What Can We Learn About the Sensitivity of Investment to Stock Prices

with a Better Measure of Tobin's *q*?

William M. Gentry
Williams College

Christopher J. Mayer
Graduate School of Business, Columbia University
and NBER

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William M. Gentry; Department of Economics, Fernald House, Williams College, Williamstown, MA 01267; (413) 597- 4257; wgentry@williams.edu.

Christopher J. Mayer; Graduate School of Business, Columbia Business School, 808 Uris Hall, 3022 Broadway, New York, NY 10025; 212-854-4221; cm310@columbia.edu.

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William M. Gentry
Williams College

Christopher J. Mayer
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Abstract:

This paper examines the responsiveness of investment to Tobin's *q* using data from Real Estate Investment Trusts (REITs). We take advantage of high-quality estimates of the market value of a firm's assets instead of the more-commonly used book value of assets to estimate a more accurate value of *q*. We have three main results. First, while REITs have institutional features that mitigate many of the complications faced by previous studies, we still find little relationship between REIT investment and a traditional accounting-based measure of *q*. Yet our appraisal-based q generates elasticities of 43 percent, as much as 8 times larger than in previous studies. Second, when we decompose measurement error over time or remove a few large outliers, our estimates of the elasticity of investment with respect to *q* grow as high as 107%. Third, we show that other factors beyond Tobin's original model are still quite important. With our improved measure of *q*, cash flow still impacts investment, even the portion of cash flow that REITs are required by IRS rules to payout to shareholders as dividends and cannot be spent on investment. Also, we show that the relationship between our improved *q* and investment is non-linear; with little impact of *q* on investment when $q < 1$, but very large elasticities when *q* exceeds 1.

I. Introduction

Traditional *q*-theory describes 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, empirical support for this prediction has been difficult to find and the estimated sensitivity of investment to *q* in most studies is quite small. This lack of empirical support could be driven either by problems with the statistical methodology, such as measurement error in key variables, or the possibility that *q*-theory is an incomplete description of firms' investment processes.

In this paper, we consider real estate investment trusts (REITs) as a vehicle for sorting out the reasons behind the lack of empirical support for *q* theory. Most studies of Tobin's *q* use the book value of assets as a 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 the market value of equipment might fall appreciably when, for example, manufacturers offer a new generation product or demand falls. 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 use an alternative measure of the replacement cost of assets based on analyst estimates of the market value of a REIT's buildings to help circumvent the measurement error problem in Tobin's *q*. 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.[1]

Several institutional features of REITs mitigate other factors that have complicated empirical studies of investment. For example, since REITs spend very little money on advertising or research and development, we sidestep issues associated with valuing intangible assets. Furthermore, REITs have relatively little market power, so we are less worried about market structure driving non-linearities in the marginal product of capital.[2] Finally, REITs may face fewer adjustment costs than other firms because most of their assets are not firm-specific. In many cases, 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 fit better for REITs than for more commonly studied industrial firms.

While these factors mitigate some of the concerns associated with previous studies of investment and *q*, other complications remain. For example, many REITs specialize by property type and region so that the industry may still have some vestiges of non-constant returns to scale

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[1] Of course, one would like to generate such a measure for other industrial firms, but it is considerably more difficult. Analysts often compute the value of oil companies by multiplying proven reserves by the current and future forecast price of oil less extraction costs. In fact, a recent *New York Times* article (Berenson, 2004) notes that analysts pay much more attention to estimated reserves than actual production in valuing these companies. 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.

[2] 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.

and intangible assets. Managers may have scarce expertise in buying assets at good prices or turning-around buildings, complicating the relationship between the market value of assets and the market value of the firm. Finally, REITs may face nonlinear adjustment costs that limit their ability to expand too quickly or to sell existing assets.

Even with these complications, we show that measurement error plays an important role in biasing the estimated relationship between investment and q. As with most other studies using manufacturing firms, we find little or no statistical link between REIT investment and traditional accounting-based measures of Tobin's q. In contrast, we find a large and statistically significant relationship between REIT investment and our appraisal-based measure of q. Our base estimates with year and firm fixed effects show that a REIT starting the year with a q of 1.1 will be 4.3 percent larger by the end of the year than if it started the year with a q of 1.0. This estimated elasticity of 43 percent is roughly five times larger than the elasticities typically found in empirical investment studies.[3]

However, when we take additional steps to examine measurement error over time or to eliminate a small number of outliers, we find the elasticities of investment with respect to appraisal-based q increases to as much as 107%. While the magnitude of the coefficients may be specific to the real estate industry, the difference between the results using traditional versus appraisal-based q suggests that even the best previous studies may still underestimate the elasticity of investment with respect to q due to acknowledged difficulties in accurately measuring q.

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

With a more accurate measure of *q*, we can examine the biases associated with measurement error in *q* and also to compare Tobin's predictions with those from alternative models of investment that allow for agency costs or consider cash flow as a signal of future investment opportunities. First, we confirm that measurement error in *q* for REITs, which we define as the difference between the appraisal-based measure of *q* and the traditional measure of *q*, is related to factors commonly thought to create measurement error in *q* in the industrial literature. Measurement error depends on the vintage of a REIT's assets (capital), so that REITs with older buildings exhibit greater measurement error. Also, changes in measurement error in *q* over time are coincident with changes in the market value of real estate.

Although reducing measurement error in the replacement cost of assets appreciably increases the economic and statistical importance of the estimated relationship between investment and Tobin's *q*, other factors seem to affect investment that are not necessarily part of traditional *q*-theory. For example, the apparently large reduction in measurement error in *q* only causes a modest reduction in the importance of cash flow in predicting investment. Hence, *q* does not appear to be a sufficient statistic for predicting investment. REITs must also pay out an appreciable portion of their cash flow in the form of dividends. Yet investment is positively associated with the portion of cash flow that must be paid out as a dividend and thus is not available to the firm to use in financing investment, suggesting that the correlation between cash flow and investment is not purely driven by liquidity constraints.

Finally, we document non-linearities in the relationship between investment and *q*.[4] When *q* is below one, our results suggest little relationship between investment and *q*. REITs do

[4] When we use the traditional accounting-based measure of *q*, we do not observe this non-linearity, potentially because the measurement error in *q* clouds the relationship.

not appear, on average, to disinvest, which would be the standard prediction from investment theory if REITs face relatively low costs of redeploying assets by selling buildings. This non-linearity suggests a role for either agency costs (managers choose not to sell assets, even if doing so would be in the best interests of shareholders) or some other asymmetric adjustment cost associated with dis-investment. The positive relationship between investment and q is driven by observations for which q is between 1.0 and 1.25, when REIT investment rises rapidly with increases in q. However, the positive relationship between q and investment flattens out when annual investment reaches about 35% of existing assets ($q > 1.25$), suggesting that REITs appear to have difficulty absorbing too much new investment in a given year. This latter finding is consistent with adjustment costs that increase with the level of new investment, possibly due to limits on managers' ability to expand the firm too quickly.

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.

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, 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. Finally, REITs face some limits on short-term asset sales and ownership (Brueggeman and Fisher, 2001).

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

Studies of investment typically begin with insights from Tobin's (1969) seminal paper on investment. Tobin shows 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 of the project is called *q*. Hayashi (1982) shows that Tobin's original hypothesis applies (i.e., a firm will invest if the market value of the firm exceeds the replacement value of the firm) only with certain relatively restrictive conditions, including a perfectly competitive output market and a constant returns to scale production technology. These conditions eliminate economic profits on inframarginal investments so that the firm's marginal project has the same value as its average project. This highlights an important difference between *marginal q*, the *q* ratio that a firm faces on its latest investment project and *average q*, which is the *q* ratio that a firm faces on all of its investment projects.

In addition, investment theory must also consider adjustment costs.[5] The simplest models of investment provide conditions for the equilibrium size of the capital stock but do not describe the dynamics of the investment process. With adjustment costs, the benefits of investment as measured by q are traded off against the non-linear costs of investing. Nonetheless, q theory still suggests that q is a sufficient statistic for the value of investing, although the functional form of this relationship depends on the form of adjustment costs. That is, q fully captures the firm's incentive to invest so the theory predicts a univariate relationship between investment and q.

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 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 such as cash flow 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. Researchers often blame measurement error for

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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.

the failure of empirical tests of q theory. For example, accounting data provide only an imperfect proxy for the true replacement cost of the firm. Instead of the market value of assets, researchers usually see the historical cost of assets, which is typically not adjusted for inflation and is computed using original cost minus General Accepted Accounting Principles (GAAP) depreciation, a very noisy approximation to 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. It is also very hard to adequately determine the market value on spending for intangible assets such as advertising or research and development.

Previous research has used many strategies to deal with measurement error and differences between marginal and average q. 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, some types of measurement error in q may persist over time. 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.

Other authors look for alternative sources of data. Cummins, Hassett, and Hubbard (1994) argue that tax reforms create surprise innovations in tax-adjusted q and create a good instrument. They find much larger coefficients on q in the investment equation, although they also continue to find a role for cash flow and show that the coefficients on *q* vary a lot depending on the specific tax reform. 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 different line of research investigates 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]

Other authors suggest that the empirical failure of *q* theory may be related to a flawed assumption of a perfectly efficient stock market in which stock prices reflect future growth opportunities. 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, they argue that the standard empirical exercises are based on the joint hypothesis of market efficiency and *q* theory. Alternatively, managers might use their superior knowledge of the true value of the firm to distort investment decisions. If stock prices include an nonfundamental component, then external equity can be cheaper than other forms of capital when the stock price is high relative to its fundamental value. Baker, Stein, and Wurgler (2003) discuss the difficulties of distinguishing this equity financing channel from the traditional interpretation of investment and *q*. They show that investment is sensitive to the "nonfundamental" component of stock prices, especially for equity dependent firms.

Despite the volume of research, there persists widespread disagreement on the size of the sensitivity of investment to *q*, the role of cash flow in the investment equation, and the relative importance of alternative models of investment. We address these issues by examining firms that specialize in owning commercial real estate (REITs). The nature of the industry allows us to obtain appraisals data on the fair market value (or replacement cost) of each firm's assets, instead of simply relying on accounting data that uses historical measures of cost. Commercial real estate is also a relatively competitive industry for which the assumption of constant returns

[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 (2003).

to scale seems plausible and there are relatively few intangible assets. As discussed in the next section, while these characteristics of the REITs reduce possible measurement error in *q*, they do not eliminate all of the potential sources. In addition, since 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. Nonetheless, this study presents new evidence on the applicability of Tobin's original model of investment and its subsequent alternatives.

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. Green Street is a buy-side equity research firm that uses its estimates to advice clients (often large institutional investors) on selecting REITs as investments. Green Street's goal is to compare the market value of the REIT's common stock with the market value of the underlying assets.

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

Green Street's analysts evaluate a REIT by studying both its financial data and the specific properties that it owns. In some cases, evaluating properties includes site visits to a REIT's major properties. Rather than merely apply financial valuations techniques based on firm-level discounted cash flow, Green Street assesses the market value of a REIT's properties. It compares the REIT's properties to other similar properties that have recently sold, adjusting for differences in tenants and leases. Thus, Green Street's NAV estimates reflect its opinion of the fair market value of the REIT's assets if they were to be liquidated under current market conditions. Green Street aggregates its property appraisals and adjusts for other ownership claims (such as the market value of debt and joint venture agreements) to calculate an NAV estimate for each REIT. Given the labor-intensive nature of this process, Green Street provides NAV estimates for only 40 percent of equity REITs in 2001, although the firms they cover represent 75 percent of total REIT value.

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 NAV estimates in the REIT industry. It is the only analyst firm to have a consistent set of NAV 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 determining the fair market value of each property owned by a REIT. 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.

In addition to the NAV estimates from Green Street, we obtain accounting data on investment, the book value of assets, debt and preferred equity, and cash flow from SNL Securities, Inc. and data on share prices from the University of Chicago's Center for Research in

Security Prices (CRSP). The SNL data also provide industry-specific information that are not available from broad-based accounting databases, such as Compustat, including details on the organizational form of the REITs and their net investment in real estate.[8] All variables are measured on an annual basis.

Our sample starts with 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 472 firm-years with non-missing data.

Over this sample period, the mean (median) share-price-to-NAV ratio is 1.05 (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 well below 0.9 for much of 1999-2000.

V. Empirical Specification and Measurement of *q*

Standard investment theory implies the following regression equation:

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

[8] One complication that we face is that many REITs operate as umbrella partnership REITs (UPREITs); see Sinai and Gyourko (2004) 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 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.

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_{t-1} is a measure of firm-specific Tobin's *q* at the beginning of the period (i.e., the value from the end of the previous period), α is a constant, β is the sensitivity of investment to *q*, and ϵ is the usual error term. The empirical model often includes year-effects, firm-effects, or both.[9] Since the error term may be serially correlated, we report robust standard errors for drawing statistical inference using the Huber-White methodology (see Woolridge 2002, P. 274-276).

Previous investment research measures *q* as:

$$q_{it} = \frac{E_{it} + D_{it} + PE_{it}}{BVA_{it}} \tag{2}$$

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

[9] We use fixed effects rather than random effects models throughout the paper because Hausman tests indicate that the assumptions underlying the use of random effects (i.e., the firm-effects are uncorrelated with other explanatory variables) can be rejected in our data.

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.

A natural question to ask is what factors lead to the variation in price-to-NAV (and, consequently, q) within our sample. Clearly, the stock market captures information that goes beyond the replacement value of existing assets. REITs tend to specialize by property type (e.g., office buildings or apartment complexes) and many concentrate on specific geographic areas. Growth opportunities could vary over time across subsectors of the industry, regions in the country, or with the relative skills of different managers. This variation is the standard investment opportunities rationale driving investment theory.

However, the ratio of price-to-NAV may not accurately capture all growth opportunities due to differences between the replacement value of existing assets and the returns from buying new assets. For example, some managers may specialize in purchasing assets at relatively low prices and "turning them around." If NAV reflects the current market value of the repositioned assets after being turned-around, not the opportunity cost of new investments, a firm's q may understate the investment opportunities of some firms. While such a scenario clearly has some merit, it is even a potentially larger problem for broader industrial firms. The relative simplicity of real estate assets and the nature of fixed lease contracts should make managerial ability relatively less important for REITs than for other companies. We include a complete set of time

[10] We do not adjust our measure of q for corporate taxes because REITs generally do not pay corporate-level tax. The standard tax adjustments for q reflect how the tax system affects the cost of acquiring new assets. We discuss investor-level taxes, below.

and firms fixed effects to pick-up any fixed biases associated with firm-level variation in managerial quality or time periods where turnarounds are particularly valuable. Nonetheless, if managers primary role is to turn-around existing assets and their ability or success varies over time, even our improved measure of asset value may not allow us to examine fully the implications of Tobin's model.

REIT share prices could also capture non-fundamental elements due to either fads in stock prices or market inefficiencies. Clayton and MacKinnon (2000) argue that the industry-wide component in the time-series of price-to-NAV represents a form of investor sentiment for REITs. Both the existence of non-fundamental factors in stock prices and the impact of such factors on investment has been hotly contested in the literature, but recent research suggests that such mispricings may lead managers to adjust their capital stock. Baker, Stein, and Wurgler (2003) show that non-fundamental elements of share price changes impact investment as managers attempt to take advantage of such mispricing.[11] Along different lines, Gilchrist, Himmelberg, and Huberman (2004) construct a model based on short-selling constraints and disperse investor beliefs that implies that stock market bubbles can lead to investment booms. If the market for share prices is not fully efficient, Tobin's original model may be less relevant as a predictor of firm investment.

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[11] In addition, managers could take advantage of any such mispricing by changing the firm's capital structure through equity issuance, share repurchases, and changes in borrowing. In a related paper (Gentry and Mayer, 2003), we examine whether REITs adjust their capital structure in response to deviations between price and net asset value. This analysis suggests that REITs do not make substantial shifts from debt to equity (or vice versa) in response to the price-to-NAV ratio. Moreover, the marginal sources of finance appear to be quite similar to the average sources of finance. However, since investment responds to price-to-NAV differences, REITs are more likely to issue equity when price-to-NAV is high and repurchase shares when price-to-NAV is low.

Other factors such as liquidity and taxes might also influence the price-to-NAV ratio and potentially impact our inferences. If investors value liquidity, then share prices in REITs may exceed the market value of their properties since REITs provide investors a more liquid alternative to investing directly in properties. This liquidity effect on the share price may reduce REITs' cost of capital (relative to the cost of raising funds through a less liquid form of venture), which might translate into another reason why REITs would have an advantage over non-public firms in buying properties. However, REITs can also compete with each other to buy properties, so it is unclear whether liquidity provides much advantage for REITs in buying properties. Also, such liquidity factors are generally thought of as varying over time within the industry and may well be soaked-up by time dummy variables in the estimation.

Tax considerations could affect the market value of REIT equity when the market value of the properties differs from the REIT's remaining tax basis in its properties. For any given future rental stream, a REIT's tax basis in its existing properties reduces the future tax liabilities of its investors. Thus, REITs with less tax basis may suffer a tax penalty in their equity price. Gentry, Kemsley, and Mayer (2003) examine the relationship between REIT share prices and their tax basis and find that share prices capitalize future investor-level taxes. Since properties have tended to appreciate over the 1990s, this affect would tend, on average, to lead to price-to-NAV below one in our sample. From the perspective of investment theory, these liquidity and tax effects could create measurement error in interpreting our measure of average q as a proxy for marginal q. Yet the inclusion of firm fixed effects might mitigate this effect, as tax differences are mostly firm-based. As an alternative, we re-ran all of the regressions using a q that was tax adjusted based on a methodology from our previous paper. The results were nearly identical to those reported below. Nonetheless, liquidity or taxes could lead to biases in our estimated *q*. That is, even when a REIT has no profitable investment opportunities, these factors could lead to an estimate of *q* that differs from one.

The use of NAV-based *q* also 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 since neither measure is based on estimates of the construction costs of new buildings.

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. Even so, the usual discussion of adjustment costs may still have a limited application for REITs since REITs do not typically use their buildings as a factor of production, but instead lease their buildings to tenants. 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.[12]

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[12] 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

Following previous studies, we augment the investment equation (1) with cash flow variables in some specifications. 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, 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 equal to 90 or 95 percent of taxable income. 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

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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 and Garmaise and Moskowitz, 2004, on such asymmetries in real estate markets.)

2000 and afterwards) and the remaining cash flow reflecting discretionary funds.[13] 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. (See Gentry, Kemsley, and Mayer 2001) Discretionary cash flow after the required dividend proxies for internal resources that 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 actually pay for the investment. We scale all cash flow variables by the total assets at the end of the preceding year, as is common practice.

We define REIT investment as the percentage change in total assets during the year, which is a commonly used measure of investment in empirical studies of corporate investment. All right-hand side variables are measured as of the beginning of the year (based on end of previous year's balance sheets). 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 more commonly used in the literature.[14] Our investment results are not sensitive to how we define investment. Neither of these measures of investment reflect changes in property value that occur once a REIT has purchased a property (other than changes in value driven by capital improvements).

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[13] 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.

[14] 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.

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.[15] 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 1.27; however, the median appraisal-based q is only 1.01. 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 typically appreciate in value). For regression analysis, however, the critical issue is not the level of the 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 7.1 percent of assets in cash flow every year. However, using GAAP net income, we estimate that the

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

median REIT must payout a dividend of approximately 3.5 percent of assets. The remaining cash flow, which is available due to depreciation allowances and other non-cash expenses that reduce net 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. The first two columns present results from specifications without cash flow. In the specification without firm or year fixed effects (see column 1), the estimated coefficient on traditional q (0.07) is larger than that found in most investment studies and is statistically different from zero at the 95 percent confidence level. However, the inclusion of firm and year effects, as is common in this literature, greatly reduces the size of the estimated coefficient on q and the estimated coefficient is no longer statistically different from zero. The remaining specifications include cash flow variables. The inclusion of cash flow variables leads to estimated coefficients on q that are small and statistically indistinguishable from zero, regardless of whether the model includes firm and year fixed effects or how cash flow is defined. Overall, despite the real estate industry arguably being closer to constant returns to scale and having fewer intangible assets than most other industries, investment regressions with traditional measures of q suggest little relationship between Tobin's q and investment.

Across the various specifications, the estimated coefficients on the cash flow variables are large and statistically different from zero, 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 an estimate of the required dividend and cash flow in excess of the required dividend. The coefficient 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 95 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.

Table III presents comparable specifications that use NAV-based *q* instead of traditional *q*. 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 0.84. Furthermore, the explanatory power of all regressions (the adjusted-R^2) increases when using the NAV-based *q* instead of traditional *q*. These estimated effects imply that REIT investment is highly sensitive to *q* as a proxy for investment opportunities when *q* is measured more accurately. For example, using the estimate of 0.43 from the specification in the fourth 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. 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. For example, the real estate industry may face lower adjustment costs than other industries so that our REIT sample may exhibit relatively larger sensitivities to *q*. However, if industry differences were the sole explanation for our results, 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*

Given the differences between REITs and other firms, in comparing our results with previous findings, we focus on how reducing measurement error (through a variety of methods) changes the estimated investment sensitivities. 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 *q* yield a sensitivity around 0.014 but their estimates using analysts forecasts of earnings to construct *q* range from 0.104 to 0.139. Our estimates are above the estimates of other papers and are thus 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). Our methodology–focusing on the difference between traditional and appraisal-based measures of *q*–suggests that reducing measurement error can increase investment sensitivities by a similar magnitude as in Cummins, Hassett, and Hubbard, suggesting a relatively large sensitivity of investment to *q*.

While the larger estimated effects of *q* on investment and the improved explanatory power in the regressions using NAV *q* suggest that measurement error is an important reason why previous research finds low investment sensitivities to *q*, other evidence implies that measurement error is not the only problem for empirical tests of basic *q*-theory. Most importantly, reducing measurement error in *q* causes only a modest reduction in the estimated effects of cash flow on investment and the estimated coefficients on cash flow are statistically different from zero at the 99 percent confidence level. For example, 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. 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.

A basic prediction from *q*-theory is that firms should invest when *q* is greater than one and disinvest when *q* is less than one. For REITs, disinvestment would take the form of selling buildings to buyers with (presumably) higher valuations. Such asset sales are feasible if the Green Street property appraisals of the market value of assets are accurate. Other firms may have a harder time disinvesting than REITs, so this analysis is unique to REITs. One problem that prior research has faced in testing this prediction is that measurement error in *q* makes it impossible to know whether q is above or below one. For example, in our sample, the median traditional q is 1.27 but the median NAV q is 1.01; thus, using book values tends to overstate q. Moreover, the linear functional form commonly assumed in the literature assumes that the relationship between investment and q is linear. To examine both the hypothesis that firms investment when q is greater than one and disinvest when q is less than one and the linearity assumption, we use a nonparametric kernel density estimator to examine the relationship between investment and q.

Figure 2 plots data on investment (on the vertical axis) against NAV q (on the horizontal axis). In Panel A, the figure includes both the data and the plot of the lowess smoother; in Panel B, the figure includes only the lowess smoother to isolate the non-parametric estimation of the relationship between investment and q. The non-parametric estimation yields several interesting conclusions. First, when q is less than one, investment does not appear to respond to differences in q. That is, the implied regression line is basically flat until NAV q approaches one. Second, on average, REITs do not disinvest when q is less than one, which contradicts the theoretical prediction. Third, the positive relationship between investment and q that we observe in the linear regressions is primarily driven by observations for which q is between 1.0 and 1.25. When q >1.25, firm investment appears to plateau, consistent with large adjustment costs associated with very high levels of investment. Overall, the relationship does not appear to be linear and the data do not support the hypothesis that firms with low q disinvest.

There are a number of possible explanations for the non-linear relationship between investment and q. First, the lack of disinvestment or selling assets when q is low could result from asymmetric adjustment costs. Potentially, REITs could face higher costs of selling properties than they face for buying properties. While asymmetric adjustment costs between investing and disinvesting are plausible in many industries, this asymmetry seems more dubious in the real estate where sales of individual or portfolios of buildings are quite common. Second, managers may be reluctant to disinvest when q is low because they would prefer to manage a larger firm rather than a smaller firm. Thus, agency costs could be an important determinant of investment. Third, the nonlinearity in investment is less surprising if the relationship between investment and q is driven by the equity financing channel (see the discussion of Baker, Stein, and Wurgler, 2003, above) or the possibility that stock market bubbles have real effects on investment (see Gilchrist, Himmelberg, and Huberman, 2004) since a q above one implies that managers view equity as a cheap source of financing; however, when q is less than one, managers may reduce investment to zero but not actually disinvest.

We perform several sensitivity tests that bolster our main conclusions.[16] First, we explore the possibility that measurement error still infects a small number of observations with unusually low or high values of q by removing 51 observations with values of q in the top and bottom 5 percent of the sample. This restriction substantially increases the magnitude of the coefficient estimates on both for traditional q (from -0.02 to 0.23) and for NAV q (from 0.43 to 1.07) relative to our base specification in column 4 in Tables 2 and 3, respectively. This result is striking and suggests that measurement error still might play a large role for a small number of observations. The elasticity of 1.07 for NAV q closely mirrors the elasticity of NAV q in the kernel regressions for REITs with q between 0.85 and 1.2. Of course, the elasticity of investment with respect to q is even bigger for those observations for q between 1.0 and 1.2.

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

Second, we examine the opposite issue–would our conclusions change if we included all REIT-years in our study? Our base sample examines on firm-years in which the REIT had net investment less than 100 percent of previous year's assets. This restriction reduces our sample by 23 observations. If we include these 23 observations in the analysis, the estimated coefficients on q are quite similar to those reported in Tables II and III though the estimates are somewhat less precise. For example, using the specification in column (4) of Tables II and III as a benchmark, the estimated coefficient on traditional q is 0.01 (with a robust standard error of 0.06) and the estimated coefficient on NAV q is 0.34 (with a robust standard error of 0.28). However, the inclusion of these outliers more than doubles the estimated coefficients on the cash flow variable.[17]

Third, we 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. Thus, the investment findings appear to be driven by investment in properties rather than investment in cash or securities. Overall, these additional tests only bolster our basic findings.

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[17] 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. Again, the estimated coefficients on q are quite similar to those found in the restricted sample and are statistically different from zero at the 95 percent confidence level; robust regression does, however, reduce the magnitude of the estimated cash flow coefficients. The robust regression generates case weights based on the absolute size of residuals, with larger residuals obtaining smaller weights. It is useful in situations where some (unknown) observations suffer from measurement error. (See Stata Reference Manual Q-St, version 8.0, Pp. 152-257 for a precise description of the algorithm.)

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

So far we have shown that an NAV-based Tobin's *q* generates a much larger investment sensitivity than the traditional accounting-based measure of *q*. If we accept that NAV *q* is a more precise measure of *q* than the traditional measure of *q*, we can model measurement error (η) in *q* as the difference between NAV *q* and traditional *q* as follows:

$$\eta_{it} = q_{it}^{NAV} - q_{it}^{Trad} \tag{3}$$

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 1.05.

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 or fall substantially based on changes in supply or demand 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 IV. 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

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

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 properties whose average age is about 24 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 umbrella partnership REITs (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 (see Sinai and Gyourko, 2004, for more details). 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 (large accrued 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.

Finally, we examine how the impact of measurement error in *q* changes over time. Figure 3 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.

The possibility that measurement error declined over time suggests that splitting our sample into the early and later years to examine whether the difference between investment sensitivities to traditional *q* and NAV *q* is stable over time. Although we have a relatively small sample, we consider an additional specification that allows the coefficient on *q* to differ between the periods 1993 - 1998 and 1999 - 2002. (Once again, these results are available on request.) For the specifications with traditional *q* (with firm and year effects), the estimated coefficient on *q* in the early period is close to zero (−0.07) but the estimated coefficient on *q* in the later period is larger (0.46) and statistically different from zero at the 99 percent confidence level. By comparison, using NAV *q*, the estimated coefficients on *q* are 0.38 in the early period and 0.64 in the later period.[20] Thus, it appears that the investment sensitivity to *q* was stronger in the later period. More importantly, the improved predictive power of the traditional *q* reinforces the conclusion that the differences between the results using the different measures of *q* are related to measurement error in *q*. This finding further supports our premise that measurement error in *q*

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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.

[20] These estimated coefficients are statistically different from zero at the 95 and 99 percent confidence levels, respectively.

can create very large biases in the coefficients in investment equations with Tobin's q, even larger biases than have been found in previous studies.

The time series pattern in the measurement error in *q* has been removed from our investment results in some of the specifications in Tables II and III by the inclusion of time dummies, as is standard in the literature. However, the time dummies wipe out an important source of variation 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 still results in 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.

VIII. Conclusion

REITs provide an opportunity to examine how investment decisions respond to Tobin's *q* when the replacement cost of assets is measured using an estimate of fair market value rather than historical cost. In this paper, we compare the sensitivity of investment to alternative measures of *q*. Investment equations using the accounting-based measure of *q* yield quite small and imprecise parameter estimates on *q*, consistent with results from naive estimation strategies using a broader spectrum of firms. Yet we show that investment is quite sensitive to an appraisal-based measure of *q*, with parameter estimates up to five times larger than the values found by studies that use various econometric methods to improve the measurement of the coefficient on *q*. 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. Sample decomposition suggests that even our improved measure of *q* still suffers from some measurement error over time, leading to a downward biased coefficient on *q*. In some equations we find estimated elasticities of investment with respect to *q* that exceed 100 percent, or almost 20 times larger than those found in previous studies.

Given our focus on the real estate industry, these 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. However, our results may 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 4^{th} 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.[21] The historical importance of real estate assets on corporate balance sheets could play a significant role in creating measurement error for studies of investment and Tobin's *q*, in addition to the more commonly-recognized problems of mis-classifying investment in advertising or R&D.

While our results confirm that measurement error in *q* is an important empirical issue for measuring investment sensitivities, our results also suggest that basic *q*-theory does not fully explain investment decisions. Cash flow variables persist in helping predict investment. Moreover, even the portion of cash flow that the IRS requires REITs to distribute as a dividend

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[21] 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.

helps explain investment, suggesting that cash flow effects capture more than just financing constraints (Abel and Eberly 2004). Finally, the sensitivity of investment to q appears to be nonlinear and we argue that asymmetric physical adjustment costs are unlikely to explain this nonlinearity. These issues suggest that other models of investment that emphasize frictions such as agency costs (Albequerque and Wang 2006 and Grenadier and Wang 2005) or stock market imperfections (Gilchrist, Himmelberg, and Huberman 2004 and Baker, Stein, and Wurgler 2003) provide useful insights into the investment process. Nonetheless, these results also suggest that q theory can explain much more of the volatility of firm investment than has been previously shown.

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Table I: Summary Statistics

Panel A: Net Investment < 100%

	N	Mean	Median	Standard Deviation
Traditional *q*	449	1.35	1.27	0.41
NAV *q*	449	1.05	1.01	0.16
Change in Assets: (Assets $_t$ - Assets $_{t-1}$)/Assets $_{t-1}$:	449	0.18	0.10	0.22
Cash flow from operating activities: Cash Flow $_t$/Assets$_{t-1}$	449	0.071	0.073	0.034
Cash flow from operating activities less Required Dividend: (Cash Flow $_t$ - Required Dividend $_t$)/Assets$_{t-1}$	449	0.036	0.040	0.030
Required Dividend $_t$ / Assets$_{t-1}$	449	0.034	0.032	0.023
Average Age (year = 2001 only)	56	16.7	16.2	7.1
UPREIT = 1	449	0.77	1	0.42
Property = Diversified / Other	449	0.08	0	0.27
Property = Hotel	449	0.02	0	0.14
Property = Industrial	449	0.05	0	0.21
Property = Office	449	0.14	0	0.35
Property = Residential	449	0.31	0	0.46
Property = Retail	449	0.34	0	0.47
Property = Self-Storage	449	0.06	0	0.23

Panel B: Whole Sample

	N	Mean	Median	Standard Deviation
Traditional *q*	472	1.36	1.28	0.42
NAV *q*	472	1.05	1.02	0.15
Change in Assets: $(\text{Assets}_t - \text{Assets}_{t-1})/\text{Assets}_{t-1}$:	472	0.24	0.12	0.38
Cash flow from operating activities: $\text{Cash Flow}_t/\text{Assets}_{t-1}$	472	0.074	0.073	0.038
Cash flow from operating activities less Required Dividend: $(\text{Cash Flow}_t - \text{Required Dividend}_t)/\text{Assets}_{t-1}$	472	0.038	0.041	0.033
$\text{Required Dividend}_t / \text{Assets}_{t-1}$	472	0.036	0.033	0.024
Average Age (year = 2001 only)	56	16.6	16.2	7.1
UPREIT = 1	472	0.77	1	0.42
Property = Diversified / Other	472	0.08	0	0.27
Property = Hotel	472	0.02	0	0.14
Property = Industrial	472	0.05	0	0.21
Property = Office	472	0.16	0	0.37
Property = Residential	472	0.31	0	0.47
Property = Retail	472	0.33	0	0.47
Property = Self-Storage	472	0.05	0	0.22

Notes: NAV *q* is a measure of Tobin's *q* that uses asset appraisals to measure the net asset value (NAV) of a firm's assets instead of the more traditional, book-based measure of *q*. UPREITs are umbrella partnership REITs are REITs who acquire some of their assets through partnership swaps and for whom the traditional book value of assets might be especially problematic (See footnote 8).

Table II:

Base Specification: OLS regressions with traditional *q*

Dependent Variable: Δ Total Assets

	(1)	(2)	(3)	(4)	(5)
Traditional *q*	0.07 (0.03)	0.02 (0.04)	0.02 (0.03)	-0.02 (0.04)	-0.05 (0.04)
Cash Flow			2.17 (0.28)	3.92 (0.73)	
Cash Flow less Required Dividend					3.25 (0.78)
Required Dividend					5.10 (0.88)
Constant	0.09 (0.04)	0.20 (0.09)	0 (0.04)	-0.06 (0.11)	-0.04 (0.10)
Year and firm effects	No	Yes	No	Yes	Yes
R^2	0.01	0.47	0.13	0.53	0.54
F-Test (p-value)*					0.02
N	449	449	449	449	449

Notes: NAV *q* is a measure of Tobin's *q* that uses asset appraisals to measure the net asset value (NAV) of a firm's assets instead of the more traditional, book-based measure of *q*. Includes observations for all firm-years with change in total assets of less than 100% in one year. Sample is 1992-2002. Robust 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: OLS regressions with NAV *q*

Dependent Variable: Δ Total Assets

	(1)	(2)	(3)	(4)	(5)
NAV *q*	0.56 (0.09)	0 .58 (0.20)	0.46 (0.09)	0.43 (0.20)	0.38 (0.20)
Cash Flow			1.64 (0.26)	3.54 (0.75)	
Cash Flow less Required Dividend					3.10 (0.79)
Required Dividend					4.30 (0.86)
Constant	-0.41 (0.09)	-0.46 (0.22)	-0.42 (0.09)	-0.57 (0.22)	-0.53 (0.23)
Year and firm effects	No	Yes	No	Yes	Yes
R^2	0.16	0.49	0.22	0.54	0.54
F-Test (p-value)*					0.09
N	449	449	449	449	449

Note: NAV *q* is a measure of Tobin's *q* that uses asset appraisals to measure the net asset value (NAV) of a firm's assets instead of the more traditional, book-based measure of *q*. Includes observations for all firm-years with change in total assets of less than 100% in one year. Sample is 1992-2002. Robust 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:

OLS regressions: Decomposition of measurement error

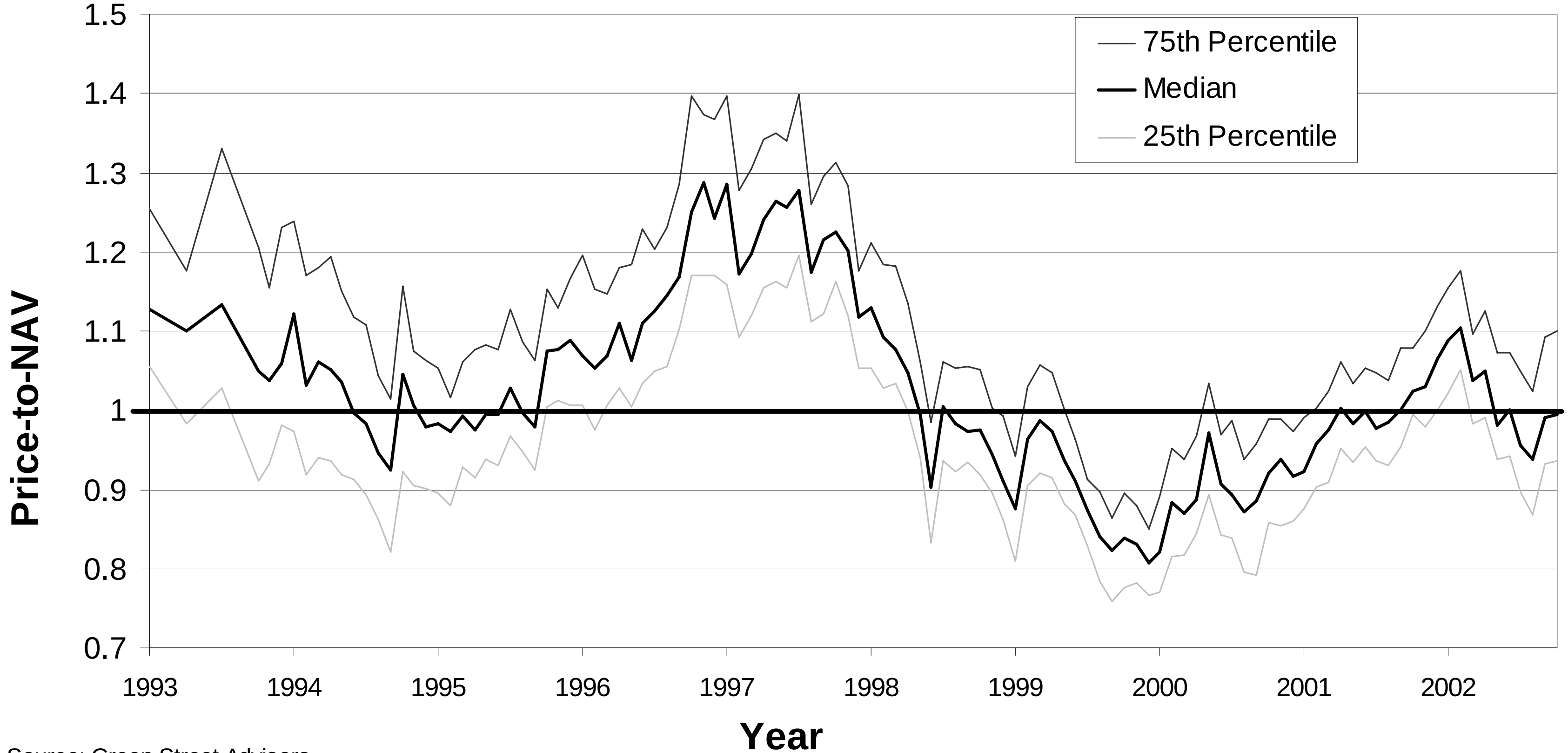
Dependent Variable: Measurement Error: NAV *q* - Traditional *q*

Only for 2001

	(1)	(2)	(3)
Average Age	0.034 (0.013)	0.031 (0.012)	0.029 (0.012)
Average Age Squared	-0.0007 (0.0003)	-0.0007 (0.0003)	-0.0006 (0.0003)
UPREIT		0.25 (0.07)	0.23 (0.08)
Hotel			0.28 (0.13)
Industrial			0.20 (0.15)
Office			0.12 (0.11)
Residential			0.04 (0.10)
Retail			0.10 (0.10)
Self-Storage			0.25 (0.12)
Constant	-0.57 (0.12)	-0.78 (0.12)	-0.84 (0.12)
R^2	0.119	0.294	0.441
N	56	56	56

Notes: NAV *q* is a measure of Tobin's *q* that uses asset appraisals to measure the net asset value (NAV) of a firm's assets instead of the more traditional, book-based measure of *q*. UPREITs are umbrella partnership REITs are REITs who acquire some of their assets through partnership swaps and for whom the traditional book value of assets might be especially problematic (See footnote 8). Standard errors are in parentheses.

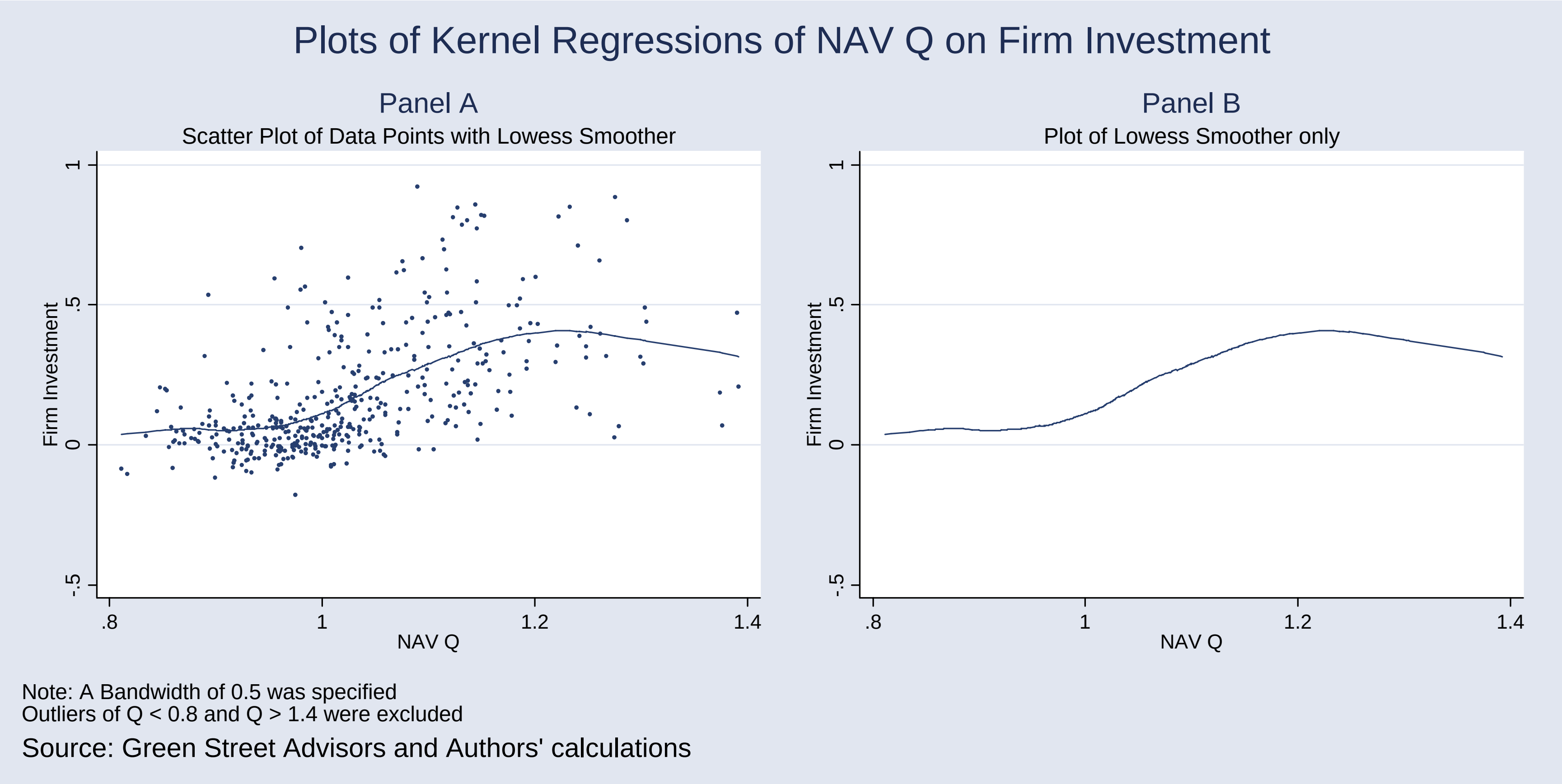
Figure 1:
Price-to-NAV for REITs (1993-2002)



Source: Green Street Advisors

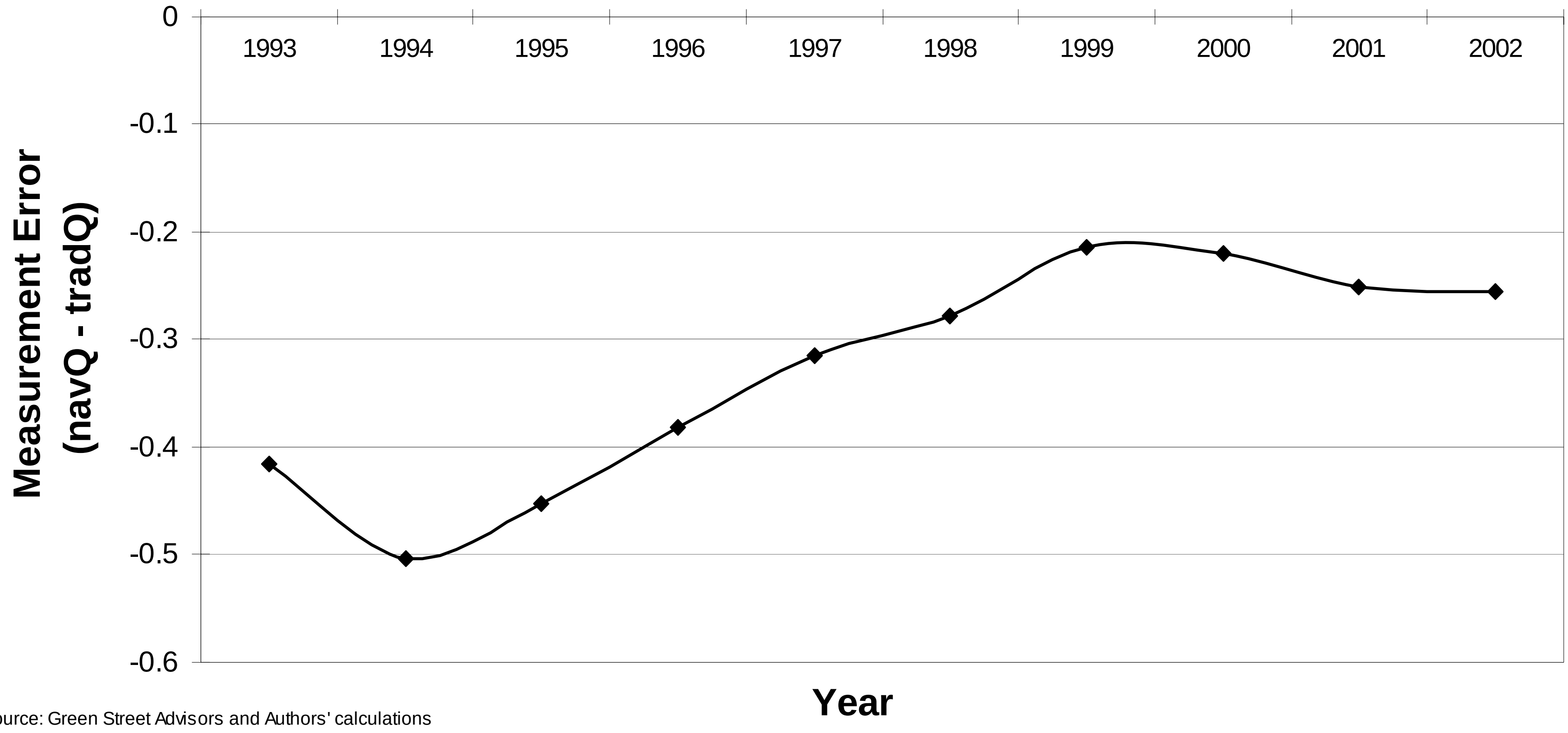
Note: Ratio of share price to NAV (net asset value).

Figure 2:



Note: NAV q is a measure of Tobin's q that uses asset appraisals to measure the net asset value (NAV) of a firm's assets instead of the more traditional, book-based measure of q.

Figure 3:
Measurement Error in Tobin's q (1993-2002)



Note: NAV *q* is a measure of Tobin's *q* that uses asset appraisals to measure the net asset value (NAV) of a firm's assets instead of the more traditional, book-based measure of *q* (*trad Q*).