividends. We also decompose cash flow into two parts, an estimate of the minimum required dividend (95 percent of financial net income before 2000 and 90 percent for 2000 and afterwards) and the remaining cash flow reflecting discretionary funds.[11] We do not observe the actual required dividend as firms do not consistently report their taxable net income, which would be necessary to compute the actual required dividend, although we expect that GAAP net income is a good proxy for most firms. Discretionary cash flow after the required dividend proxies for internal resources that

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[11] We subtract an estimate of the required dividend rather than the actual dividend because REITs often distribute a larger dividend than is required by the tax rule. We are examining the choice and timing of these discretionary dividends versus share repurchases in a related paper (Gentry and Mayer, 2003).

may mitigate financing constraints. To the extent that the required dividend helps predict investment, it may be evidence in favor of the hypothesis that cash flow captures an unobserved component in profitability since REITs cannot use these funds to pay for the investment. We scale all cash flow variables by the total assets at the end of the preceding year.

We define REIT investment as the percentage change in total assets during the year. We also develop an alternative measure of investment based on changes in real estate assets, which is closer to the property, plant and equipment definition of investment that is most common in the literature.[12] Our investment results are not sensitive to how we define investment. We choose to use the broader measure of investment in most of the analysis because we will be able to decompose the financing of that investment, as below.

In general, REITs are not construction companies and most of their acquisitions are from previously developed projects. Most REIT investment involves buying and selling existing buildings, as well as making capital improvements to their existing buildings. Nonetheless, some REITs have joint ventures arrangements with developers or directly construct new buildings themselves. While REITs often buy existing assets, Jovanovic and Rousseau (2002) show that between 10 and 43.5 percent of annual general corporate investment between 1970 and 2000 is spent on used equipment or involves the merger of two companies. Thus an appreciable portion of investment for industrial companies also involves investment in existing assets. Nonetheless, the usual discussion of adjustment costs may have a limited application for REITs since REITs do not typically use their buildings as a factor of production, but instead

[12] The difference between these two measures is that the change in total assets includes changes in the cash (or liquid asset) position of the REIT, while the change in net investment in real estate focuses specifically on investment in properties.

lease their buildings to tenants. Thus many of the buildings would have a very similar value to a non-REIT owner who would likely use the building in a similar manner as the REIT itself. Adjustment costs are likely limited to the direct cost of selling the building plus any indirect costs associated with the difficulties of selling a building when the existing owner has more information about the building than an outside buyer would have. (See Genesove, 1993, for evidence of the impact of adverse selection on the prices of used cars.)

VI. Results

Table I provides summary statistics for the variables used in our base regressions. In order to minimize the effects of firms going through major changes, such as mergers, our base specification restricts the sample to REITs with annual net investment rates (as opposed to gross investment rates that would include replacement investment) of less than 100 percent of the previous capital stock (Panel A), reducing the sample size by 23 observations. The median (mean) net investment rate is 10 (18) percent in this restricted sample, which is consistent with the rapid growth in the industry.[13] Panel B shows summary statistics for the entire sample with all REITs.

For the traditional accounting-based measure of q, the median value in our sample is 1.28; however, the median appraisal-based q is only 1.02. The difference between these median values suggests that measures of q based on historical cost overstate the true value of q (i.e., accounting depreciation rates exceed economic depreciation rates or properties may appreciate in value). For regression analysis, however, the critical issue is not the level of the

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[13] For the full sample (including observations with net investment greater than 100 percent), the median (mean) net investment rate is 12 (24) percent.

mismeasurement of q but how the measurement error varies across observations. The distribution of the appraisal-based measure of q is much less variable than the distribution of the accounting-based measure of q. The standard deviation of the NAV q is 0.12 compared to a standard deviation of 0.41 for the traditional measure, which suggests that the NAV-based measure is less noisy.

The cash flow measures show that the median REIT generates approximately 7.3 percent of assets in cash flow every year. However, the median REIT must payout a dividend of approximately 3.2 percent of assets. The remaining cash flow, which is available due to depreciation allowances and other non-cash expenses that reduce taxable income, can be retained or paid out as an additional dividend at the discretion of management.

Table II presents the results of estimating several investment equations using the traditional measure of q and cash flow. In column (1), the estimated coefficient on traditional q (0.028) is typical or even slightly higher than that found in most investment studies. This estimate is not statistically different from zero, although our sample is considerably smaller than usual sample sizes in other studies of industrial firms. The specification in the second column includes year and firm fixed effects as is also common in previous studies. With the inclusion of these fixed effects, the estimated coefficient on traditional q becomes negative but not statistically different from zero. Thus, despite the real estate industry arguably being closer to constant returns to scale and more competitive than most other industries, investment regressions with traditional measures of q do not indicate a statistically significant relationship between Tobin's q and investment.

For the specifications in the first two columns, we find large and statistically significantly different from zero estimated coefficients on cash flow, consistent with previous research on industrial firms. Unlike industrial firms, however, REITs face restrictions on reinvesting their cash flow since the tax law requires them to pay almost all of their taxable income as dividends. While the portion of cash flow that must be paid as a dividend may contain information about the profitability of the firm, this cash flow cannot be used to fund investment. To further explore the role of cash flow on investment, the specifications in the third and fourth columns decompose the cash flow measure into a required dividend portion and cash flow in excess of the required dividend portion. For the specifications without and with year and firm fixed effects, the estimated coefficients on the required dividend is higher than the coefficient on remaining cash flow and an F-test rejects equality of the estimated coefficients of the two types of cash flow at the 99 percent confidence level. The larger coefficient on the required dividend, which is equal to 90 or 95 percent of net income, but cannot be retained by the firm, suggests that an important part of the correlation between cash flow and investment is driven by the association of cash flow with current earnings and also the future prospects of the firm.[14]

Table III presents comparable specifications that use NAV-based *q* instead of traditional *q*. Across the board, relative to the estimates using the traditional measure of *q*, the estimated sensitivity of investment to NAV-based *q* is much larger in magnitude and statistically different than zero at conventional significance levels. For investment, the estimated coefficient on NAV *q* ranges from 0.37 to 0.70. Furthermore, for the specification without fixed effects, the explanatory power of the regression (the adjusted-R^2) more than doubles when using the NAV-based *q* when compared with Table II. These estimated effects imply that REIT investment is highly sensitive to *q* as a proxy for investment opportunities when *q* is measured more

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[14]Decomposing the cash flow variable into separate components leads to slightly lower estimated effects of *q* on investment but these estimated coefficients remain statistically insignificant.

accurately. For example, using the estimate of 0.43 from the specification in the second column of Table III, a REIT that started the year with a *q* of 1.1 would be 4.3 percent larger than if it had started the year with a *q* of 1.0.

A natural question is how our estimates of the responsiveness of investment to the appraisal-based measure of *q* compare to estimates in the previous literature. Even among papers that argue in support of *q* theory, our estimates are relatively large. For example, Erickson and Whited (2000) report ordinary least squares estimates of around 0.014 but Generalized Method of Moments (GMM) estimates of between 0.033 and 0.045. Bond and Cummins (2000) report estimates using traditional measures of around 0.014 but their estimates using analysts forecasts of earnings to construct *q* range from 0.104 to 0.139. However, our estimates are more similar to those found by Cummins, Hassett, and Hubbard (1994). They report a vast array of estimated coefficients for *q* based on different years, under the hypothesis that years around tax reforms provide better measured values of *q*; for the major tax reform years of 1962, 1972, 1981, and 1986 using GMM estimators, they report estimated *q* coefficients of 0.585, 0.136, 0.262, and 0.245, respectively (taken from Table 4 of their paper).

Comparing estimated coefficients across papers is complicated because empirical methodology and sample design differ across studies. Most studies of investment include a variety of industries while focusing on manufacturing firms, but we focus exclusively on real estate firms so that the sensitivities may not be directly comparable. The real estate industry may face lower adjustment costs than other industries so that REITs may respond quickly, possibly by buying existing properties. However, if industry differences were the sole explanation for our result, one would expect that the traditional measures of *q* would also yield large estimated investment sensitivities but we only find the large sensitivities when we use the appraisal-based measure of *q*. While such appraisal-based measures are unavailable for other industries, our results can be taken as support for the claim that measurement error in *q* is a major hurdle for empirical work on investment.

Examining other variables in the investment equation, we find that the inclusion of NAV *q* reduces the estimated coefficient on cash flow by forty percent in the specification without fixed effects and by about ten percent in the specification with fixed effects. This result indicates that measurement error in *q* is an important factor in explaining the significance of cash flow in investment equations, which is consistent with the findings of Gilchrist and Himmelberg (1995), amongst others.[15] Nonetheless, the estimated coefficient on cash flow is still positive and statistically significant.[16] While the statistical significance of the coefficient on cash flow may suggest that our NAV-based measure of *q* suffers from some measurement error, it is also consistent with Abel and Eberly's (2002) model in which cash flow is positively correlated with investment, even when *q* is measured accurately. Two features of REITs suggest they may be good candidates for Abel and Eberly's model. First, Abel and Eberly do not assume convex adjustment costs, which is reasonable for REITs since they can plausibly just as easily sell buildings as buy them. Second, Abel and Eberly argue that the correlation between cash flow and investment should be larger for small, fast growing firms, such as the REITs in our sample.

[15] When we decompose cash flow into the discretionary component and the minimum dividend in columns (3) and (4) the coefficient on the required dividend falls much more (relative to the Table II estimates with traditional *q*) than the coefficient on the discretionary portion of cash flow. This difference suggests that the relationship between cash flow and measurement error in *q* depends on the future prospects of firm.

[16] The relatively large size of the cash flow coefficients in our work relative to other papers in the fixed effects specification may reflect the relatively low variation in cash flow within a given REIT over time.

Table IV examines three robustness checks of these results. The first two columns re-run re-run the fixed effects regressions for both measures of *q* without restricting the sample to observations with net investment less than 100 percent. This change in sample increases the sample by 23 observations but has only a modest effect on the estimated coefficients on *q*; in contrast, the estimated coefficients on cash flow increase dramatically. As an alternative method for dealing with these outliers in investment, we use robust regressions to downweight outliers based on the goodness of fit rather than based on an arbitrary cutoff. We report the robust regression results for the two measures of *q* in the third and fourth columns of Table IV. Again, the estimated coefficients on *q* are quite similar to those found in the restricted sample; robust regression does, however, reduce the magnitude of the estimated cash flow coefficients. Overall, excluding outliers in net investment does not appear to drive our estimates of the relation between *q* and investment.

We also explore outliers along a different dimension: observations with unusually low or high values of *q*. In the last two columns of Table IV, we present results for a sample that excludes the observations with the lowest and highest one percent of the relevant measure of *q* for each regression. While this restriction has little effect on the estimated coefficient on traditional *q*, the estimated coefficient on NAV-*q* more than doubles to 0.93 (column 6) from 0.39 (column 2). One possible explanation for this change is that the actual relationship between investment and *q* is stronger than suggested by the results in Table III but some observations for NAV-*q* suffer from measurement error that attenuates the estimated effect.

We also consider the possibility that our measure of investment might be too broad relative to the previous literature. While REITs are required to restrict their investment to real estate and real estate-related activities, they can have a portion of their holdings in financial assets such as government securities. REITs may systematically vary the portion of their investment in real estate versus other assets in response to changes in *q*. Our results are virtually unchanged when we use a more limited measure of investment that includes only real estate assets[17] Thus, the investment findings appear to be driven by investment in properties rather than investment in cash or securities.

VII. Determinants of Measurement Error in Tobin's *q*

Our results suggest that an NAV-based Tobin's *q* generates much larger investment sensitivity than the traditional accounting-based measure of *q*. Under the assumption that our NAV *q* is a more precise measure of *q* than the traditional measure of *q*, we model the measurement error (η) in *q* as the difference between NAV *q* and traditional *q* as follows:

$$\eta_{it} = q_{it}^{NAV} - q_{it}^{Trad} \qquad ()$$

In most cases, η is less than zero because the sample mean of traditional *q* is 1.35, while the mean of NAV *q* is 1.04.

As discussed above, the literature has mentioned a wide variety of reasons that investment is not very sensitive to changes in traditional *q*, including market power, increasing returns to scale, difficulties in valuing intangible assets or measuring the replacement cost of assets, and adjustment costs. Of these factors, the most likely problem for REITs is that the book value of capital does not equal the replacement cost of capital, possibly because the market value of assets in place can often rise of fall substantially based on changes in supply or demand

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[17] To save space, these results are available from the authors upon request.

for buildings in particular markets and for specific property types, as well as time series trends in the overall rate of property price inflation.

We examine the possibility of vintage and property sector effects by regressing the measurement error (η) on the average age of a REIT's properties, the average age squared, and the property sector of the REIT in Table V. We are only able to measure the average age of a REIT's properties for a single year (2001), so we have a single cross-section of 57 REITs.[18] The results in column (1) are consistent with vintage effects having a large and statistically significant impact on the measurement error in q. The coefficient on average age is positive, while the coefficient on age squared is negative. The coefficients suggest that REITs with an average age of about 23 years have the largest measurement error in q, or alternatively, have the biggest difference between the book value and the market value of the assets.

Columns (2) and (3) add controls for UPREITs and the primary property sector for each REIT. UPREITs are REITs that acquire some of their properties through a partnership transaction in which a private owner of properties contributes the properties to the REIT and receives partnership units that are convertible into common shares of the REITs. This transaction avoids capital gains taxes for the contributor and is thus particularly attractive to owners of buildings that have a large difference between book value and market value and thus large potential capital gains. Not surprisingly, UPREITs have a much larger measurement error in q. Finally, the property sector can also have a big impact on measurement error as actual depreciation (and appreciation) rates of assets can vary across these various sectors.

[18] The data on average age are missing for two REITs in 2001.

Finally, we examine how the impact of measurement error in q changes over time. Figure 2 shows the mean value of traditional q and NAV q, by year, from 1993-2002. Clearly the difference between these series exhibits a strong time series pattern. The value of measurement error was at its highest at the beginning of the sample when there were few REITs in existence. The typical REIT in the sample in 1992 had acquired many assets in the 1980s when accelerated depreciation was common, artificially driving the book value of real estate assets relative to the market value. From 1993 to 1997, the mean measurement error began to fall as REITs acquired new assets whose market value and book value were naturally quite similar.[19] After 1997, REITs stopped acquiring many new properties as their value of q fell. Between 1998-2000, commercial real estate prices continued to rise even though the book value of REIT assets fell due to the inevitable effect of depreciation. Finally, the value of measurement error stabilized as commercial real estate values have leveled-off or even fallen slightly during the recent recession.

This time series pattern in the measurement error in q has been removed from our investment results in some of the specifications in Tables 2-4 by the inclusion of time dummies. However, the time dummies wipe out an important source of variation in the measurement error in q. Years when NAV q were high were also years when REITs acquired most of their properties. While the remaining variation across firms over time is enough to find a large coefficient on NAV q, the coefficient on NAV q would be more than twice as big (0.91 versus 0.37) if we were to drop the time dummies and keep the firm fixed effects.

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[19] The equity market capitalization of the REIT industry grew from $32 Billion in 1993 to $140 Billion in 1997 as REITs embarked on an acquisition boom. During this entire period, the mean NAV q for our sample always exceeded unity.

VIII. Conclusion

REITs provide a good opportunity to examine how investment decisions respond to Tobin's q. In this paper, we compare the sensitivity of investment to a traditional measure of q, constructed with accounting based measures of the replacement cost of assets, and a NAV-based estimate of q that is computed using appraisals. Investment equations using the accounting-based measure of q yield small and imprecise parameter estimates on q, consistent with results from naive estimation strategies using the broader spectrum of firms. In contrast, investment is quite sensitive to the appraisal-based measure of q, with parameter estimates considerably larger than the values found by studies that use econometric methods to improve the measurement of q. For example, REITs with a Tobin's q of 1.1 will increase its assets by 4.3 percent during the year relative to a REIT with a q value of 1.0. In addition, we find that the difference between the alternative measures of q (which we refer to as measurement error) depends on the vintage of a firm's assets and the specific types of property it owns.

Given our focus on the real estate industry, our results are not directly comparable to previous studies. Nevertheless, the difference in results across the two measures of q indicates that problems in measuring q can have major implications for estimated parameters, even in an industry which meets many of the assumptions made in Tobin's original paper. Furthermore, given that real estate comprises at lease 25 percent of the assets of the average non-financial firm, our results may help explain the poor statistical performance of traditional measures of q in other, broader studies.

Our results suggest several avenues for further research. First, REITs vary in whether they acquire existing properties or engage in joint ventures that develop new properties; this variation may provide more information on how adjustment costs vary across types of investment. Second, empirical tests of the q theory of investment assume that the value of equity relative to the replacement cost of assets reflects real investment opportunities of the firm. In contrast, if stock prices are subject to "fads," then the difference between the stock market value and the value of underlying assets might present an investment opportunity for investors and for the firm but the value-maximizing response would not involve real investment. Instead, when the share price is relatively high, the firm could issue shares and reduce its debt; when the share price is relatively low, the firm could borrow and repurchase shares. Finally, we can use the NAV-based estimates of q to look for non-linearities in the responsiveness of investment to q. In particular, agency problems might lead managers to be more willing to increase the size of the firm when q is high but be unwilling to shrink the size of the firm (through property sales or other types of disinvestment) when q is low.

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Table I: Summary Statistics

Panel A: Net Investment < 100%

	N	Mean	Median	Standard Deviation
Traditional *q*	458	1.35	1.27	0.41
NAV *q*	458	1.04	1.01	0.12
Change in Assets: (Assets $_t$ - Assets $_{t-1}$)/Assets $_{t-1}$:	458	0.18	0.10	0.22
Cash flow from operating activities: Cash Flow $_t$/Assets$_{t-1}$	458	0.071	0.073	0.034
Cash flow from operating activities less Required Dividend: (Cash Flow $_t$ - Required Dividend $_t$)/Assets$_{t-1}$	458	0.036	0.040	0.031
Required Dividend $_t$ / Assets$_{t-1}$	458	0.035	0.032	0.024
Average Age (year = 2001 only)	57	16.6	16.2	7.0
UPREIT = 1	458	0.77	1	0.42
Property = Diversified / Other	458	0.08	0	0.27
Property = Hotel	458	0.02	0	0.14
Property = Industrial	458	0.05	0	0.21
Property = Office	458	0.15	0	0.35
Property = Residential	458	0.31	0	0.46
Property = Retail	458	0.34	0	0.48
Property = Self-Storage	458	0.05	0	0.23

Panel B: Whole Sample

	N	Mean	Median	Standard Deviation
Traditional *q*	481	1.36	1.28	0.42
NAV *q*	481	1.04	1.02	0.12
Change in Assets: (Assets $_t$ - Assets $_{t-1}$)/Assets $_{t-1}$:	481	0.24	0.12	0.38
Cash flow from operating activities: Cash Flow $_t$/Assets$_{t-1}$	481	0.074	0.074	0.038
Cash flow from operating activities less Required Dividend: (Cash Flow $_t$ - Required Dividend $_t$)/Assets$_{t-1}$	481	0.038	0.042	0.033
Required Dividend $_t$ / Assets$_{t-1}$	481	0.036	0.033	0.025
Average Age (year = 2001 only)	57	16.6	16.2	7.0
UPREIT = 1	481	0.77	1	0.42
Property = Diversified / Other	481	0.08	0	0.27
Property = Hotel	481	0.02	0	0.14
Property = Industrial	481	0.05	0	0.21
Property = Office	481	0.16	0	0.37
Property = Residential	481	0.31	0	0.46
Property = Retail	481	0.33	0	0.47
Property = Self-Storage	481	0.05	0	0.22

Table II:

Base Specification with Traditional *q*

Dependent Variable: Δ Total Assets

	(1)	(2)	(3)	(4)
Traditional *q*	0.028 (0.024)	-0.017 (0.036)	0.0043 (0.0251)	-0.048 (0.038)
Cash Flow	2.11 (0.29)	3.95 (0.57)		
Cash Flow less Required Dividend			1.72 (0.31)	3.27 (0.62)
Required Dividend			3.07 (0.44)	5.16 (0.72)
Constant	-0.012 (0.034)	-0.066 (0.091)	0.0013 (0.0344)	-0.044 (0.090)
Year and firm effects	No	Yes	No	Yes
R^2	0.13	0.53	0.14	0.54
F-Test (p-value)*			0.0043	0.0069
N	458	458	458	458

Note: Includes observations for all firm-years with change in total assets of less than 100% in one year. Standard errors are in parentheses.
* - The F-test is on the null hypothesis that the coefficients of the Cash Flow less Required Dividend and Required Dividend variables are equal.

Table III:

Base Specification with NAV *q*

Dependent Variable: Δ Total Assets

	(1)	(2)	(3)	(4)
NAV *q*	0.70 (0.08)	0.43 (0.14)	0.70 (0.09)	0.37 (0.14)
Cash Flow	1.33 (0.27)	3.52 (0.57)		
Cash Flow less Required Dividend			1.32 (0.30)	3.08 (0.62)
Required Dividend			1.35 (0.43)	4.33 (0.72)
Constant	-0.64 (0.08)	-0.56 (0.17)	-0.64 (0.08)	-0.51 (0.17)
Year and firm effects	No	Yes	No	Yes
R^2	0.25	0.54	0.25	0.55
F-Test (p-value)*			0.9403	0.0642
N	458	458	458	458

Note: Includes observations for all firm-years with change in total assets of less than 100% in one year. Standard errors are in parentheses.
* - The F-test is on the null hypothesis that the coefficients of the Cash Flow less Required Dividend and Required Dividend variables are equal.

Table IV:

Regression Results and Outliers

Dependent Variable: Δ Total Assets

	(1)	(2)	(3)	(4)	(5)	(6)
Estimation	OLS	OLS	Robust	Robust	OLS	OLS
Sample	whole	whole	whole	whole	outliers excluded*	outliers excluded*
Traditional *q*	0.012 (0.053)		0.003 (0.030)		0.001 (0.073)	
NAV *q*		0.388 (0.207)		0.389 (0.114)		0.928 (0.233)
Cash Flow	9.77 (0.62)	9.60 (0.61)	6.41 (0.34)	6.11 (0.33)	10.52 (0.71)	9.68 (0.60)
Constant	-0.45 (0.12)	-0.87 (0.25)	-0.04 (0.17)	-0.54 (0.17)	-0.50 (0.14)	-1.40 (0.27)
Year and firm effects	Yes	Yes	Yes	Yes	Yes	Yes
N	481	481	481	481	471	471

* - The sample excludes the top and bottom 1% of observations with respect to Traditional *q* (Column 5) and NAV *q* (Column 6).

Standard errors are in parentheses.

Table V:

Decomposition of Measurement Error

Dependent Variable: Measurement Error: NAV *q* - Traditional *q*

Only for 2001

	(1)	(2)	(3)
Average Age	0.029 (0.013)	0.027 (0.011)	.025 (0.012)
Average Age Squared	-0.0006 (0.0003)	-0.0006 (0.0003)	-0.0005 (0.0003)
upreit		0.29 (0.07)	0.26 (0.08)
Hotel			0.28 (0.12)
Industrial			0.21 (0.14)
Office			0.13 (0.11)
Residential			0.04 (0.10)
Retail			0.06 (0.09)
Self-Storage			0.26 (0.12)
Constant	-0.55 (0.12)	-0.78 (0.12)	-0.85 (0.12)
R^2	0.089	0.309	0.469
N	57	57	57

Standard errors are in parentheses.

Figure 1:
Price-to-NAV Ratio for REITs (1992-2002)

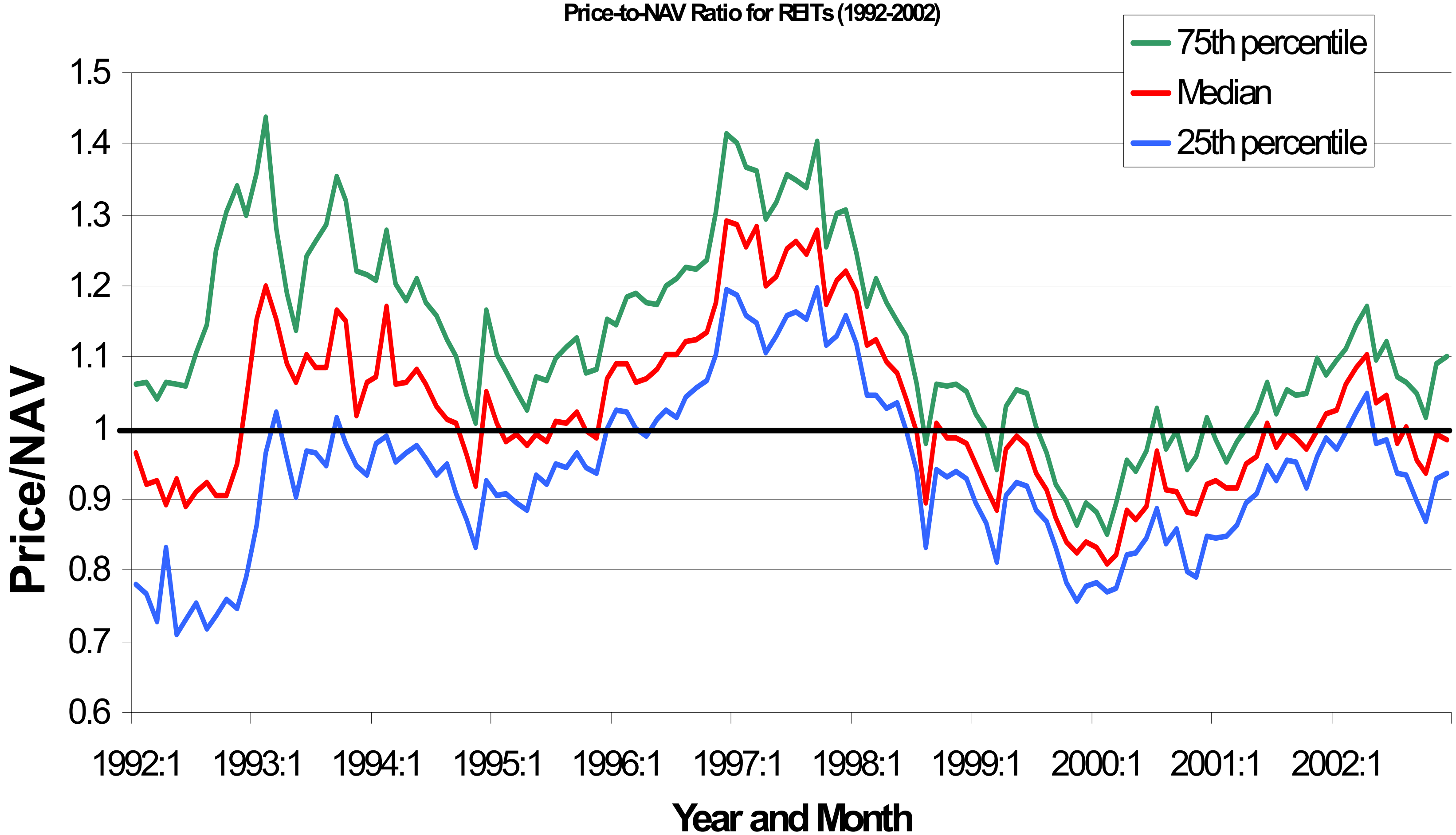

Figure 2:
Measurement Error in Tobin's q (1993-2002)