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The Stock Market and Investment in the New Economy: Some Tangible Facts and Intangible Fictions

In the Old Economy, the value of a company was mostly in its hard assets—its buildings, machines, and physical equipment. In the New Economy, the value of a company derives more from its intangibles—its human capital, intellectual property, brainpower, and heart. In a market economy, it's no surprise that markets themselves have begun to recognize the potent power of intangibles. It's one reason that net asset values of companies are so often well below their market capitalization.

—Vice President Al Gore, speech at the Microsoft CEO Summit, May 8, 1997

I think there is such an overvaluation of technology stocks that it is absurd . . . and I'd put our company's stock in that category.

—Steve Ballmer, president of Microsoft Corporation, quoted in the *Wall Street Journal*, p. C1, September 24, 1999

BROADLY SPEAKING, there are two opposing views about the relationship between the stock market and the new economy. In one view, expressed in the quotation from Vice President Gore, intangible investment helps explain why companies' market values are so much greater than the values of their tangible assets. In the other view, expressed, ironically, by the president of one of the leading firms in the new economy, stock market valuations have become unhinged from company fundamentals.[1] Whatever the motivations of Gore and Ballmer in making these comments, their perspectives frame the debate about the relationship between the stock market and the new economy.

One way to start thinking about this relationship is in terms of the theory of stock market efficiency. When the stock market is strongly efficient, the market value of a company is, at every instant, equal to its fundamental value, defined as the expected present discounted value of future payments to shareholders. If we abstract from adjustment costs and market power, we can highlight the central role that strong stock market efficiency plays: it equates the company's market value to its enterprise value—that is, the replacement cost of its assets.

However, the most readily available measure of enterprise value in a company's accounts, the book value of tangible assets, is typically just a fraction of the company's market value. For companies in the new economy, book value is an even smaller fraction of market value, because these companies rely more on intangible assets than old economy companies do. Hence, the rest of this enterprise value must come from adjusting for the replacement cost of tangible assets and including intangible assets. When price inflation, economic depreciation, and technical progress are modest, the difference between the replacement cost and the book value of tangible assets is relatively small.[2] This means that intangibles account for the remaining difference.

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1. In his public comments, Ballmer consistently emphasizes this point, saying, for example, that market participants' expectations about Microsoft's growth are "outlandish and crazy," because Microsoft has "more competition than we ever have had before" (www.microsoft.com/msft/speech/analystmtg99/ballmerfam99.htm).

2. Economic depreciation and technical progress affect the relationship between book value and replacement cost in the opposite way from price inflation. Rapid inflation makes the book value of assets less than their value at current prices, whereas rapid economic depreciation and technical progress cause the book value of assets to exceed their value in quality-adjusted prices. In this sense, book value may actually exceed replacement cost for certain types of capital goods that have experienced rapid depreciation and technical progress, such as computers.

Unfortunately, it is difficult to gauge whether intangibles do in fact make up the difference, because they are, by their very nature, difficult to measure. For this reason, the Financial Accounting Standards Board (FASB) calls for a conservative treatment of intangibles: companies must select methods of measurement that yield lower net income, lower assets, and lower shareholders' equity in earlier years than other measures would. Thus expenditures for research and development (R&D), advertising, and the like are expensed rather than treated as assets, even though they are expected to yield future profits.[3] The stock market forms an expected value of these future profits, but the assets generating them will *never* show up on the balance sheet.[4] Consequently, many researchers argue that the fundamental accounting measurement process of periodically matching costs with revenues is seriously distorted, and that this reduces the informativeness of financial information.[5]

The practical appeal of thinking in terms of strong efficiency is that the purported growth of intangible capital that characterizes the new economy provides a ready explanation for the recent sharp rise in stock prices. Some researchers have even argued that the value of intangible assets can be inferred from the gap between market capitalization and the measured value of tangible assets.[6] The practical drawback, however, is that this makes the inferred valuation of intangible capital the critical determinant of market efficiency. At a basic level, then, the logic of this approach is circular: accounting principles for intangible assets are unsatisfactory, making it difficult for market participants to value companies; but strong stock market efficiency is assumed in order to assign a value

3. The difficulty of measuring these future benefits is the reason usually advanced for the requirement to expense these items. Generally Accepted Accounting Principles require that internal R&D, advertising, and other such costs be written off to expense when incurred. In contrast, purchases of intangibles from outside the firm—such as patents, trademarks, formulas, and brands—are recorded as assets, because market prices are available for these. The only exception to this asymmetric treatment is the capitalization of some software development costs (FASB, 1985).

4. This overview of the accounting treatment of intangibles is standard fare in introductory accounting textbooks. We base our discussion on Horngren, Sundem, and Elliot (1996).

5. The seminal research on intangibles by Baruch Lev and his collaborators forms much of the empirical basis for those who advocate fundamental reform of accountancy. For an overview of this research see Lev and Zarowin (1999).

6. Hall (1999) makes this case, for example.

to intangibles.[7] In essence, intangibles are the new economy version of dark matter in cosmology. The fundamental question in the two fields is the same: can an elegantly simple model be justified based on what we cannot easily measure?

When the stock market is not strongly efficient, a firm's market value can differ from its fundamental value. This formulation sidesteps the question of whether intangibles account for the missing value of companies, only to point up another question just as thorny. If the stock market fails to properly value intangibles, what do market prices represent? One perspective is that the stock market is efficient in the sense that prices reflect all information contained in past prices, or that they reflect not only past prices but all other publicly available information. The first of these is called weak efficiency and the second semistrong efficiency. These weaker concepts of market efficiency are not necessarily inconsistent with deviations of market prices from fundamental prices that are caused, for example, by bubbles. Another perspective eschews efficiency in favor of behavioral or psychological models of price determination. For our purposes we focus only on whether market prices deviate from fundamentals, not why, so we use the term "noisy" share prices as synecdoche for any of the potential reasons for mispricing.

Another way to begin thinking about the relationship between the stock market and the new economy is purely empirical. Tobin's average *q*—which is defined, in its simplest form, as the ratio of the stock market value of the firm to the replacement cost of its assets—provides the empirical link. Under conditions familiar from the *q* theory of investment, average

7. The perspective of Blair and Wallman (www.stern.nyu.edu/ross/ProjectInt/about.html), who head up the Brookings Institution's Intangible Assets research project (which is spearheading an effort to reform the accounting for intangibles), is so remarkable in this regard that it is worth quoting at length: "Currently, less than half (and possibly as little as one-third or less) of the market value of corporate securities can be accounted for by 'hard' assets—property, plant and equipment. . . . The rest of the value *must, necessarily*, be coming from organizational and human capital, ideas and information, patents, copyrights, brand names, reputational capital, and possibly a whole host of other assets, for which we do not have good rules or techniques for determining and reporting value" (italics added). Yet only under a number of strong assumptions, of which strong efficiency is just one, must intangibles make up the rest of a company's market value. Blair and Wallman believe that accountancy fails to convey crucial information about intangibles, so the assumption of strong efficiency would seem to be questionable. Of course, one need not take such an extreme position to justify efforts to collect better data.

q equals unity when the stock market is strongly efficient and taxes, debt, and adjustment costs are ignored. This means that the market value of the firm is just equal to the replacement cost of its tangible and intangible assets. Since intangible capital is difficult to measure, in practice average q is computed using tangible capital. This is why average q can exceed unity and why it must increase as intangible assets become a larger fraction of total assets.

To take specific examples, consider two companies that are intangibles-intensive: Coca-Cola and Microsoft. Most of the market value of the Coca-Cola Company consists of the value of its secret formula and marketing know-how, neither of which is recorded on its balance sheet.[8] Similarly, according to its chairman Bill Gates, Microsoft's "primary assets, which are our software and our software development skills, do not show up on the balance sheet at all."[9] Hence average q, constructed using only the replacement cost of tangible capital, should exceed unity for these companies.

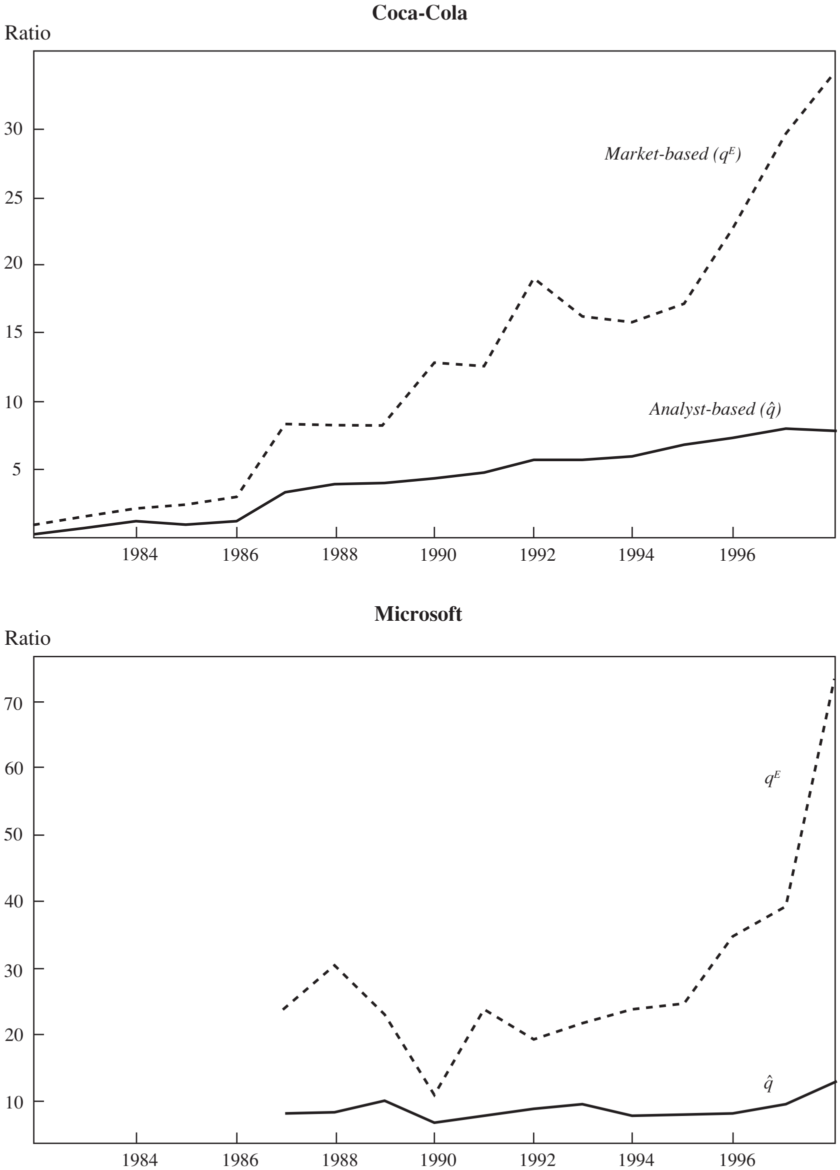
The upper panel of figure 1 plots Coca-Cola's average q, denoted as q^E, where the superscript indicates that we construct the variable using equity price data. In 1982, at the start of the time period we use in our empirical work, Coca-Cola's q^E is equal to one.[10] If we assume for the sake of argument that we constructed the replacement cost value of tangible assets without error, this indicates that the market undervalued Coca-Cola's intangible assets—indeed, it gave them no value at all. In contrast, in 1998, at the end of our sample period, Coca-Cola's q^E exceeds 34. If we assume strong efficiency, this means that the value of Coca-Cola's intangible assets increased from zero to thirty-three times the value of the company's tangible assets over those sixteen years. In other words, according to the market, Coca-Cola's intangibles are now worth thirty-three times what its tangible assets are worth, whereas they used to be worth nothing.

8. Coca-Cola divested itself of most of its physical assets when it spun off Coca-Cola Enterprises in 1986. In the calculations that follow we use consistent time-series data from Compustat that relate only to what is now the Coca-Cola Company.

9. www.microsoft.com/BillGates/Speeches/03-26london.htm.

10. Each annual observation here refers to the start of the firm's financial year. We discuss in greater detail the composition of our broader sample and the construction of the variables in it, including the ones we introduce in this section, below, and in appendix B. In particular, the two measures of fundamentals that we introduce here contain all the usual adjustments for debt, taxes, and so forth.

Figure 1. Market-Based and Analyst-Based *q* Ratios for Coca-Cola and Microsoft, 1982–98[a]



Source: Authors' calculations based on Compustat and I/B/E/S data.

a. q^E is the ratio of the market valuation of the firm's equity to the replacement cost of its tangible capital; $\hat{q}$ is the ratio of the present discounted value of analysts' consensus earnings forecasts to the replacement cost of tangible capital. Both q ratios adjust for debt, taxes, and current assets as described in appendix B. Microsoft first issued public equity in 1986.

We can benchmark Coca-Cola's q^E by comparing it with a measure of the company's fundamental value based on the profits that the company is expected to generate. We do so using earnings forecasts made by professional securities analysts, supplied by I/B/E/S International and also contained in our data set. The upper panel of figure 1 also plots Coca-Cola's $\hat{q}$, which estimates q using the present discounted value of stock market analysts' consensus earnings forecasts for the firm rather than the firm's market value.

The construction uses analysts' one- and two-year-ahead forecasts and their five-year growth forecast.[11] We discount expected earnings over the next five years using the current interest rate on thirty-year U.S. Treasury bonds plus an 8 percent risk premium, and we include a terminal value correction to account for the value of the company beyond our forecast horizon. We choose the timing of the forecasts so that $\hat{q}$ is based on the same information set as q^E. Through the choice of this timing, the market-based measure already incorporates the information contained in the forecasts. In all other respects $\hat{q}$ is identical to q^E. The time-series comparison between Coca-Cola's $\hat{q}$ and its q^E suggests that professional analysts do not expect the company's intangible asset growth (as inferred using the assumption of strong efficiency) to generate similar profit growth.

The lower panel of figure 1 plots Microsoft's q^E and $\hat{q}$. When Microsoft enters our sample in 1987, having first issued public equity in 1986, its q^E is equal to 24. By the end of the sample period it has risen to 74. The volatility of this measure in Microsoft's case is perhaps even more notable than the threefold increase. Consider these two facts: that in 1990 Microsoft's q^E dropped by more than half, only to more than double in the following year; and that around half the total increase over the sample period occurred after 1997, when the value of q^E was 39. We can benchmark these changes by comparing them with changes in Microsoft's $\hat{q}$. When the 50 percent drop in q^E occurred, $\hat{q}$ also dropped, but only by about 30 percent. And when q^E recovered dramatically in the following year, $\hat{q}$ increased by less than 15 percent. Finally, when q^E doubled from 1997 to

11. A large literature examines the properties of earnings forecasts. The consensus in the finance and accounting literature is that analysts are too optimistic about the near-term prospects of companies: see, for example, Brown (1996) and Fried and Givoly (1982). Keane and Runkle (1998) show, however, that the studies in this literature suffer from material econometric deficiencies. When these are corrected, Keane and Runkle find that analysts' quarterly forecasts are rational expectations forecasts.

1998, $\hat{q}$ grew by about one-third. This comparison suggests that the change in the value of Microsoft's intangibles (as inferred using the assumption of strong efficiency) is not closely associated with changes in what the analysts expect Microsoft to earn in the future.

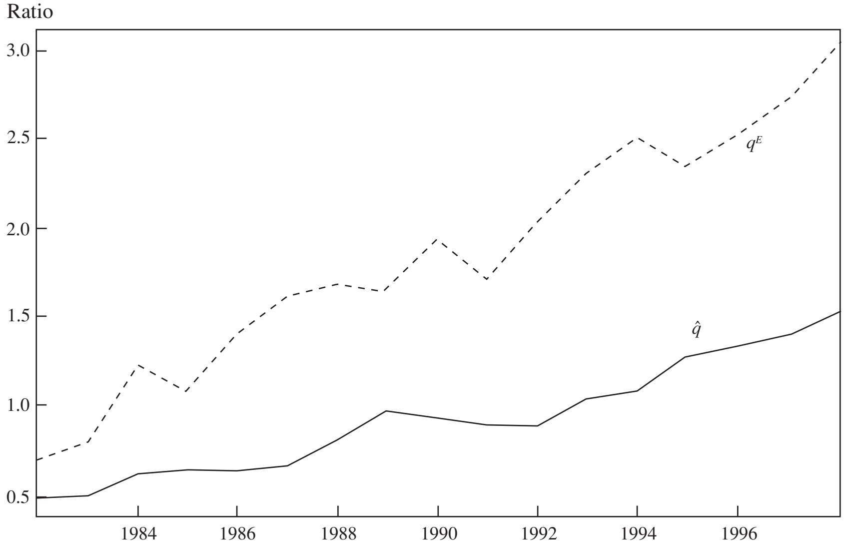
We have chosen these companies because they are widely familiar and because their experience has been remarkable, but they are by no means unusual examples. Rather, the sharp increase in the level of q^E (illustrated by Coca-Cola) and the high volatility of q^E (illustrated by Microsoft) make these companies microcosms of the broader experience of the more than 1,100 companies in our sample. Figure 2 plots the unweighted average of q^E in each year for the entire sample of companies we observe in that year. In 1982 there are about 300 companies in the sample, and the average of q^E is about 0.7. By the end of the sample there are more than 1,000 firms, and q^E is about 3.0—a 330 percent increase. Our sample is an unbalanced panel of firms, and so the increase could reflect entry and exit, but it does not: the average value of q^E increases by about 300 percent for those firms that are in the sample from 1982 to 1998.

Figure 2 also plots the average annual values of $\hat{q}$ for the entire sample. This variable is about 0.5 in 1982 and about 1.5 in 1998, a 200 percent increase.[12] In every year the standard deviation of q^E across firms is greater than that of $\hat{q}$. We can further measure the difference between q^E and $\hat{q}$ by defining a new variable $QDIF = (q^E - \hat{q})/\hat{q}$. The median value of $QDIF$ is 0.15 in 1982 and 0.75 in 1998, indicating that a wide gap has opened over time for the median firm in the sample.

Figure 3 plots the average annual growth rates of q^E and $\hat{q}$ for the whole sample. In a number of years the two move together. Notably, the two measures rise and fall dramatically at the start of the sample and track each other through the one recession in the sample, that of 1990–91. But what is striking overall is that the series are only loosely correlated, with a correlation coefficient of only 0.14. Hence there seems to be limited agreement between the market valuation and the analysts' valuation of companies. One way for those who believe that we have entered a new economy to rationalize this finding is to argue that the market is more

12. The comparable increase for the firms that are continuously in the sample from 1982 to 1998 is 150 percent, indicating that new entrants do have an appreciable effect on growth in $\hat{q}$ for the sample as a whole. This is perhaps not surprising, since part of the entry in our sample comes from firms that analysts have chosen to track precisely because of their high potential growth opportunities.

Figure 2. Average Market-Based and Analyst-Based q Ratios for the Entire Sample of Firms, 1982–98[a]

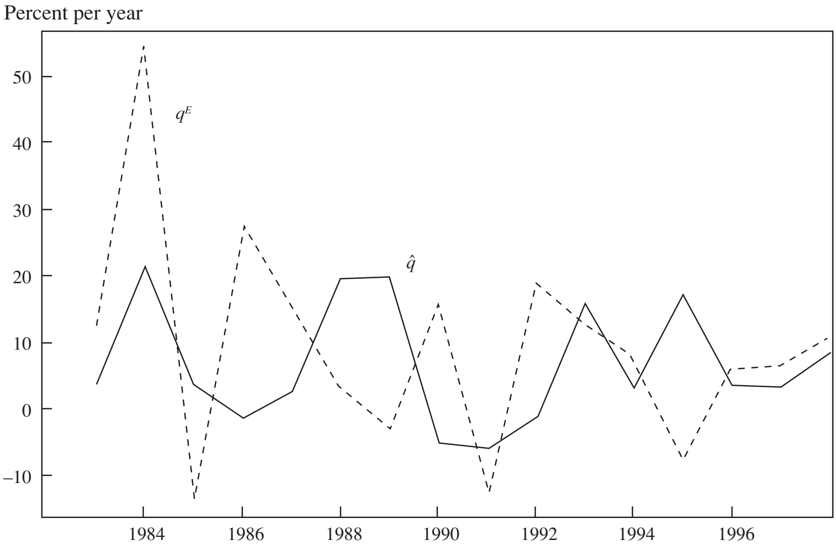


Source: Authors' calculations based on Compustat and I/B/E/S data.
a. Sample size grows from about 300 in 1982 to more than 1,100 in 1998.

farsighted than the analysts who cover the firms. If intangibles are like dark matter, this is akin to saying that the average person who looks up into the sky is better able to measure the missing mass of the universe than the professional astronomer.

To put the issue simply, q^E can increase in either of two ways: its denominator may increasingly omit assets that generate value, or its numerator may increasingly overvalue assets in general. Although the comparison between q^E and $\hat{q}$ seems to support the latter interpretation, we cannot conclusively distinguish between these explanations by examining just these two variables. But we can distinguish between them by focusing on the relationship between our measures of q and investment behavior. Under certain assumptions, detailed below where we formally derive our model, average q is a sufficient statistic for total investment. This means that it embodies all the relevant information about investment opportunities.

Figure 3. Growth Rates of Average Market-Based and Analyst-Based *q* Ratios for the Entire Sample, 1983–98[a]



Source: Authors' calculations based on Compustat and I/B/E/S data.
a. Same sample as in figure 2. The correlation coefficient between the growth rates of q^E and $\hat{q}$ is 0.14.

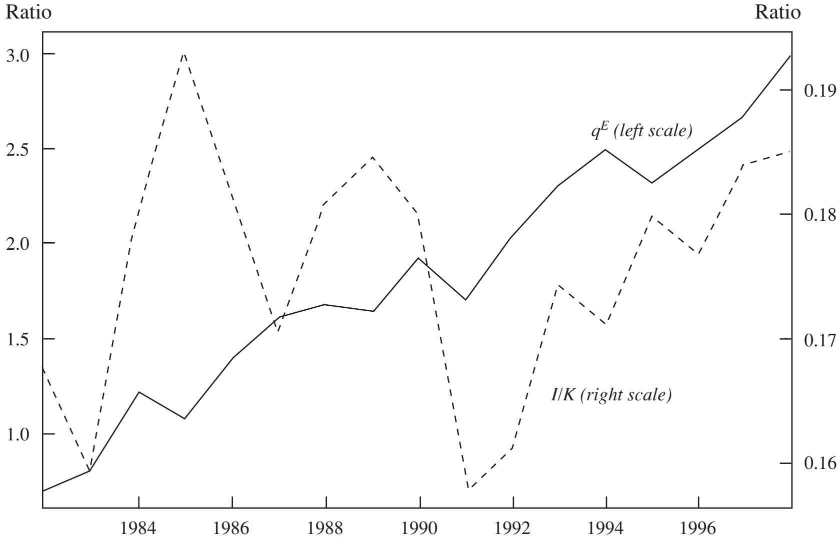
To understand why studying investment behavior is helpful, consider the first of the two reasons why q^E can increase. If a firm's assets increasingly consist of intangibles, it would be unsurprising to find that q^E is only loosely related, or perhaps even unrelated, to tangible investment behavior. Turning to figures 4 and 5, we find that this possibility is not inconsistent with the data. Figure 4 plots q^E and the tangible investment rate, denoted I/K, where I is tangible investment and K is the stock of tangible capital. Figure 5 compares the growth rates of I/K and q^E. The correlation coefficient for the two series is positive, but I/K does not closely track q^E: the growth rate of I/K follows the growth rate of q^E during the 1990–91 recession, but the correlation is actually negative since 1994.[13]

13. Results of an ordinary least-squares (OLS) regression of the growth of I/K, GIK, on the growth of q^E, Gq^E, are as follows:

$$GIK_t = \underset{(0.019)}{-0.002}INT + \underset{(0.102)}{0.100}Gq_t^E \qquad t = 1983\text{–}98$$

Adjusted $R^2 = -0.003$; Durbin-Watson = 2.08

Figure 4. Average Market-Based *q* Ratios and Investment-Capital Ratios for the Entire Sample, 1982–98[a]



Source: Authors' calculations based on Compustat data.
a. *I/K* is the ratio of tangible investment to the stock of tangible capital. Same sample as in figure 2.

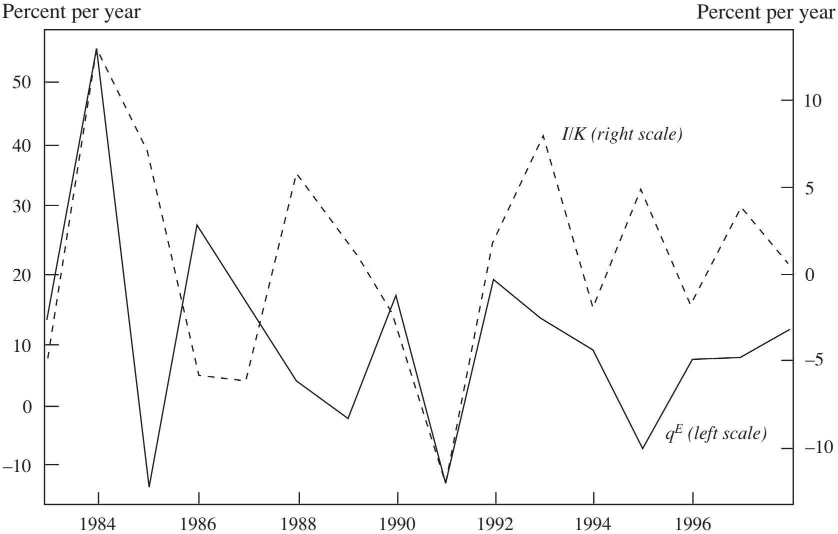
This is the basic puzzle about investment behavior that has been confirmed time and again in empirical studies.[14] The disconnect between *I/K* and q^E results in econometric estimates of the coefficient on q^E that are small in magnitude or imprecise, or both, which implies that investment is subject to enormous adjustment costs.[15] This has sparked a number of active research inquiries. The most prominent of these focus on whether capital market imperfections or nonconvex adjustment costs help rationalize this finding.[16]

14. See, for example, Chirinko (1993a).

15. The consensus view seems to be that this result remains even when the underlying firm data are used in conjunction with an estimator that attempts to address the endogeneity of q^E. A number of papers by Cummins and collaborators argue that this consensus is premature. Cummins, Hassett, and Oliner (1999) and Cummins, Hassett, and Hubbard (1994, 1996) all obtain more economically significant estimates of the effect of fundamentals when they control for endogeneity, measurement error, or both.

16. For surveys of these literatures see Hubbard (1998) and Caballero (1999), respectively.

Figure 5. Growth Rates of Average Market-Based *q* Ratios and Investment-Capital Ratios for the Entire Sample, 1983–98[a]



Source: Authors' calculations based on Compustat data.
a. *I*/*K* is defined as in figure 4. Same sample as in figure 2. The correlation coefficient between the growth rates of q^E and *I*/*K* is 0.25.

We believe, in contrast, that the previous results may be spurious for either or both of two reasons: that the underlying model ignores intangibles that are an important part of total investment, or that share prices are noisy signals of the fundamentals. These possibilities have not been extensively considered because intangibles and fundamentals are difficult to measure.[17] Our strategy uses a two-step procedure to deal with these measurement problems. The first step is to develop a model that requires data on the flow of intangible capital only, not its stock. There is no practical way to calculate the stock of intangible assets for the companies in our sample—indeed, we have already alluded to the active debate about whether such an endeavor would be feasible even with new accounting

17. The techniques used by Blundell and others (1992) and Hayashi and Inoue (1991) correct for measurement error in average *q* when it is serially uncorrelated by using lagged values of average *q* as instrumental variables. We argue below that the measurement error in q^E is serially correlated, and that this explains why using lagged values of average *q* does not successfully control for measurement error.

regulations. But no one disputes that intangible investments in the form of advertising, R&D, and the like are observable—these items are expensed on the income statement. We show how we use this information in the following section where we introduce our model.

The second ingredient is analysts' earnings expectations, which we have already introduced. Jason Cummins, Kevin Hassett, and Steven Oliner first showed that there is a close *time-series* link between investment and analysts' forecasts.[18] Although we use the earnings forecasts in a different way, we confirm this finding. Figures 6 and 7 plot, respectively, annual averages and growth rates of I/K from figures 4 and 5 along with those of $\hat{q}$. Figure 7 shows the close correlation between the two series. What is particularly striking is that the growth of $\hat{q}$ predicts the *turning points* in the growth of I/K.[19] Of course, this finding is meant only to be suggestive. Tobin's average q, whether constructed with equity price data or with analysts' earnings expectations, is an endogenous variable. News, for example about a new product invention, affects investment as well as the stock market price and analysts' forecasts. The econometric approach we discuss in detail later in this paper can correct for this endogeneity. In addition, in constructing our measures of fundamentals we have almost surely introduced measurement error. This is likely to be particularly acute in the case of $\hat{q}$ because a number of assumptions are needed to calculate the present discounted value of expected future profits. However, under certain conditions our econometric approach can also control for this type of measurement error. In our empirical work, we show that the close association between tangible investment and $\hat{q}$ is robust to controlling for these econometric issues.

Figures 1 through 7 have set the stage for our investigation. Figures 1, 2, and 3 showed, using specific company examples and our entire sample of firms, that much is happening in the level and variance of the stock market–based measure of company fundamentals that has nothing to do with

18. Cummins, Hassett, and Oliner (1999).

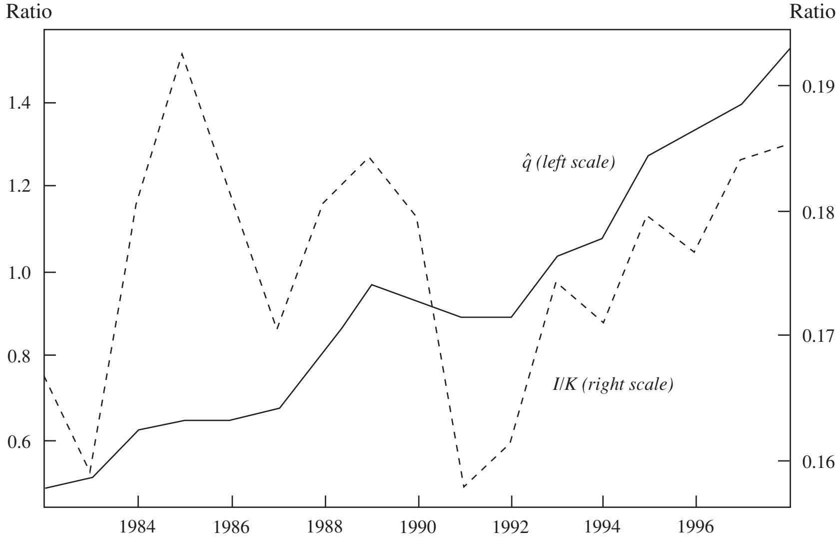
19. The results of an OLS regression of the growth of I/K, GIK, on the growth of $\hat{q}$, $G\hat{q}$, are as follows:

$$GIK_t = \underset{(0.015)}{-0.033}INT + \underset{(0.124)}{0.534}G\hat{q}_t \qquad t = 1983\text{–}98$$

Adjusted $R^2 = 0.53$; Durbin-Watson = 2.23

The measure of $\hat{q}$ is constructed using earnings forecasts that are available at the start of the period over which this investment expenditure occurs.

Figure 6. Average Analyst-Based *q* Ratios and Investment-Capital Ratios for the Entire Sample, 1982–98[a]

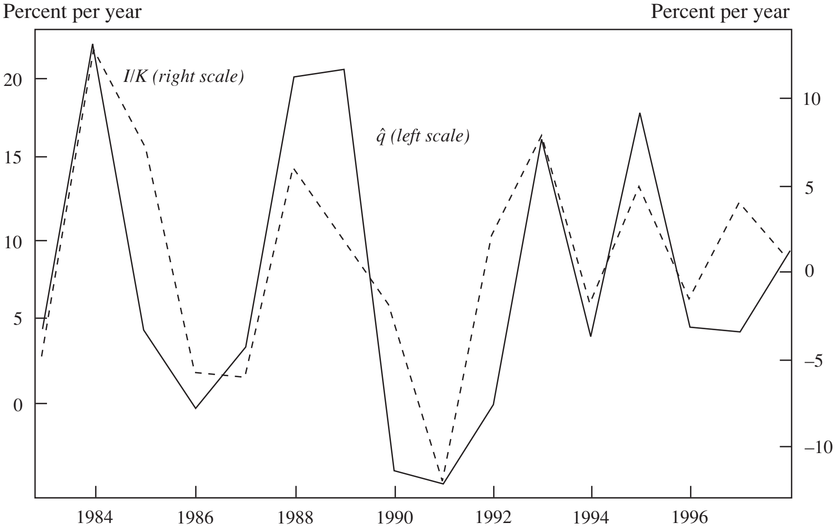


Source: Authors' calculations based on Compustat and I/B/E/S data.
a. *I/K* is defined as in figure 4. Same sample as in figure 2.

the measure based on analysts' expected earnings. Figures 4 and 5 illustrated the weak relationship between tangible investment and the stock market–based measure of average *q*. Although this could reflect the growing importance of intangible capital, if this were the main reason, we should also find a weak relationship between tangible investment and our measure of average *q* based on analysts' earnings forecasts. In fact, we find a close relationship between tangible investment and this measure of *q*, as shown in figures 6 and 7. Thus, although it is conceivable that more and more capital has gone missing from the balance sheet, a compelling alternative explanation of the divergence of q^E from $\hat{q}$ is that share prices are noisy.

Our formal empirical work confirms these findings. Although we find a limited role for intangibles in our model of tangible investment, we nevertheless find a strong relationship between tangible investment and $\hat{q}$ that is not mirrored in the relationship between tangible investment and q^E. The puzzle in the relationship between stock prices and investment can be explained by the importance of noisy share prices, and the story of the new economy as it relates to the stock market rise appears to be largely a fiction.

Figure 7. Growth Rates of Average Analyst-Based *q* Ratios and Investment-Capital Ratios for the Entire Sample, 1983–98[a]



Source: Authors' calculations based on Compustat and I/B/E/S data.

a. *I*/*K* is defined as in figure 4. Same sample as in figure 2. The correlation coefficient between the growth rates of $\hat{q}$ and *I*/*K* is 0.75.

The Model

We use the neoclassical model of investment as the basis for our investigation. First we describe the model and present the empirical investment equation that relates Tobin's *q* and the demand for fixed capital when there is a single capital good. Next we show how this empirical model can be modified to incorporate the key feature of the new economy, namely, that we should distinguish between two different types of capital, only one of which can be measured. Finally, we modify the model to incorporate the key feature of noisy share prices, namely, that we should allow for the value of the firm being mismeasured because asset prices deviate from their fundamental value.

The Q Model of Investment

In each period, a firm chooses investment in each type of capital good: $\mathbf{I}_t = (I_{1t}, \ldots, I_{Nt})$, where *j* indexes the *N* different types of capital goods and

t indexes time.[20] Given equation 2 below, this is equivalent to choosing a sequence of capital stocks $\mathbf{K}_t = (K_{1t}, \ldots, K_{Nt})$, given $\mathbf{K}_{t-1}$, to maximize V_t, the value of the firm inclusive of dividends paid in period t, defined as

$$(1) \qquad V_t = E_t \left\{ \sum_{s=t}^{\infty} \beta_s^t \Pi(\mathbf{K}_s, \mathbf{I}_s, \epsilon_s) \right\},$$

where E_t is the expectations operator conditional on the set of information available at the beginning of period t; β_s^t discounts net revenue in period s back to time t; Π is the revenue function net of factor payments, which includes the productivity shock ϵ_s as an argument. We assume that Π is linearly homogeneous in (K_s, I_s) and that the capital goods are the only quasi-fixed factors—or, equivalently, that variable factors have been maximized out of Π. For convenience in presenting the model, we also assume that there are no taxes and that the firm issues no debt, although we incorporate taxes and debt in our empirical work when we construct q.

The firm maximizes equation 1 subject to the following series of constraints:

$$(2) \qquad K_{j,t+s} = (1 - \delta_j) K_{j,t+s-1} + I_{j,t+s} \quad s \geq 0,$$

where δ_j is the rate of depreciation for capital good j. In this formulation, investment is subject to adjustment costs but becomes productive immediately. Furthermore, current profits are assumed to be known, so that both prices and the productivity shock in period t are known to the firm when it chooses I_{jt}. Other formulations, such as those that include a production lag, a decision lag, or both, are possible, but we choose this, the most parsimonious specification, because the results we highlight in this study are insensitive to these alternatives.

In appendix A we follow the approach introduced by Fumio Hayashi to derive an empirical investment equation based on Tobin's q for the case of a single homogeneous capital good subject to quadratic adjustment costs:[21]

20. The firm index i is suppressed to economize on notation except when we present the empirical investment equations, where it clarifies the variables that vary by firm.

21. Hayashi (1982). We use lowercase q_{it} to denote the valuation ratio $V_{it}/[p_t(1 - \delta)K_{i,t-1}]$ and capital Q_{it} to denote the function of this ratio that enters the investment equation.

$$
\begin{aligned}
\left(\frac{I}{K}\right)_{it} &= a + \frac{1}{b}(q_{it} - 1)\frac{p_t}{g_t} + \epsilon_{it} \\
&= a + \frac{1}{b}\left[\frac{V_{it}}{p_t(1-\delta)K_{i,t-1}} - 1\right]\frac{p_t}{g_t} + \epsilon_{it} \qquad (3) \\
&= a + \frac{1}{b}Q_{it} + \epsilon_{it},
\end{aligned}
$$

where p_t and g_t are the price of the investment good and the price of output, respectively, and a and b are the technical coefficients of the adjustment cost technology. The goal of the econometric procedure is to estimate these structural parameters.

The productivity shock in equation 3 affects I_{it}, since ϵ_{it} is known when I_{it} is chosen. It also affects Π_{it} and is therefore correlated with V_{it}. As a result, this model is unidentified without further assumptions. To estimate it we need to control for the endogeneity of Q_{it}. We turn our attention to this task later in the paper.

A Model of the New Economy

The key idea behind the story of the new economy is that capital is composed of a tangible and an intangible component. The tangible part—property, plant, and equipment—is easier to measure, whereas the intangible part is more difficult, since it depends on how advertising, R&D, and the like create assets for the firm. For practical reasons this intangible component has been ignored in most studies of investment.[22]

One can estimate a very general model with two types of capital using two interrelated Euler equations. This is a common approach in the literature on dynamic factor demand.[23] Such an approach is ill suited to our investigation, however, for two reasons. First, even though intangible investment is observable, as we pointed out in the introduction, it is impractical to construct intangible capital stocks firm by firm. Second, the Euler equation approach eschews the information contained in share prices, and therefore it is unsuitable for studying whether share prices are

22. Lach and Schankerman (1989) and Nickell and Nicolitsas (1996) have considered the relationship between R&D expenditures and subsequent investment.

23. For example, Cummins and Dey (2000) estimate the dynamic demand for equipment and structures using firm-level panel data.

noisy. Instead we take an approach, based on Tobin's q, that nests both the multiple capital goods of the new economy and noisy share prices.

Appendix A considers the case of two capital goods subject to additively separable adjustment costs.[24] Denoting tangible investment and the stock of tangible capital by I_1 and K_1, and intangible investment and the stock of intangible capital by I_2 and K_2, we derive an equation for investment in tangible capital as follows:

$$\left(\frac{I_1}{K_1}\right)_{it} = a_1 + \frac{1}{b_1}\left[\frac{V_{it}}{p_{1t}(1-\delta_1)K_{1i,t-1}} - 1\right]\frac{p_{1t}}{g_t} - \frac{b_2}{b_1}\left(\frac{1-\delta_2}{1-\delta_1}\right)\left(\frac{I_2}{K_1}\right)_{it} + \frac{a_2 b_2}{b_1}\left(\frac{1-\delta_2}{1-\delta_1}\right)\left(\frac{K_2}{K_1}\right)_{it} - \frac{1}{b_1}\left(\frac{1-\delta_2}{1-\delta_1}\right)\left(\frac{p_{2t}}{p_{1t}}\right)\left(\frac{K_2}{K_1}\right)_{it} + \epsilon_{it}. \tag{4}$$

This equation cannot be estimated without data on the stock of intangible capital (K_2), which, we have argued, is difficult if not impossible to measure. However, so long as the ratio of intangible to tangible capital (K_2/K_1) is stable over time for a given firm, and the ratio of the prices of the two types of capital (p_2/p_1) is similarly stable, the last two terms in equation 4 will be well approximated by a firm-specific effect (e_i). Although these assumptions are certainly restrictive, they are not ruled out by the model with two types of capital that we present in appendix A, and they allow us to proceed in the absence of data on the stock of intangibles. Maintaining these assumptions, we obtain the following estimable equation for tangible investment:

$$\left(\frac{I_1}{K_1}\right)_{it} = a_1 + \frac{1}{b_1}\left[\frac{V_{it}}{p_{1t}(1-\delta_1)K_{1i,t-1}} - 1\right]\frac{p_{1t}}{g_t} - \frac{b_2}{b_1}\left(\frac{1-\delta_2}{1-\delta_1}\right)\left(\frac{I_2}{K_1}\right)_{it} + e_i + \epsilon_{it}. \tag{5}$$

This equation differs in a number of important ways from the standard formulation in equation 3. Notice that the tangible investment–capital ratio—not the total investment–capital ratio, which we have argued is unobservable—is related to Tobin's q and the ratio of intangible investment to tangible capital. The coefficient on the last ratio is a function of the

24. For previous treatments of the Q model with multiple capital inputs see Chirinko (1993b) and Hayashi and Inoue (1991).

adjustment cost parameters and depreciation rates for tangible and intangible capital. This shows that the basic Q model that ignores intangible capital is misspecified unless b_2 is zero or δ_2 is one, or the covariance between Tobin's q and intangible investment is zero. A priori reasoning suggests that these conditions are unlikely to be satisfied: intangible capital surely has at least some adjustment costs and does not depreciate completely in each period, and presumably intangible investment is undertaken because it affects the average return to capital and hence V_t. The negative coefficient on I_2/K_1 is easy to interpret. For companies making intangible investments, $V_{it}/[p_{1t}(1-\delta_1)K_{1i,t-1}]$ will tend to be high. But in part, this is just a signal to the company to invest in intangible rather than tangible capital. So in modeling tangible investment specifically we need to correct the high value of $V_{it}/[p_{1t}(1-\delta_1)K_{1i,t-1}]$, which is what the negative coefficient on the I_2/K_1 term achieves.

A Model with Noisy Share Prices

Under the assumption that stock market prices are strongly efficient, the firm's equity valuation V_t^E coincides with its fundamental value V_t, and the empirical investment equations 3 and 5 can be estimated consistently—if the endogeneity of average q is controlled for with suitable instrumental variables—by using the equity valuation to measure V_t. We relax this strong efficiency assumption to allow for the possibility that $V_t^E \neq V_t$, and we consider the implications of the resulting measurement error in average q for the estimation of the investment models. We illustrate the approach using the basic empirical investment equation 3, since the application to the new economy investment equation 5 is immediate, but notationally more cumbersome.

We first write

$$Q_t = \frac{V_t}{g_t(1-\delta)K_{t-1}} - \frac{p_t}{g_t} \tag{6}$$

and

$$V_t^E = V_t + m_t, \tag{7}$$

where m_t is the measurement error in the equity valuation V_t^E, regarded as a measure of the fundamental value V_t. The measure of Q_t that uses the firm's equity valuation then has the form

$$
\begin{aligned}
Q_t^E &= \left[\frac{V_t + m_t}{p_t(1-\delta)K_{t-1}} - 1 \right] \frac{p_t}{g_t} \\
&= \left(q_t^E - 1\right) \frac{p_t}{g_t} \\
&= Q_t + \frac{m_t}{g_t(1-\delta)K_{t-1}} \\
&= Q_t + \mu_t,
\end{aligned} \tag{8}
$$

where μ_t is the corresponding measurement error induced in Q_t^E. Substituting Q_t^E for Q_t in equation 3 then gives the empirical investment equation when there are noisy share prices:

$$
\left(\frac{I}{K}\right)_{it} = a + \frac{1}{b} Q_{it}^E + \left(\epsilon_{it} - \frac{\mu_{it}}{b}\right). \tag{9}
$$

When the measurement error μ_{it} is persistent and correlated with the kinds of variables that are used as instrumental variables, there is no way to identify this model. This scenario seems particularly plausible if one's prior is that the stock market is prone to certain types of behavior, like bubbles, that introduce noise into share prices.[25] Consider a bubble that is related to observable measures of the fundamentals—for example, to current cash flow. Suppose that when Coca-Cola announces its current cash flow, this news affects the bubble in its share price today and in the future, since the bubble is persistent. If we roll forward, say, three years and think about using cash flow from three years back as an instrumental variable for the current measure of Q_{it}^E, it is immediately obvious that this lagged cash flow variable is correlated with μ_{it} when μ_{it} is persistent. Hence, lagged variables that are correlated with firm performance are inadmissible as instruments when there is persistent measurement error in share prices that is correlated with firm performance. This form of measurement error simply cannot be dealt with using conventional techniques.

To breach this impasse, we need another way to measure fundamentals that does not suffer from this problem. We propose to use securities analysts' consensus forecasts of future earnings as a measure of $E_t[\Pi_{t+s}]$.

25. Shiller (1981), among others, has suggested that equity valuations are excessively volatile compared with fundamental values. Blanchard and Watson (1982) and Froot and Obstfeld (1991) have developed models of rational bubbles that do not violate weaker concepts of market efficiency. Campbell and Kyle (1993) have analyzed models with noise traders that have similar empirical implications.

Combining these forecasts with a simple assumption about the discount rates β^t_{t+s}, we can construct an alternative estimate of the present value of current and future net revenues as

$$\hat{V}_t = E_t\,(\Pi_t + \beta^t_{t+1}\Pi_{t+1} + \ldots + \beta^t_{t+s}\Pi_{t+s}). \tag{10}$$

We then use this estimate in place of the firm's stock market valuation to obtain an alternative estimate of average q, and hence

$$\hat{Q}_t = \left[\frac{\hat{V}_t}{p_t(1-\delta)K_{t-1}} - 1\right]\frac{p_t}{g_t} = (\hat{q}_t - 1)\frac{p_t}{g_t}. \tag{11}$$

Clearly our estimate of $\hat{V}_t$ will also measure the firm's fundamental value V_t with error. The potential sources of measurement error include truncating the series after a finite number of future periods, using an incorrect discount rate, and the fact that analysts forecast net profits rather than net revenues. Letting $\nu_t = \hat{Q}_t - Q_t$ denote the resulting measurement error in our estimate of Q_t, the econometric model is then

$$\left(\frac{I}{K}\right)_{it} = a + \frac{1}{b}\hat{Q}_{it} + \left(\epsilon_{it} - \frac{\nu_{it}}{b}\right). \tag{12}$$

The measurement error ν_{it} may also be persistent. Identification will depend on whether this measurement error is uncorrelated with suitably lagged values of instruments, for example, sales, profits, or investment. We regard this as an empirical question that will be investigated using tests of overidentifying restrictions.

The Data

The Compustat data set consists of data for an unbalanced panel of firms from the industrial, full coverage, and research files. The variables we use are defined as follows. The replacement cost of the tangible capital stock is calculated using the standard perpetual inventory method, with the initial observation set equal to the book value of the firm's first reported net stock of property, plant, and equipment (Compustat data item 8) and an industry-level rate of depreciation.[26] Gross tangible investment is defined as

26. This depreciation rate is constructed as in Hulten and Wykoff (1981).

the direct measure of capital expenditures in the Compustat data (data item 30). Cash flow is the sum of net income (data item 18) and depreciation (data item 14). Both gross investment and cash flow are divided by the current-period replacement cost of the tangible capital stock. The measures of fundamentals, Q^E and $\hat{Q}$, both contain a variety of adjustments to account for debt, taxes, inventories, and current assets. We discuss these adjustments and the construction of $\hat{Q}$ in detail in appendix B. The implicit price deflator (IPD) for total investment for the firm's three-digit Standard Industrial Classification (SIC) code is used to deflate the investment and cash flow variables and in the perpetual inventory calculation of the replacement value of the firm's capital stock. The three-digit IPD for gross output is used to form the relative price of capital goods.

To understand the different measures of intangible investment we use, it is helpful to review some basic accounting. The income statement contains information about expenditures internal to the firm that generate intangible assets. Accountants highlight two types of information about intangible investment that are available on the income statement: advertising (data item 45) and R&D (data item 46).[27] (Some intangible expenditures are also included in selling, general, and administrative expenses, but that category of expenses is so broad that it is unlikely to be useful as a measure of intangible investment.) Both of these measures of intangible investment are deflated using the sectoral IPD for total investment and divided by the current-period replacement cost of the firm's tangible capital stock. Using alternative deflators did not affect the empirical results.

We employ data on expected earnings from I/B/E/S International Inc., a private company that has been collecting earnings forecasts from securities analysts since 1971.[28] To be included in the I/B/E/S database, a company must be actively followed by at least one securities analyst who agrees to provide I/B/E/S with timely earnings estimates. According to I/B/E/S, an analyst "actively follows" a company if he or she produces research

27. The FASB has acted to ensure that special items (data item 17) on the income statement, which typically represent restructuring charges, do not include costs that will benefit future periods. In effect, the FASB has ruled that special items do not represent investment (Horngren, Sundem, and Elliott, 1996).

28. This discussion draws on joint work with Steven Oliner and Kevin Hassett.

reports on the company, speaks to company management, and issues regular earnings forecasts. These criteria ensure that I/B/E/S data come from well-informed sources. The I/B/E/S earnings forecasts refer to net income from continuing operations as defined by the consensus of securities analysts following the firm. Typically, this consensus measure removes from earnings a wider range of nonrecurring charges than the "extraordinary items" reported on firms' financial statements.

For each company in the database, I/B/E/S asks analysts to provide forecasts of earnings per share over the next four quarters and each of the next five years. We focus on the annual forecasts to match the frequency of our Compustat data. In practice, few analysts provide annual forecasts beyond two years ahead. I/B/E/S also obtains a separate forecast of the average annual growth of the firm's net income over the next three to five years—the "long-term growth forecast." To conform with the timing of the stock market valuation we use to construct Q^E, we construct $\hat{Q}$ using analysts' forecasts issued at the beginning of the accounting year.

We abstract from any heterogeneity in analysts' expectations for a given firm-year by using the mean across analysts for each earnings measure (which I/B/E/S terms the "consensus" estimate). We multiply the one-year-ahead and two-year-ahead forecasts of earnings per share by the number of shares outstanding to yield forecasts of future earnings. Forecasts of earnings for subsequent periods are obtained by increasing the average of these two levels in line with the forecast long-term growth rate. We discount expected earnings over the next five years using the current interest rate on thirty-year U.S. Treasury bonds plus an 8 percent risk premium, and we use a terminal value correction to account for earnings in later years. Appendix B provides further details.

The sample we use for estimation includes all firms with at least four consecutive years of complete Compustat and I/B/E/S data. We require four years of data to allow for first-differencing and the use of lagged variables as instruments. We determine whether the firm satisfies the four-year requirement after deleting observations that fail to meet a standard set of criteria for data quality.

We deleted observations in cases where q^E or $\hat{q}$ is less than zero, the theoretical minimum, or greater than 50. These types of rules are common in the literature, and we employ them because extreme outliers can affect the empirical results.

Empirical Specifications

Following Blundell and others, our empirical specification allows for the productivity shock ϵ_{it} for firm i in period t to have the following first-order autoregressive structure:[29]

$$\epsilon_{it} = \rho\epsilon_{i,t-1} + \varepsilon_{it}, \tag{13}$$

where ε_{it} can further be allowed to have firm-specific and time-specific components. Allowing for this form of serial correlation in equation 9 gives the following dynamic specification:

$$\begin{aligned}\left(\frac{I}{K}\right)_{it} &= a(1-\rho) + \frac{1}{b}Q^{E}_{it} - \frac{\rho}{b}Q^{E}_{i,t-1} \\ &+ \rho\left(\frac{I}{K}\right)_{i,t-1} + \left[\varepsilon_{it} - \frac{1}{b}(\mu_{it} - \rho\mu_{i,t-1})\right]\end{aligned} \tag{14}$$

and a similar dynamic specification based on the model defined by equation 12, where $\hat{Q}$ replaces Q^E; and for the model defined by equation 5, where we include $(I_2/K_1)_{it}$ and $(I_2/K_1)_{i,t-1}$ as additional regressors. We allow for time effects by including year dummies in the estimated specifications. Estimation allows for unobserved firm-specific effects by using first-differenced generalized method of moments (GMM) estimators with instruments dated $t-3$ and earlier. This is implemented using DPD98 for GAUSS.[30]

We report four diagnostic tests for each model we estimate. We test the validity of our instrument set in three ways. First, we report the p-value of the m_2 test proposed by Arellano and Bond to detect second-order serial correlation in the first-differenced residuals.[31] The m_2 statistic, which has a standard normal distribution under the null hypothesis, tests for nonzero elements on the second off-diagonal of the estimated serial covariance matrix. Second, we test whether the first off-diagonal has nonzero elements. Since first-differencing should introduce an MA(1) error, we expect that the null hypothesis of no first-order serial correlation should be rejected in virtually every case. Third, we report the p-value of the Sargan statistic (also known as Hansen's J-statistic), which tests the joint null

29. Blundell and others (1992).
30. Arellano and Bond (1998).
31. Arellano and Bond (1991).

hypothesis that the model is correctly specified and that the instruments are valid.[32] Unfortunately, it is not possible to test either hypothesis separately. Thus, considerable caution should be exercised in interpreting why the null is rejected: the instruments may be invalid because of serial correlation in the residuals, the model may be misspecified, or both problems may be present. The final diagnostic test we report is the *p*-value for the common factor restriction that we impose, which is not rejected in any of the specifications we consider.

Empirical Results

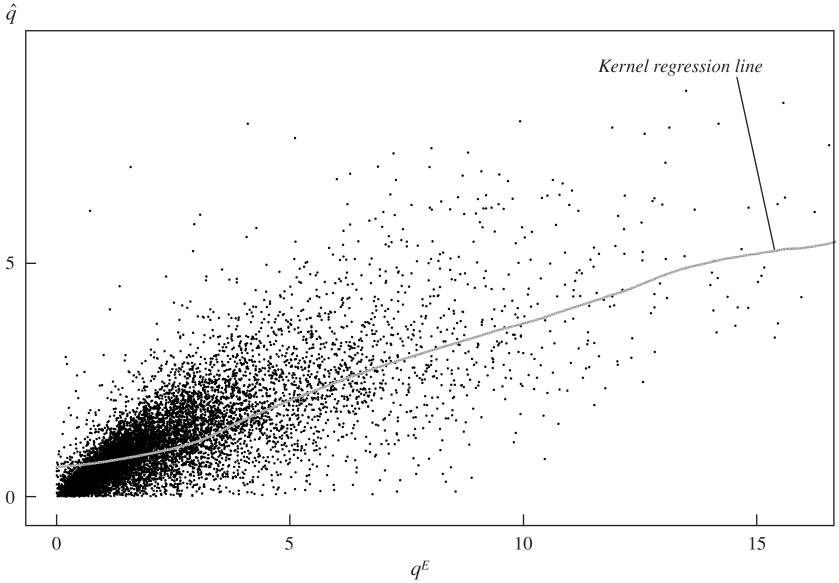
We present our empirical results in three stages. First we establish the prima facie case that share prices may be noisy measures of fundamentals by comparing the cross-sectional and time-series behavior of our measures of fundamentals and our measures of tangible and intangible investment. Next we present our formal empirical work where we estimate, using GMM, the dynamic investment equations for the new economy model and the noisy-share-prices model. Finally, we compare the cross-sectional and time-series behavior of fundamentals and investment for companies that are likely to operate mostly in the new economy and those likely to operate in the old economy.

Some Stylized Facts About Fundamentals and Investment

We set the stage for our formal empirical work by examining the relationship between the measure of fundamentals based on share prices, q^E, and that based on earnings expectations, $\hat{q}$. Figure 8 plots the relationship between q^E and $\hat{q}$ in the domain where most of the data lie (values from zero to 15). Each dot represents an observation for one firm in one year. The curve depicts a normal kernel smooth through the data, with the bandwidth set by cross-validation, which depicts $E(\hat{q}|q^E)$. The plot and smooth indicate that the two measures are positively correlated. But neither this

32. For further details see, for example, Arellano and Bond (1991) and Blundell and others (1992). Formally, the Sargan statistic is a test that the overidentifying restrictions are asymptotically distributed χ^2_{n-p}, where n is the number of instruments and p is the number of parameters.

Figure 8. Relationship Between Market-Based and Analyst-Based q Ratios for the Entire Sample, 1982–98[a]

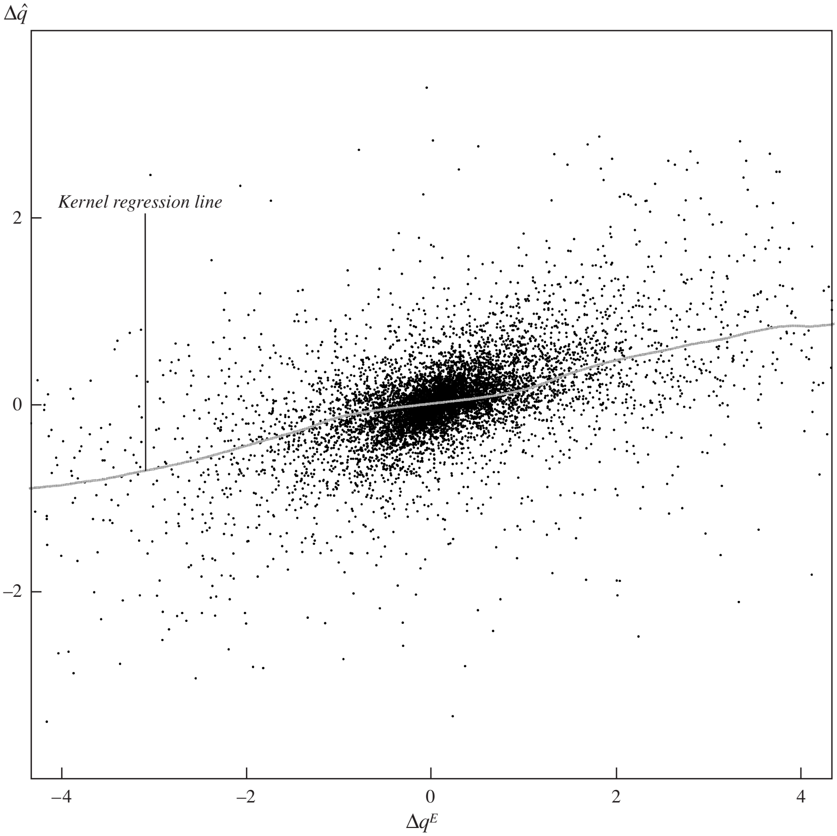


Source: Authors' calculations based on Compustat and I/B/E/S data.
a. The kernel regression line plots a nonparametric estimate of $E(\hat{q}|q^E)$. Each point represents an observation for one firm in one year.

correlation nor the slope of the relationship is close to unity, as one would expect if share prices tracked expected earnings on average. In fact, in the domain of q^E where most of the data lie—roughly values from zero to 3—the expected value of $\hat{q}$ is nearly constant about unity; that is, the slope of the kernel regression is close to zero. In other words, for most of the sample, regardless of the value of q^E, when we use expected earnings to value the company there is no compelling evidence that $\hat{q}$ deviates from unity. We can relate this to the example of Coca-Cola presented in the introduction. There we argued that the high value of Coca-Cola's q^E did not accord with its $\hat{q}$. This figure confirms this for the broader sample by comparing q^E and $\hat{q}$ for the sample: high q^Es are associated with much lower $\hat{q}$s. This pattern makes sense if share prices are noisy measures of fundamentals.

One concern is that q^E and $\hat{q}$ are mismeasured because they ignore intangible capital. Moreover, $\hat{q}$ suffers from the problem that the discount

Figure 9. Relationship Between Annual Changes in Market-Based and Analyst-Based *q* Ratios for the Entire Sample, 1983–98[a]



Source: Authors' calculations based on Compustat and I/B/E/S data.

a. The kernel regression line plots a nonparametric estimate of $E(\Delta\hat{q}|\Delta q^E)$. Each point represents an observation for one firm in one year.

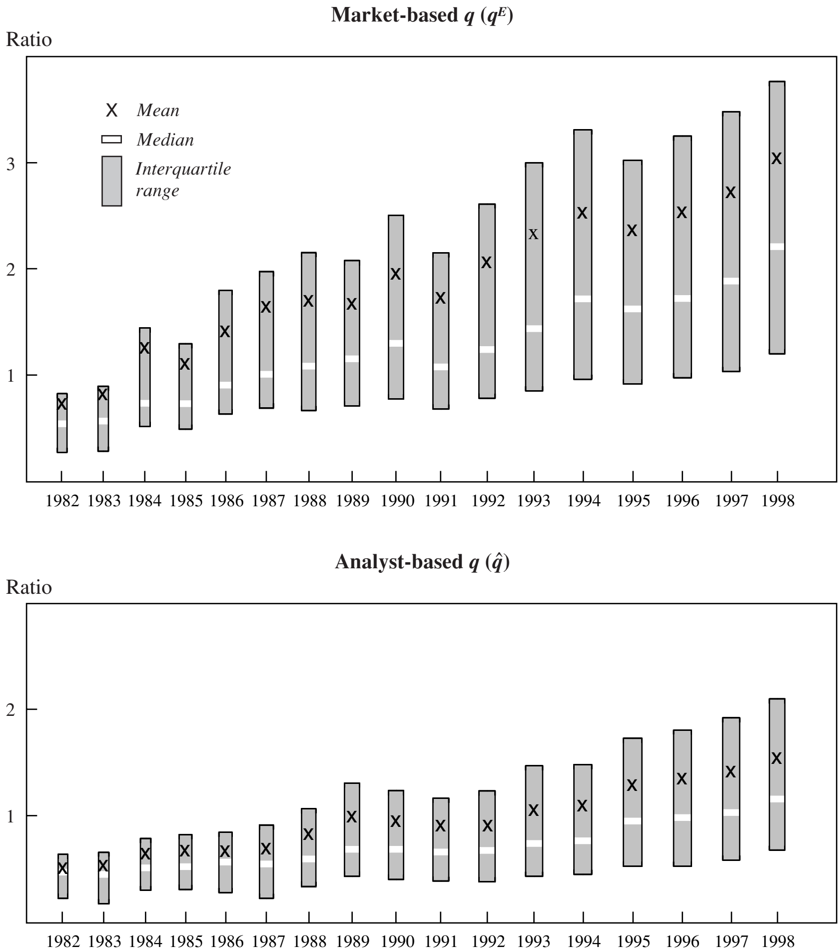
rates used to value expected future profits are almost surely mismeasured. In our formal empirical work we have explicit ways to address these difficulties. But if the year-to-year changes in the stock of intangible capital and the year-to-year changes in the discount rates are small, comparing the differences of $\hat{q}$ and q^E controls for measurement error in a gross way. In figure 9 we plot the relationship between the change in $\hat{q}$, denoted as $\Delta\hat{q}$, and the change in q^E, denoted as Δq^E, in the domain where almost all of the data lie (values of Δq^E from –4 to 4). The plot and smooth indicate that the two measures are also positively correlated, but the magnitude of the correlation is again slight. In fact, in the domain of Δq^E where most of the data lie—roughly values from –1 to 1—the expected value of $\Delta\hat{q}$ is about zero. We can relate this to the example of Microsoft presented in the introduction. There we argued that the large changes in Microsoft's q^E did not closely accord with changes in its $\hat{q}$. This figure confirms this finding for the broader sample by comparing Δq^E and $\Delta\hat{q}$: large changes in q^Es are associated with tiny changes in $\hat{q}$s. This evidence further supports the idea that share prices are very noisy measures of fundamentals.

Figure 10 examines the time-series evidence on q^E and $\hat{q}$. The width of each band is proportional to the square root of the number of observations in the year. Hence a bandwidth that is one-half the size of another one depicts one-quarter the number of observations. When the distributions are compared over time, two features stand out. First, the annual interquartile ranges of q^E fan out more than do those for $\hat{q}$. Over time, the market's assessment of companies has become more heterogeneous than has a measure based on expected earnings. The second striking feature is that both the mean and the median of q^E are increasing more than the mean and the median of $\hat{q}$. There are two basic ways to interpret this: either the market is more farsighted in valuing future profits than are the analysts' who follow the companies, or the market has tended to become more overvalued. Some combination of the two is also possible.[33]

We argued in the introduction that it is unlikely that this difference means that the market is more farsighted. But since the terminal values of $\hat{q}$ are almost surely constructed with error, we cannot conclusively rule out such a possibility. To assess this possibility we turn to the means, medians, and interquartile ranges of tangible and intangible investment in figure 11. Again the width of each band is proportional to the number of observations. If q^E is high because the market is valuing the profits that intangibles will eventually generate, then, necessarily, there must be a lot of intangible investment going on. As the figure shows, tangible investment is much more variable than either of the measures of intangible investment. Those companies that do invest in intangibles vary these expenditures little over the entire eighteen-year period. This certainly casts

33. A third possibility is that the discount rate that should be used to value expected future profits has fallen faster than our construction of $\hat{q}$ allows. We allow the discount rate to fall in line with nominal interest rates, but we assume a time-invariant risk premium.

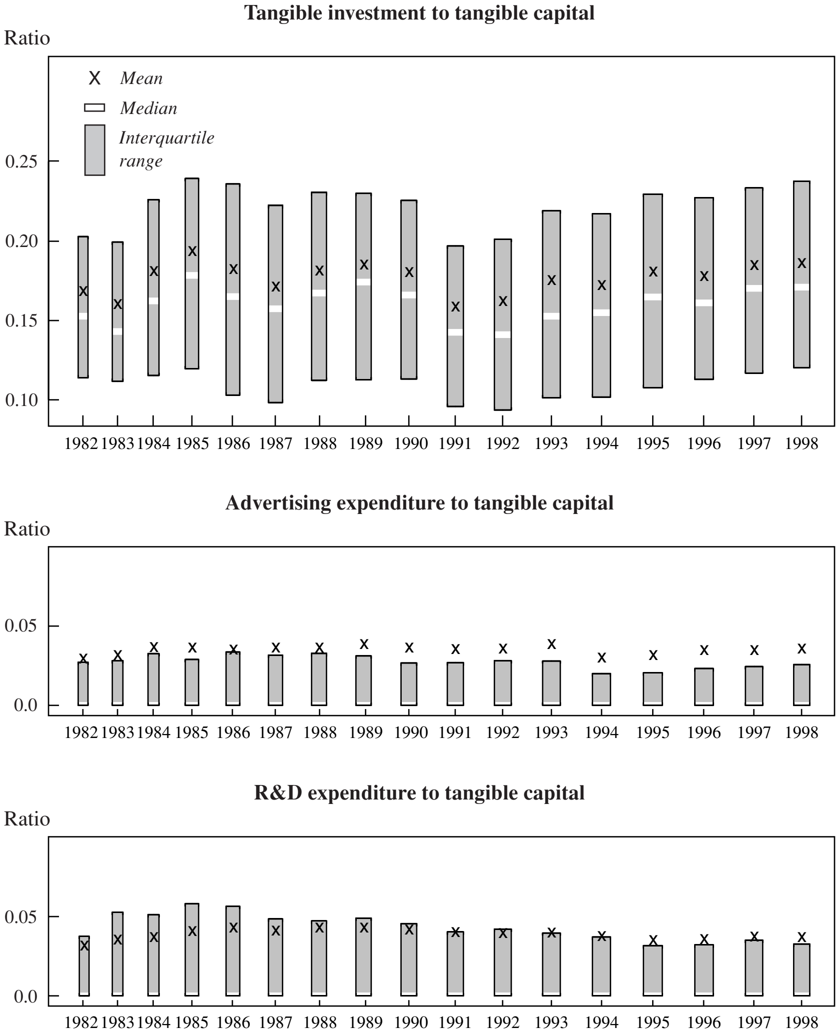
Figure 10. Mean, Median, and Interquartile Range of Market-Based and Analyst-Based *q* Ratios for the Entire Sample, 1982–98[a]



Source: Authors' calculations based on Compustat and I/B/E/S data.

a. The width of each band is proportional to the square root of the number of firms in the sample in that year. Interquartile range is the range between companies at the 25th and 75th percentiles.

Figure 11. Mean, Median, and Interquartile Range of Selected Investment Ratios for the Entire Sample, 1982–98[a]



Source: Authors' calculations based on Compustat data.
a. Bandwidths are defined as in figure 10. Interquartile range is the range between companies at the 25th and 75th percentiles.

some doubt on the new economy story that a boom in intangible investment is what is driving the stock market. In fact, the median firm does not do *any* measured intangible investment. Of course, it could be that only certain types of firms—call them new economy firms—are making intangible investments, and they account for the increase in q^E. The rest of this section considers this possibility in detail. First we estimate the empirical investment equations for subsamples of intangibles-intensive firms. Then we split the sample into new economy and old economy companies and examine the time-series and cross-sectional behavior of investment and the fundamentals in each group.

Econometric Results

Table 1 presents GMM estimates of the first-differenced new economy and noisy-share-price investment equations for the full sample of companies using our different controls for fundamentals and intangible investment. We implement GMM with an instrument set that contains the period $t-3$ and $t-4$ values of I/K and CF/K (where CF is cash flow), as well as a full set of year dummy variables.

We discuss first the results based on the noisy-share-price investment equations (equations 9 and 12; columns 1-1 and 1-5 in table 1). The coefficient on Q^E (column 1-1) is small and statistically insignificant at the 5 percent level. The p-value of the Sargan test, reported with the other diagnostic tests below the estimate, decisively rejects the joint test of model and instrument validity. These results are consistent with the presence of an important measurement error component in share prices that is both persistent over time and correlated with our instruments. In contrast, the coefficient on $\hat{Q}$ (column 1-5) is ten times greater than that on Q^E and precisely estimated. More important than the magnitude of the estimate is the fact that the diagnostic tests provide no evidence that the model containing $\hat{Q}$ is misspecified. These results are consistent with orthogonality between the measurement error in our measure of $\hat{Q}$ and the lagged investment and cash flow variables used as instruments.

If intangibles are important and are not captured by the fixed effects, these results should be viewed with skepticism. So we move to the new economy investment equation, where we introduce sequentially the two measures of intangible investment (scaled, as the model dictates, by tangible capital). We then include both of the variables together.

Table 1. GMM Estimates of First-Differenced Dynamic Investment Equations with Alternative Intangible Investment Measures, Full Sample[a]

Independent variable	*1-1*	*1-2*	*1-3*	*1-4*	*1-5*	*1-6*	*1-7*	*1-8*	*1-9*	*1-10*	*1-11*	*1-12*
Q_t^E	0.011	0.014	0.011	0.014					–0.007	–0.006	–0.008	–0.007
	(0.007)	(0.007)	(0.007)	(0.007)					(0.009)	(0.010)	(0.009)	(0.010)
$\hat{Q}_t$					0.110	0.136	0.104	0.135	0.119	0.139	0.112	0.137
					(0.021)	(0.022)	(0.022)	(0.022)	(0.024)	(0.024)	(0.025)	(0.024)
ADV_t/K_{1t}		–0.745		–0.679		–1.260		–1.238		–1.249		–1.206
		(0.366)		(0.362)		(0.510)		(0.496)		(0.547)		(0.525)
RD_t/K_{1t}			–1.540	–1.504			–0.454	–0.082			–0.358	–0.118
			(0.618)	(0.625)			(0.642)	(0.724)			(0.665)	(0.746)
ρ	0.340	0.381	0.387	0.420	0.176	0.169	0.215	0.175	0.168	0.210	0.209	0.228
	(0.057)	(0.059)	(0.049)	(0.055)	(0.059)	(0.061)	(0.055)	(0.060)	(0.058)	(0.070)	(0.054)	(0.069)
					Diagnostic tests (p-values)							
First-order serial correlation	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Second-order serial correlation	0.765	0.531	0.345	0.261	0.227	0.185	0.427	0.212	0.221	0.270	0.387	0.337
Sargan test	0.003	0.022	0.012	0.042	0.323	0.932	0.310	0.897	0.257	0.923	0.259	0.900
Common factor restriction	0.222	0.595	0.325	0.475	0.436	0.785	0.529	0.906	0.743	0.782	0.739	0.849

Source: Authors' calculations using Compustat and I/B/E/S data.

a. The dependent variable is the first difference of the ratio of tangible investment to tangible capital, I_{1t}/K_{1t}. Year dummies are included (but not reported) in all regressions. Robust standard errors on coefficients are in parentheses. The full sample includes those firms with at least four years of complete Compustat and I/B/E/S data. The number of firms in this sample is 1,114, for a total of 7,484 observations. The estimation period is 1986–98. Instrumental variables are the period $t-3$ and $t-4$ values of I/K and CF/K, where CF is cash flow. The instrument sets also contain year dummies. The tests for first- and second-order serial correlation in the residuals are asymptotically distributed as $N(0,1)$ under the null hypothesis of no serial correlation. The test of the overidentifying restrictions, called the Sargan test, is asymptotically distributed as χ^2_{n-p}, where n is the number of instruments and p the number of parameters.

When Q^E is used as the control for fundamentals, the coefficients on the ratio of advertising to tangible capital and on the ratio of R&D to tangible capital are negative and statistically significant when included separately (columns 1-2 and 1-3), as predicted by our model. When both measures are included together (column 1-4), both are statistically significant at the 10 percent level and jointly significant at the 5 percent level (this F-test is not reported in the table). The coefficient on Q^E is little affected when any or all of the measures are included, although it is more precisely estimated in two of the four cases. The Sargan test rejects the model at the 5 percent level in all four cases.

The Sargan test does not reject the investment equations that use $\hat{Q}$ and the measures of intangible investment, but only the estimate on advertising, when included alone, is significantly different from zero (column 1-6). The coefficient on R&D, included alone, is negative but not significant in these results for the full sample (column 1-7).

When both measures are included, the estimate on advertising is still significant, but that on R&D remains insignificant (column 1-8). The two are jointly significant, however, at the 5 percent level (this F-test is not reported in the table). In both equations where the advertising variable is included, the estimated coefficient on $\hat{Q}$ increases, consistent with the prediction that including this flow measure of investment in intangibles will correct the measure of average q for the presence of intangible assets.

In the final four columns of table 1, we use both measures of fundamentals in the investment equation. In all cases, when $\hat{Q}$ is included in the model, the Sargan test is not rejected, nor are the other key diagnostic tests. The estimated coefficients on $\hat{Q}$ are about the same as when Q^E is not included, whereas the estimated coefficients on Q^E lose significance. This is a surprising result: when $\hat{Q}$ is in the equation, the conventional share price measure of average q provides no additional information relevant for tangible investment. (Recall that the timing of the variable construction is such that the market-based measure incorporates the analysts' forecasts, and both measures are instrumented using lagged publicly available information.) Hence, our results mean that the part of Q^E that is uncorrelated with $\hat{Q}$ has no explanatory power for investment. In other words, that part of stock market valuations that is uncorrelated with analysts' earnings forecasts is a sideshow for investment; and as figures 8 through 10 make clear, there is a lot of such variation both across companies and over time. Whether or not we account for intangibles does not affect this conclusion.

One concern is that, in the full sample, R&D is empirically unimportant in the models using $\hat{Q}$. One possibility, already suggested, is that intangible investment is important only for a subset of firms. If so, the effect of intangibles may be swamped in the full sample. In table 2 we consider this possibility by focusing on two smaller samples of intangibles-intensive firms, defined as those that record intangible investment (advertising or R&D) on the income statement. This will pick up most of the firms that do advertising and R&D, because these variables are usually separately reported for firms undertaking such investments.

The first three columns of the table consider the advertising-intensive sample. When Q^E is used, the model is rejected, and the estimated coefficient on advertising is insignificant (column 2-1). When $\hat{Q}$ is included in the investment equation, without or with Q^E (columns 2-2 and 2-3, respectively), the coefficients on it and on the ratio of advertising to tangible capital are statistically significant (and of opposite sign, as the model predicts). In accordance with the results from table 1, when both Q^E and $\hat{Q}$ are included in the model, the estimated coefficient on Q^E is insignificant. The coefficient estimates on advertising in the models containing $\hat{Q}$ are smaller than in table 1. Although it is certainly possible that the differences are spurious, given the relatively large standard errors, substantive differences between the coefficients can be rationalized using equation 5. The depreciation rate on the intangible asset (δ_2) created by advertising may be greater for firms that do a lot of advertising; and adjustment costs may be smaller for firms that advertise heavily relative to the full sample.

The remaining columns consider the R&D-intensive subsample. These results mirror those reported in table 1, with one important exception. The coefficient estimate on R&D is negative and statistically significant when $\hat{Q}$ is used to control for fundamentals (columns 2-5 and 2-6). Hence there appears to be evidence of a significant role for intangibles in empirical investment equations. But this role is secondary to the main finding that share prices are completely uninformative once we have controlled for fundamentals using $\hat{Q}$.

A reasonable concern is whether the noisy-share-prices story is robust. Table 3 examines one implication of the model: when there is less measurement error in share prices, the estimates using Q^E should be more similar to those using $\hat{Q}$. Regardless of the magnitude of measurement error, if the noisy-share-prices model is correct, we should still find that when both Q^E and $\hat{Q}$ are included in the investment equation, Q^E is sta-

Table 2. GMM Estimates of First-Differenced Dynamic Investment Equations with Alternative Intangible Investment Measures, Intangibles-Intensive Subsamples[a]

	Advertising-intensive firms[b]			*R&D-intensive firms*[c]		
Independent variable	*2-1*	*2-2*	*2-3*	*2-4*	*2-5*	*2-6*
Q^E_t	0.023		–0.003	0.019		0.004
	(0.009)		(0.011)	(0.007)		(0.008)
$\hat{Q}_t$		0.122	0.125		0.079	0.070
		(0.016)	(0.021)		(0.015)	(0.018)
ADV_t/K_{1t}	–0.168	–0.591	–0.628			
	(0.197)	(0.281)	(0.284)			
RD_t/K_{1t}				–0.730	–0.584	–0.563
				(0.222)	(0.242)	(0.245)
ρ	0.459	–0.075	–0.018	0.291	0.160	0.235
	(0.081)	(0.020)	(0.004)	(0.061)	(0.058)	(0.049)
			Diagnostic tests (*p*-values)			
First-order serial correlation	0.000	0.006	0.003	0.000	0.000	0.000
Second-order serial correlation	0.904	0.177	0.203	0.225	0.080	0.045
Sargan test	0.033	0.677	0.783	0.046	0.091	0.194
Common factor restriction	0.208	0.945	1.000	0.658	0.663	0.424

Source: Authors' calculations based on Compustat and I/B/E/S data.

a. See table 1 for details of the estimated equations and of the diagnostic tests.

b. The advertising-intensive sample contains those firms that report advertising expenditures. The number of firms is 459, for a total of 3,117 observations.

c. The R&D-intensive sample contains those firms that report R&D expenditures. The number of firms is 443, for a total of 3,171 observations.

tistically insignificant; that is, the portion of Q^E that is uncorrelated with $\hat{Q}$ should still be completely uninformative for investment.

These are the results we find when we divide the sample into three roughly equal groups according to the value of *QDIF*, the proportional deviation of q^E from $\hat{q}$. The estimate on Q^E for the firms with the smallest values of *QDIF* (column 3-1) is more than five times that for those with the largest differences (column 3-7), and nearly twice that for the middle group (column 3-4). In all cases, however, when both Q^E and $\hat{Q}$ are included, the former loses its statistical significance.

Time-Series and Cross-Sectional Evidence on the New Economy

Finally, we separate the companies in our sample by industry. We classify firms as being representative of the new economy if they are in the North American Industrial Classification System under computer and

Table 3. GMM Estimates of First-Differenced Dynamic Investment Equations, Subsamples by Discrepancy in *q* Measures[a]

	Smallest QDIF[b] *(QDIF < 50 percent)*			*Intermediate QDIF*[c] *(50 percent ≤ QDIF ≤ 150 percent)*			*Largest QDIF*[d] *(QDIF > 150 percent)*		
Independent variable	*3–1*	*3–2*	*3–3*	*3–4*	*3–5*	*3–6*	*3–7*	*3–8*	*3–9*
Q^E_t	0.056		0.011	0.032		–0.001	0.010		–0.003
	(0.014)		(0.022)	(0.009)		(0.015)	(0.006)		(0.008)
$\hat{Q}_t$		0.130	0.116		0.142	0.141		0.052	0.055
		(0.032)	(0.038)		(0.025)	(0.031)		(0.015)	(0.019)
ρ	0.175	0.217	0.201	0.244	0.144	0.158	0.153	0.023	0.034
	(0.048)	(0.109)	(0.114)	(0.089)	(0.090)	(0.086)	(0.049)	(0.014)	(0.023)
				Diagnostic tests (*p*-values)					
First-order serial correlation	0.002	0.000	0.000	0.000	0.001	0.001	0.000	0.002	0.002
Second-order serial correlation	0.854	0.889	0.890	0.791	0.432	0.359	0.194	0.081	0.090
Sargan test	0.068	0.094	0.086	0.112	0.492	0.610	0.052	0.110	0.096
Common factor restriction	0.440	0.570	0.915	0.780	0.577	0.751	0.515	0.914	0.986

Source: Authors' calculations based on Compustat and I/B/E/S data.

a. The subsamples divide the full sample roughly into thirds based on the firm's average value of *QDIF,* defined as the difference between q^E and $\hat{q}$ as a percentage of $\hat{q}$. See table 1 for details of the estimated equations and of the diagnostic tests.

b. The number of firms is 371, for a total of 2,380 observations.

c. The number of firms is 368, for a total of 2,587 observations.

d. The number of firms is 375, for a total of 2,517 observations.

electronic product manufacturing, computer software, or telecommunications. These firms account for just over 10 percent of all firms and firm-year observations in the overall sample. Broader categorizations are certainly possible; for example, one might also include pharmaceutical and biotechnology companies. But when we tried broader categorizations, we found no effect on the central result that we highlight here. New economy and old economy firms are surprisingly similar: share prices are noisy for both groups, and when we consider $\hat{Q}$ we can better understand the time-series behavior of tangible investment.

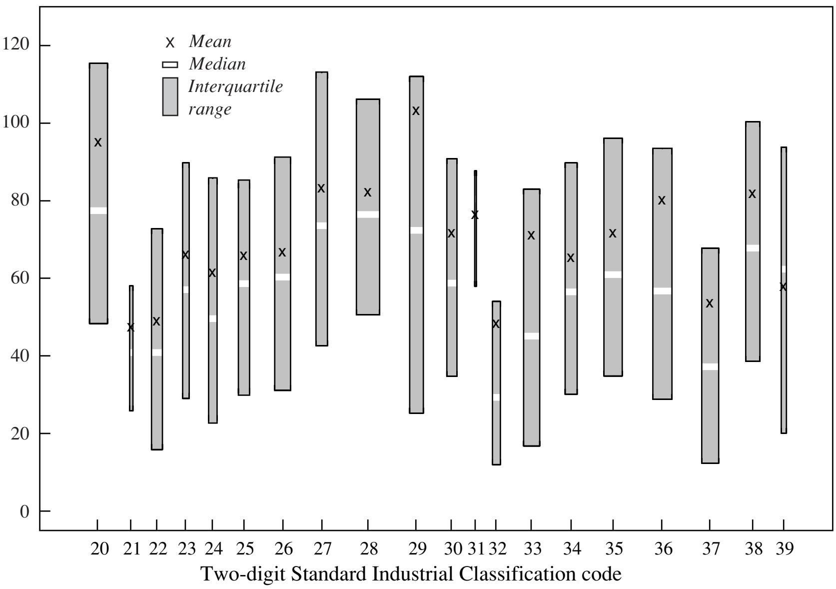
Figures 12 and 13 plot, for the old economy and the new economy companies, respectively, the mean, median, and interquartile ranges of the difference between the share price–based and analyst-based measures of the value of the company, as a percentage of the latter.[34] The two figures also define the old economy and new economy companies by the more familiar SIC codes and industry names.

Within industries, regardless of whether one looks at old economy or new economy companies, the interquartile ranges are all broad. Hence there is considerable disagreement between the two measures, regardless of the type of company. Across industries, there do appear to be important variations in the mean and the median difference in the valuations. In some industries, such as paper and allied products in figure 12 and computer and office equipment in figure 13, the mean and the median are similar. But in others, such as petroleum and coal products in figure 12 and telephone communications in figure 13, the differences are rather dramatic. Hence in some sectors there is a bigger gulf between the market-based and the analyst-based valuations. The interesting thing to notice is that these large differences occur in both types of companies. Noisy share prices, then, seem to be a much broader feature of the data; they are not confined to certain easily categorized sectors.

Perhaps counterintuitively, there does not appear to be strong evidence that the market mismeasures the value of new economy companies more than it does the value of old economy companies. The correlation coefficient between the growth rate of q^E and the growth rate of $\hat{q}$ is only 0.15 for new economy companies, about the same as for the entire sample (0.14;

34. We plot only manufacturing firms among old economy companies, because there are so few firms in some industries outside of manufacturing that their inclusion would make the figure difficult to read.

Figure 12. Mean, Median, and Interquartile Range of the Difference Between Market-Based and Analyst-Based Company Valuations for Old Economy Companies, by Industry, 1982–98[a]

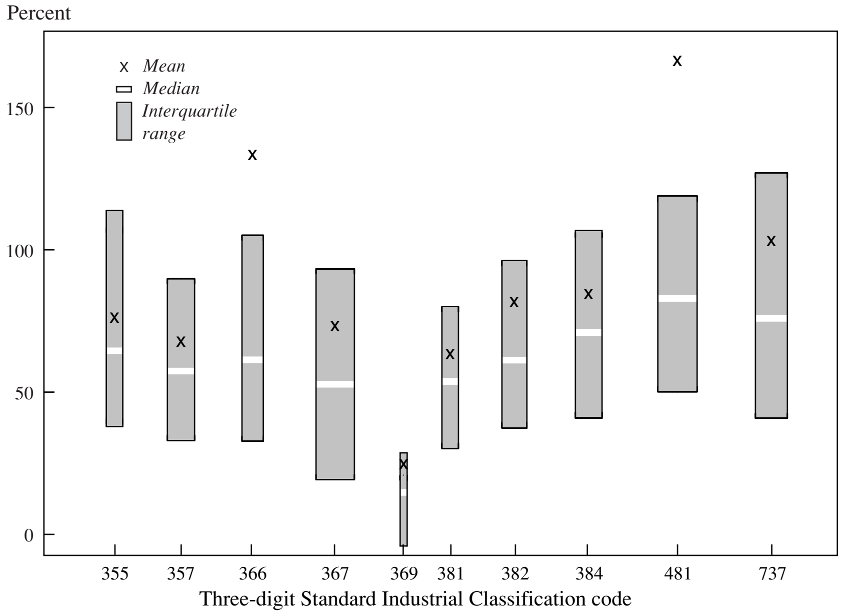


Source: Authors' calculations based on Compustat and I/B/E/S data.
a. Values are the differences between V^E and $\hat{V}$ as a percentage of $\hat{V}$. Interquartile range is the range between companies at the 25th and the 75th percentiles. SIC codes are for the following manufacturing industries: 20, Food and kindred products; 21, Tobacco manufactures; 22, Textile mill products; 23, Apparel and other textile products; 24, Lumber and wood products; 25, Furniture and fixtures; 26, Paper and allied products; 27, Printing and publishing; 28, Chemicals and allied products; 29, Petroleum and coal products; 30, Rubber and miscellaneous plastics products; 31, Leather and leather products; 32, Stone, clay, glass, and concrete products; 33, Primary metal industries; 34, Fabricated metal products; 35, Industrial machinery and equipment; 36, Electrical and electronic equipment; 37, Transportation equipment; 38, Instruments and related products; 39, Miscellaneous manufacturing industries. Bandwidths are defined as in figure 10.

see figure 3). Indeed, as can be seen by comparing figure 14 with figure 5, tangible investment tracks q^E more closely for new economy companies than for the entire sample of companies (which were overwhelmingly old economy companies at least until very recently). But as can been seen by comparing these two figures with figure 15 and figure 7, our measure of $\hat{q}$ based on analysts' earnings forecasts predicts tangible investment better than q^E does, for both old economy and new economy companies.

By itself, the difference in V^E and $\hat{V}$ could indicate measurement error in the latter (as a measure of the firm's fundamental valuation) rather than error in V^E. But we have now shown that our $\hat{V}$ measure provides much more information about firms' tangible investment behavior than does the V^E measure.

Figure 13. Mean, Median, and Interquartile Range of the Difference Between Market-Based and Analyst-Based Company Valuations for New Economy Companies, by Industry, 1982–98[a]



Source: Authors' calculations based on Compustat and I/B/E/S data.

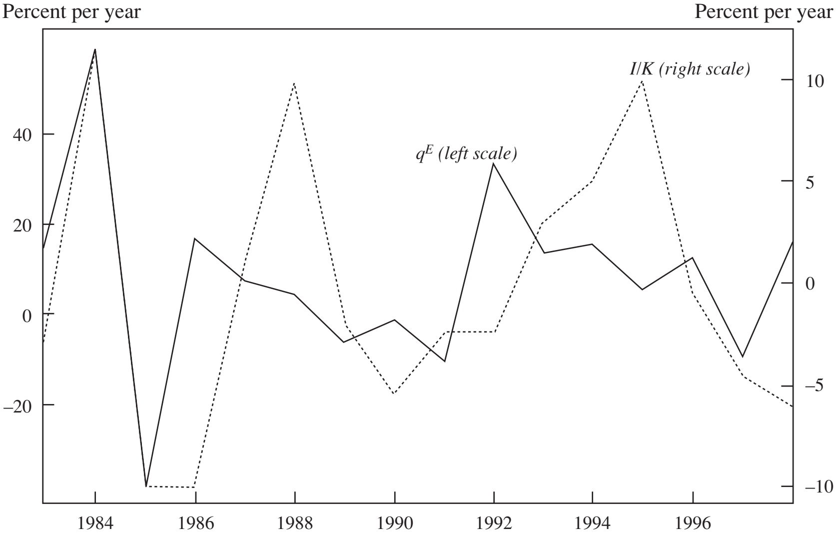
a. Values are as defined in figure 12. SIC codes are for the following industries: 355, Special industrial machinery; 357, Computer and office equipment; 366, Communication equipment; 367, Electronic components and accessories; 369, Magnetic and optical recording media; 381, Search, detection, navigation, guidance, aeronautical, and nautical systems and instruments; 382, Laboratory apparatus, optical instruments, measuring and controlling devices; 384, Surgical, medical, and dental instruments; 481, Telephone communications; 737, Computer programming and data processing. Bandwidths are defined as in figure 10.

So at least within the structure of the *Q* model, we infer that the more serious measurement error pertains to the equity valuations. This finding holds whether or not we allow for the presence of intangible assets, and whether or not we focus on intangibles-intensive or new economy firms.

Conclusion

The fundamental issue we have addressed is whether the increase in stock market prices relative to the measured stock of tangible capital reflects a growing role of intangible capital in generating profits (that is,

Figure 14. Growth Rates of Average Market-Based *q* Ratios and Investment-Capital Ratios for New Economy Companies, 1983–98[a]

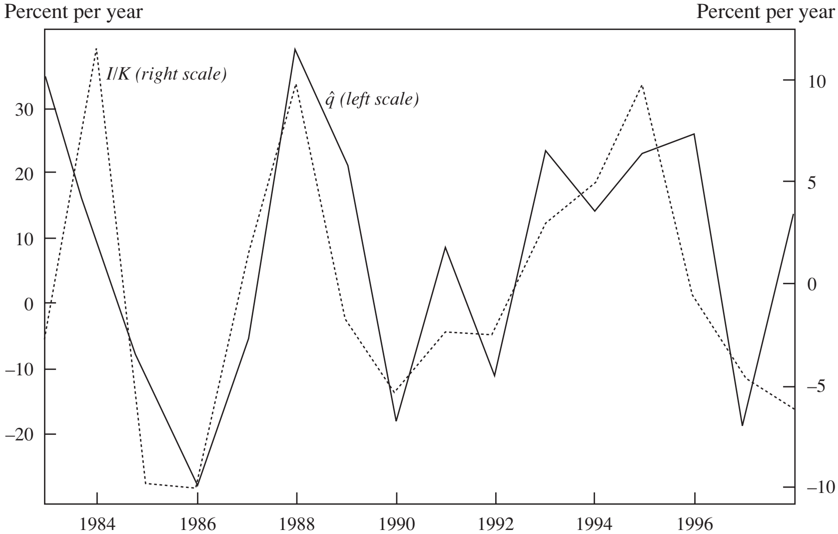


Source: Authors' calculations based on Compustat data.
a. *I*/*K* is as defined in figure 4. The correlation coefficient between the growth rates of q^E and *I*/*K* is 0.48.

the birth of the new economy) or a persistent and broadly based increase in the market valuation of companies relative to their fundamental value (that is, noisy share prices). We introduced a new approach based on the *Q* model of investment that is rich enough to encompass both these possibilities. We then studied investment behavior, in both tangible and intangible capital, and assessed whether it is consistent with one or both explanations. Although we could identify a limited role for intangible investment, we found no evidence that this factor alone can account for the spectacular rise in the stock market valuation of firms. Our evidence points to serious anomalies in the behavior of share prices.

Our findings suggest that even when we account for the role of intangible investment, there is a wide, and growing, gap between the market valuation of firms and a valuation based on expected future profits. The latter is demonstrably more informative about these firms' tangible investment behavior. Perhaps most surprising, we found that stock prices contain no information about investment behavior once we control for fundamen-

Figure 15. Growth Rates of Average Analyst-Based *q* Ratios and Investment-Capital Ratios for New Economy Companies, 1983–98[a]



Source: Authors' calculations based on Compustat data and I/B/E/S data.
a. I/K is as defined in figure 4. The correlation coefficient between the growth rates of $\hat{q}$ and I/K is 0.60.

tals using expected future profits. Hence fluctuations in share prices that are unrelated to earnings forecasts appear to be both pervasive and a sideshow for investment. And although this is found to be true for intangibles-intensive or new economy companies, our results are not limited to these firms. Our findings suggest that persistent deviations of equity values from firms' fundamental valuations are an important feature of U.S. stock markets over the past two decades, and that this can account for the weak observed relationship between share prices and investment. Our findings further suggest that managers make investment decisions to maximize the present value of expected future profits and are not influenced by the seemingly anomalous behavior of share prices. One implication is that monetary policymakers need not be unduly concerned about the impact of "irrational exuberance" on business investment, although they may nevertheless be interested in the behavior of the stock market for other reasons, such as wealth effects on consumption.

APPENDIX A

Derivation of Models

Derivation of the *Q* Model

Let the multipliers associated with the constraints in text equation 2 be $\lambda_{j,t+s}$. Then the first-order conditions for maximizing equation 1 subject to equation 2 are

$$-\left(\frac{\partial \Pi_t}{\partial I_{jt}}\right) = \lambda_{jt} \quad \forall j = 1, \ldots, N \tag{A1}$$

and

$$\begin{aligned} \lambda_{jt} &= \left(\frac{\partial \Pi_t}{\partial K_{jt}}\right) + (1-\delta_j)\beta^t_{t+1} E_t\left[\lambda_{j,t+1}\right] \ \forall j = 1, \ldots, N \\ &= E_t\left[\sum_{s=0}^{\infty} \beta^t_s (1-\delta_j)^s \left(\frac{\partial \Pi_{t+s}}{\partial K_{j,t+s}}\right)\right], \end{aligned} \tag{A2}$$

where the first line in equation A2 is the basis for estimating the Euler equation of investment, and the second line is the basis for Andrew Abel and Olivier Blanchard's forecasting approach.[35]

To derive an empirical investment equation based on Tobin's q for a single homogeneous capital good, we proceed in two steps. We first express marginal q in terms of observable variables, and then we use it in the first-order condition for investment in equation A1.

Combining equations A1 and A2, assuming that $N = 1$ and using the linear homogeneity of $\Pi(K_t, I_t, \epsilon_t)$,

$$\begin{aligned} \lambda_t(1-\delta)K_{t-1} &= \Pi_t + \beta^t_{t+1} E_t\left[\lambda_{t+1}(1-\delta)K_t\right] \\ &= E_t\left[\sum_{s=0}^{\infty} \beta^t_{t+s} \Pi_{t+s}\right] \\ &= V_t. \end{aligned}$$

Thus we have

35. Abel and Blanchard (1986).

$$\lambda_t = \frac{V_t}{(1-\delta)K_{t-1}}$$

and

(A3) $$q_t = \frac{\lambda_t}{p_t} = \frac{V_t}{p_t(1-\delta)K_{t-1}},$$

where p_t is the price of capital goods, and q_t is marginal q.

We assume that the net revenue function, Π, is composed of a production function, F, and an adjustment cost function, G, which are additively separable:

(A4) $$\Pi(K_t, I_t, \epsilon_t) = g_t\,[F(K_t) - G(I_t\; K_t, \epsilon_t)] - p_t I_t,$$

where g_t is the price of output.

We can use equation A4 to reexpress the first-order condition for investment in equation A1 in terms of the adjustment cost function, marginal q, and the relative price of capital:

$$\frac{\partial G_t}{\partial I_t} = (q_t - 1)\,\frac{p_t}{g_t}.$$

Assuming that the adjustment cost function is quadratic in investment and symmetric about some "normal" investment rate a:

(A5) $$G(I_t, K_t, \epsilon_t) = \frac{b}{2}\left[\left(\frac{I_t}{K_t}\right) - a - \epsilon_t\right]^2 K_t,$$

we obtain

(A6) $$\frac{I_t}{K_t} = a + \frac{1}{b}\,(q_t - 1)\,\frac{p_t}{g_t} + \epsilon_t.$$

Marginal q is unobservable, and therefore this equation cannot be estimated directly. To derive an empirical investment equation we combine equation A3 with equation A6:

(A7) $$\frac{I_t}{K_t} = a + \frac{1}{b}\left[\frac{V_t}{p_t(1-\delta)K_{t-1}} - 1\right]\frac{p_t}{g_t} + \epsilon_t.$$

This equation is the basis for our investigation of the new economy and noisy-share-price hypotheses.

Derivation of the New Economy Model

Combining equations A1 and A2, assuming that $N = 2$ and using the linear homogeneity of $\Pi(K_t, I_t, \epsilon_t)$,

$$\sum_{j=1}^{2} \lambda_{jt}(1-\delta_j)K_{j,t-1} = \Pi_t + \beta_{t+1}^{t} E_t \left[\sum_{j=1}^{2} \lambda_{j,t+1}(1-\delta_j)K_{jt} \right]$$
$$= E_t \left[\sum_{s=0}^{\infty} \beta_{t+s}^{t} \Pi_{t+s} \right]$$
$$= V_t .$$

Thus marginal q for the first type of capital can be expressed as

$$\text{(A8)} \qquad q_{1t} = \frac{\lambda_{1t}}{p_{1t}} = \frac{V_t}{p_{1t}(1-\delta_1)K_{1t}} + \frac{1}{p_{1t}} \left(\frac{\partial \Pi_t}{\partial I_{2t}} \right) \left(\frac{1-\delta_2}{1-\delta_1} \right) \left(\frac{K_{2t}}{K_{1t}} \right),$$

and similarly for q_{2t}.

If we assume that the adjustment cost function is additively separable in tangible and intangible capital, we can derive an empirical investment equation based on Tobin's q. If it is not additively separable, such an equation can be derived, but it cannot be econometrically identified. In our case the assumption is not unappealing, since the cost of installing fixed capital is unlikely to have an effect on the adjustment costs of advertising, R&D, and the like. We choose the two-capital-good analogue of the adjustment cost function introduced in equation A5 where we have imposed additive separability:

$$\text{(A9)} \quad G(\mathbf{I}_t, \mathbf{K}_t, \epsilon_t) = \frac{b_1}{2} \left[\left(\frac{I_{1t}}{K_{1t}} \right) - a_1 - \epsilon_t \right]^2 K_{1t} + \frac{b_2}{2} \left[\left(\frac{I_{2t}}{K_{2t}} \right) - a_2 \right]^2 K_{2t},$$

where tangible and intangible variables are indicated by the subscripts 1 and 2, respectively. Then we can obtain the following empirical investment equation:

(A10)
$$\frac{I_{1t}}{K_{1t}} = a_1 + \frac{1}{b_1}\left[\frac{V_t}{p_{1t}(1-\delta_1)K_{1,t-1}} - 1\right]\frac{p_{1t}}{g_t} - \frac{b_2}{b_1}\left(\frac{1-\delta_2}{1-\delta_1}\right)\left(\frac{I_{2t}}{K_{1t}}\right) + \frac{a_2 b_2}{b_1}\left(\frac{1-\delta_2}{1-\delta_1}\right)\left(\frac{K_{2t}}{K_{1t}}\right) - \frac{1}{b_1}\left(\frac{1-\delta_2}{1-\delta_1}\right)\left(\frac{p_{2t}}{p_{1t}}\right)\left(\frac{K_{2t}}{K_{1t}}\right) + \epsilon_t.$$

To estimate this model without requiring data on the stock of intangible capital (K_2), we assume that intangible capital and its price are an exogenously fixed proportion of tangible capital and its price:

(A11)
$$K_1 = \frac{1}{c_i} K_2 \quad \infty > c_i > 0;$$

(A12)
$$p_1 = \frac{1}{d_i} p_2 \quad \infty > d_i > 0.$$

for each firm i. This allows us to rewrite equation A10 in the following way:

(A13)
$$\frac{I_{1t}}{K_{1t}} = a_1 + \frac{1}{b_1}\left[\frac{V_t}{p_{1t}(1-\delta_1)K_{1,t-1}} - 1\right]\frac{p_{1t}}{g_t} - \frac{b_2}{b_1}\left(\frac{1-\delta_2}{1-\delta_1}\right)\left(\frac{I_{2t}}{K_{1t}}\right) + \frac{a_2 b_2}{b_1}\left(\frac{1-\delta_2}{1-\delta_1}\right)c_i - \frac{1}{b_1}\left(\frac{1-\delta_2}{1-\delta_1}\right)c_i d_i + \epsilon_t.$$

Since the parameters and depreciation rates are nonstochastic, we can redefine the terms that are multiplied by c_i and d_i as e_i. Doing so yields equation 5 in the text.

APPENDIX B

Construction of Variables

Construction of *Q*

Incorporating the usual adjustments for debt, taxes, and current assets, Q is defined as

(B1)
$$Q_{it} = \frac{1}{1-\tau_t}\left[\frac{L_{it}V_{it} + B_{it} - A_{it} - C_{it}}{p_t(1-\delta)K_{i,t-1}} - (1-\Gamma_{it})\right]\frac{p_t}{g_t},$$

where τ is the marginal corporate tax rate; L is an indicator variable equaling unity if the firm is not paying dividends and $(1 - m_t)/(1 - z_t)$ if it is, where m is the personal tax rate on dividends and z is an accrual-equivalent capital gains tax rate; V is the expected present discounted value of future payments to shareholders (what we call in the text the firm's fundamental valuation); B is the book value of its outstanding debt; A is the present value of the depreciation allowances on investment made before period t; C is current assets; K is the replacement value of the firm's tangible capital stock; p_t and g_t are the price of the investment good and the price of output, respectively; and Γ is the present value of the tax benefit for each dollar of current investment spending. For example, with an investment tax credit at rate k, Γ is

$$\Gamma_{it} = k_{it} + \sum_{s=t}^{\infty} (1 + r_s + \pi_s^e)^{s-t} \tau_s \; DEP_{is} \; (s - t),$$

where r is the default risk–free real interest rate (assumed to equal 3 percent), π^e is the expected inflation rate, and $DEP_{is}(a)$ is the depreciation allowance permitted for an asset of age a.

We discuss below how we construct V^E and $\hat{V}$. Unless noted otherwise, the rest of the components of Q_{it} come from Compustat data. The value of debt is the sum of short-term debt (data item 34) and long-term debt (data item 9), both measured at book value. The present value of the depreciation allowances on investment made before period t is calculated using the method of Salinger and Summers.[36] Current assets are total current assets (data item 4), the sum of short-term cash and marketable securities, inventories, accounts receivable, and other current assets. The replacement cost of the tangible capital stock is calculated using the standard perpetual inventory method, with the initial observation set equal to the book value of the firm's first reported net stock of property, plant, and equipment (data item 8) and an industry-level rate of depreciation constructed from Hulten and Wykoff.[37]

Among the remaining components of tax-adjusted Q, the data on expected inflation are the annual averages of monthly expectations reported in the Livingston Survey, administered by the Federal Reserve Bank of Philadelphia. The tax parameters (τ, m, z, A, k, and DEP) are

36. Salinger and Summers (1983).
37. Hulten and Wykoff (1981).

updated from those used in Cummins, Hassett, and Hubbard;[38] we construct firm-specific investment tax credits and depreciation allowances to reflect the asset composition of the firm's two-digit SIC category.

The price index for tangible capital is the IPD for tangible investment for the firm's three-digit SIC category. The price index for output is the three-digit IPD for gross output. These price deflators are obtained from the National Bureau of Economic Research/Census database.[39]

Construction of V^E and $\hat{V}$

V^E, which replaces the fundamental valuation of the firm V to form Q^E, is the sum of the market value of common equity at the start of period t and the market value of preferred stock. The market value of common equity is defined as the number of shares of common stock outstanding multiplied by the share price at the end of the previous accounting year, and the market value of preferred stock is defined as the firm's preferred dividend payout divided by Standard & Poor's preferred dividend yield, obtained from Citibase.

$\hat{V}$, which replaces the fundamental valuation of the firm V to form $\hat{Q}$, is constructed in the following way. Let NI_{it} and $NI_{i,t+1}$ denote firm i's expected profits in periods t and $t + 1$, respectively, formed using beginning-of-period information (that is, information from the end of period $t - 1$). Let GR_{it} denote firm i's expected growth rate of profits in the following periods, formed using beginning-of-period information. We date the stock market valuation of the firm, V^E, in Q^E as of the end of period $t - 1$ so the market information set contains these forecasts. We calculate the implied level of expected profits for periods after $t + 1$ by growing out the average of NI_{it} and $NI_{i,t+1}$ at the rate GR_{it}.[40] Let this average be ANI_{it}. In principle, the horizon for calculating $\hat{V}$ should be infinity. However, the analysts forecast GR over a horizon of five years. Thus, in order to match the horizon for which we have information, we set the forecast horizon to five years. We then calculate a terminal value correction to account for

38. Cummins, Hassett, and Hubbard (1994).

39. http: //www.nber.org/nberprod.

40. We grow out the average of the one- and two-year-ahead forecasts rather than the two-year-ahead forecast because I/B/E/S defines *GR* as the expected trend growth of the company's earnings, not the growth rate from the two-year-ahead forecast of earnings.

the value of the firm's expected profits beyond year five. The correction assumes that the growth rate for earnings beyond this five-year horizon is equal to that for the economy. Specifically, the last year of expected earnings is turned into a growth perpetuity by dividing it by $\bar{r} - \bar{g}$, where we assume that $\bar{r}$ is the mean nominal interest rate for the sample period as a whole (about 15 percent, which includes a constant 8 percent risk premium) and $\bar{g}$ is the mean nominal growth rate of the economy for the sample period as a whole (about 6 percent).

Depending on the firm and the industry, five years may be an over- or an underestimate of when growth opportunities converge to that for the economy. Unfortunately, we do not have any firm-level data from which to construct more precise measures. Even if we had richer data, there is no clearly preferred method for calculating a firm's terminal value.[41] We follow the suggestion of Richard Brealey and Stewart Myers to use this particular method because it "forces managers to remember that sooner or later the competition catches up."[42] The important thing to keep in mind is that our empirical results are robust to the wide range of different formulations that we considered.

The resulting sequence of expected profits defines $\hat{V}_{it}$:

$$\hat{V}_{it} = NI_{it} + \beta_t NI_{i,t+1} + \beta_t^2(1+GR_{it})ANI_{it} + \beta_t^3(1+GR_{it})^2 ANI_{it} + \beta_t^4(1+GR_{it})^3 ANI_{it} + \beta_t^5 \frac{(1+GR_{it})^3 ANI_{it}}{\bar{r}-\bar{g}}.$$

We set the discount factor to reflect a static expectation of the nominal interest rate over this five-year horizon. That is, we use the thirty-year Treasury bond interest rate in year t (plus a fixed 8 percent risk premium as suggested by Brealey and Myers, among others).

41. As noted by Brealey and Myers (1996).
42. Brealey and Myers (1996, p. 78).

Comments and Discussion

Janice Eberly: Since 1995 the Standard & Poor's 500 index has risen by a factor of three, or about 25 percent per year. Impressive as this performance is, it is modest in comparison with the sevenfold, or 45 percent per year, increase logged over the same period by the S&P High Technology Index as of the date of this conference. This astounding performance suggests to many that an asset bubble has developed in equity markets. Alternatively, the value of firms' intangible capital may have risen substantially, accounting for at least part of the spectacular increase in their market values, particularly in "new economy" industries.

Stephen Bond and Jason Cummins attempt to sort out these two explanations empirically. This is an admirable and difficult task, since neither the market values of intangible assets nor asset bubbles are directly observable. Lacking direct measures, the authors construct a model and use proxies for the desired data and argue that intangible and bubble effects can be inferred from the results.

The starting point of Bond and Cummins' argument is a measure of firms' value based on analysts' earnings forecasts. This is used to construct a measure of average q based on expected earnings rather than markets' valuation of those earnings. To tackle the problem of unobserved intangible capital, the authors then set up a model that allows them to use only the flow of investment in, rather than the stock of, intangibles. They estimate this model as a linear regression of physical capital investment on their constructed measure of fundamentals and intangible investment. An asset-based measure of fundamentals, Tobin's q, is added to this regression as a diagnostic: if the "fundamental measure" is correctly capturing investment incentives, then any additional value in Tobin's q is simply noise, or a bubble.[1] Such a bubble, they argue, should not affect investment and therefore should not be significant in the regression. The final test is to analyze new economy firms separately. Even if the measure of intangibles is not perfect or does not apply to all firms, then by dividing the sample, it should be possible to ascertain whether intangibles are relatively more important in the new economy.

Based on this empirical strategy, the paper finds that the asset-based measure of Tobin's *q* does not provide incremental information in the investment equation, and that the effect of intangibles in these equations is modest—in both old and new economy firms. The paper concludes that the explanation for equity prices based on intangibles is a "fiction" and that equity prices instead contain a large bubble component—"noisy share prices"—that is pervasive across firms and industries and over time.

The approach the authors use to reach these conclusions has four necessary ingredients: the measure of fundamentals, the use of the investment equation to identify the fundamental part of the firm's value, the measure and specification of the effects of intangibles, and the identification of the new economy. Each of these links deserves careful attention.

To construct their measure of fundamentals, Bond and Cummins use data from equity analysts who forecast earnings at the firm level. The authors gather two years of earnings forecasts and project a "long run" growth rate that goes out to year five. To calculate a firm's value based on these three pieces of data, the authors have to make a number of assumptions. For example, they assume that earnings after year five will grow at a fixed, economy-wide rate of 6 percent, and they discount the future earnings of all firms at the same rate. This common discount rate is the current-year long-term Treasury bond rate plus a constant risk adjustment of 8 percent. Thus, all firms implicitly have a beta of one and assume a fixed interest rate over a five-year horizon. In addition, by discounting forecasted earnings rather than cash flows, the valuation incorrectly allows for depreciation but not investment expenditure.

Although all of these measurement problems would be likely culprits if the resulting valuation were not empirically relevant, the results suggest instead that it is strongly associated with investment. Moreover, this

1. Bond and Cummins refer to a deviation of Tobin's *q* from fundamentals as their "noisy share price" model. I will refer to this deviation as a bubble to clearly distinguish it from white noise or classic measurement error, since the paper assumes it to be persistent.

finding is robust to the inclusion of Tobin's q measured with asset prices, which has little marginal empirical impact. I found this to be the most intriguing result of the paper. Although in a formal sense it is consistent with a q model of optimal investment, it is also clearly at odds with the original asset market rationale of the model as laid out by William Brainard and James Tobin.[2]

The link from these very interesting investment equations to valuations comes from the assumption that investment should respond only to the fundamental part of a firm's valuation. There is a serious unresolved question, however, of how investment should respond to a bubble in asset prices.

Olivier Blanchard, Changyong Rhee, and Lawrence Summers considered this question in a closely related paper using aggregate data.[3] An optimizing firm may respond to a positive bubble by issuing equity, to take advantage of this now-cheaper source of financing. However, the firm must consider the signal it sends to investors by its use of these funds. Investing the proceeds of an equity issue in safe securities, while preserving the fundamental path of the capital stock, may burst the bubble, if it exists. Thus a firm may consider investing in physical capital even though this distorts its capital choice. In this case, one would expect investment to respond to the nonfundamental part of valuation as well as the fundamental part. More generally, an asset bubble may not be independent of the actions of the firm, and vice versa. Thus, on the basis of current theory, physical investment cannot serve as a reliable device for identifying asset bubbles. Investment may respond to bubbles, and conversely, the part of valuation not driving investment need not be a bubble, as I discuss below.

The measure of intangibles and their inclusion in the investment equation are a critical component of the paper's argument that intangibles cannot explain the observed high values of Tobin's q. Since the market value of intangible capital is not observed, the authors adopt a two-step strategy. First, they make modeling assumptions such that it is only necessary to observe the flow (investment) rather than the stock of intangible capital. Second, they measure the flow of intangible capital as a firm's advertising expenditure and research and development expense.

2. Brainard and Tobin (1968).
3. Blanchard, Rhee, and Summers (1993).

Regarding the modeling, the initial framework is a standard, linearly homogeneous, quadratic adjustment cost model. This motivates the basic investment regression using Tobin's q. The authors' new economy model is a two-types-of-capital version, which is also standard in the literature. However, empirical implementation of this model would require data on the stock of intangible capital, but these data are unavailable. Therefore the authors assume that, for each firm, the stock of intangible capital is proportional to the stock of physical capital; the prices of the two types of capital are also assumed to be proportional to each other. This assumption is very strong and lacks both theoretical and empirical justification. In their model, stocks of capital are endogenous variables; thus, if the two stocks are to be proportional, the model must have a particular form. For example, if there are no adjustment costs on intangible capital, then in the authors' linearly homogeneous framework, it will track physical capital, as required by the proportionality assumption. However, if there are no adjustment costs on intangibles (the parameter b_2 is zero), intangibles do not appear in the investment equation for physical capital (equation A10), which is the main estimation equation. Moreover, if intangible and physical capital values are proportional, then the new economy story cannot explain a "persistent … increase in the market valuation of companies relative to their fundamental value" (from the conclusion) by construction. This story requires a source of value that is growing relative to physical capital. By assuming that the two are proportional, the authors have assumed that intangibles are not the explanation.

Once the assumption has been made, the next step is to measure investment in intangibles. Advertising and R&D are prime examples of intangible assets, but of course they are not the only candidates. Proponents of the new economy would consider much of the customer service work force, marketing, and other "investments" in market share by these firms to be investment in intangible capital. It is understandably difficult for the authors to include these other intangibles in their estimation. However, the limited scope of advertising and R&D may explain their modest empirical success, rather than demonstrate a more general failure of the intangible capital explanation.

Admittedly, the "new economy" of the paper's title is hard to define precisely, but it is not clear that this approach completely captures and explores what is meant by this concept. Consider, for example, two prominent new economy firms. Yahoo! Inc. had sales in 1998 of \$200 million—

an almost threefold increase from its $70 million in sales the previous year. Its expenditures on sales and marketing in 1998 were $90 million, yet its investment in physical capital was only $8 million. This paper attempts to understand Yahoo!'s price-earnings ratio of 420 by looking at that $8 million physical capital investment, which seems rather like the proverbial tail wagging the dog. Yahoo! is a particularly weightless firm, but a similar picture emerges from looking at Dell Computer Corp. Dell's 1999 revenue was over $18 billion. Physical capital investment was less than $700 million, or less than 4 percent of revenue—that ratio is, in fact, quite similar to that of Yahoo! R&D expenditure was less than half of investment expenditure.

Less anecdotally, the authors can use the physical capital investment equation to infer the presence of intangible capital because they assume a linearly homogeneous value function. This is a common assumption in the investment literature, but in this case the results are quite sensitive to it. In a standard formulation the value of the firm is $V(K_1, K_2)$, where K_1 and K_2 are tangible and intangible capital, respectively.[4] The derivative of the value function with respect to tangible capital, $V_{K1}(K_1, K_2)$, gives the marginal value of an additional unit of capital. This marginal value determines investment in physical capital, so the investment equation depends on both types of capital. Suppose instead that another part of the firm's value depends only on intangibles. Then the total value of the firm could be defined as $W(K_1, K_2) = V(K_1, K_2) + v(K_2)$. In this case, tangible investment should only respond to $V_{K1}(K_1, K_2)$ and could have an arbitrarily small response (even zero) to intangibles in the investment equation; the strength of this effect depends on the importance of K_2 in $V(.)$. Nonetheless, intangibles could account for a large part or even most of the firm's value, through the second term $v(K_2)$. This paper finds that investment in physical capital interacts only modestly with investment in intangibles, but only under very specific assumptions does this rule out a role for intangibles (or other capital) in valuation. Intangibles may have a modest (or even no) effect on physical investment, while still having an arbitrarily large effect on the firm's valuation.

Finally, the paper compares the results for intangibles-intensive firms and for new economy firms with the results for the whole sample. Such benchmark observations, however, are limited in both the time series and

4. This suppresses the dependence of the value function on the productivity shock.

the cross section. First, the new economy is a relatively recent phenomenon, so the estimation period (1986 to 1998) includes at best a limited sample of these observations. Second, in the cross section, firms are labeled new economy firms if they are in certain industries identified as new economy industries, and they are labeled intangibles-intensive if they have any advertising or R&D expenditure. However, a large number of new economy firms are ruled out by the sample selection criteria. Firms must have four years of Compustat data and be followed by at least one equity analyst to even be included in the sample. Thus, the two examples given above—Yahoo! and Dell—are excluded, even though these are prime candidates for the new economy label. Indeed, all of the firms in the Chicago Board Option Exchange (CBOE) Internet Index are excluded from the sample, as are all of the firms in the Dow Jones e-Commerce Index. Looking more broadly at technology firms, the sample includes only twelve of the thirty firms in the CBOE Technology Index, or even more broadly, only twenty-three of the seventy-one firms in the S&P High Technology Composite. This relatively slim coverage of the most relevant firms suggests that the paper's general conclusions should be cautiously interpreted.

In conclusion, this paper explores one of the most provocative issues in current financial markets: are equities overvalued, or can the high valuations be justified by increasing amounts of intangible capital? Since both intangibles and excess valuations are difficult to observe, this is quite a challenging question. Bond and Cummins address this problem with two sorts of resources. First, they bring additional data in the form of analysts' earning forecasts. Second, they impose assumptions sufficient to allow them to measure intangible capital using expenditures on advertising and R&D. Bringing in additional data is typically a most fruitful way of addressing measurement problems, and that is the case here. This effort raises some interesting questions about the information content of earnings forecasts and asset prices; these results will likely spawn future work to understand these implications. The second part of the effort, specifying and measuring the role of intangible capital, is more tenuous. A series of assumptions are necessary to get from the investment equations to general conclusions about asset market bubbles and the role of intangibles in valuation. In this way the new economy and asset values largely escape from the authors' sights, although they do leave some interesting findings about corporate investment behavior.

Robert J. Shiller: Stephen Bond and Jason Cummins say that "The fundamental issue we address is whether the increase in stock market prices relative to the measured stock of tangible capital reflects a growing role of intangible capital in generating profits (that is, the birth of the new economy) or a persistent and broadly based increase in the market valuation of companies relative to their fundamental value (that is, noisy share prices)." This is certainly an issue of fundamental importance today. In fact, so much has it been debated that it might be called the "issue of the year," endlessly discussed in the news media, at dinner parties, and in Internet chat rooms. This paper is an exceptional piece of evidence to enter into this debate. The authors' approach is refreshingly different from that in most discussions, and it opens up some important new avenues, although it does not finally resolve the issue.

The authors base their analysis on firm-level U.S. data on stock market valuations, investment, earnings forecasts, the capital stock, advertising expenditure, and research and development expenditure over the period 1982–98, when most of the phenomenal recent increase in stock market valuation took place. These data reflect the fundamental activities, pricing, and outlook of the firms, and so looking at them might be seen as an important avenue to understand this valuation increase. In fact, they may be regarded as the only available essential data on which a systematic analysis of the soundness of firm valuations might possibly be derived. It is encouraging to see the authors try to answer their basic question with such data.

In my own work on stock market valuations, I had doubted that one could use such data to resolve whether many stocks are overpriced. The Standard & Poor's Composite Stock Price Index has tripled since 1995, an amazing and historic increase in value. The question is whether the boost of the "new economy," as exemplified by the Internet, justifies this increase in value. If markets are efficient, this enormous increase in price reflects new information about the present value of future dividends, a present value whose mean lead time is something on the order of decades. Because of recent technological changes involving the Internet and other high-technology activities, the question revolves around whether the production function will shift upward in coming decades. How can we hope to learn from the last five years' data on the past activities of firms whether these hopes today for coming decades are indeed justified?

Bond and Cummins hope to answer this question by seeing whether firms themselves act, in making their own investment decisions, as if they believe the valuation of the market, or whether they act instead as if they are merely basing those decisions on earnings forecasts. If firms themselves act more as if they are reacting to the present value of forecasted earnings, rather than to the market value of the firm, it suggests that the market valuations are not valid.

Indeed, we see from their regressions in table 1 that when investment is predicted by the usual Q ratio, which they call Q^E, the coefficient is smaller (0.011) than when it is predicted by their measure based on analysts' earnings forecasts, $\hat{Q}$ (0.110). This evidence is suggestive of their basic thesis, namely, that managers react less to information in market prices than they do to information contained in forecasts of earnings growth. But the evidence is not conclusive. One sees from their figure 3 that $\hat{Q}$, in the aggregate, is much less variable than, and still highly correlated with, Q^E. Part of the difference in coefficients might be described as little more than the result of rescaling the Q variable.

The authors' statement that the coefficient of 0.011 is "small" needs some examination. This coefficient, according to their model, represents the reciprocal of the parameter b in equation A5 in their appendix A. Unfortunately, I find it hard to decide what a "small" or a "large" coefficient is in this equation, perhaps partly because I do not know what these adjustment costs represent, and partly because I do not find the quadratic assumption natural, even if it is convenient for the analysis. Understanding the adjustment costs model is essential, since the only parameters that are estimated in this model are adjustment cost parameters.

What are these adjustment costs? The simplest story is that they represent the costs of bolting down new machines on the factory floor, the costs of training new employees to use them, the costs of setting up new supply lines and distribution networks, and so on. Taken literally, these adjustment costs do not sound like the important barriers to the expansion of the capital stock. Perhaps a more plausible story of adjustment costs is that they represent the scarcity of time of the firm's managers. Firms cannot undertake every worthwhile project at once; instead, they have to get around to them in the managers' own time.

For concreteness, think of a retail firm, such as a grocery store chain, operating successfully in one part of the country. Naturally, the managers will wonder whether they can set up a carbon copy of the firm in another part of the country and do as well. There are apparently real barriers to doing this, most notably competitive barriers. The managers may feel that their success is due to working hard and accumulating intimate knowledge of the local market situation, and that they cannot simply hire managers at random in another part of the country and expect them to duplicate their success.

Equation A5 might serve to represent such adjustment costs, but it does not do so extremely well. One defect, in my mind, is that adjustment costs in the authors' model depend on investment relative to the capital stock. The capital stock does not seem to be exactly the right scaling variable for adjustment costs. Maybe lagged investment or total profits should be used to scale these costs instead.

The plausibility of the estimated coefficient depends a lot on whether one is thinking of making a large or a small adjustment in the capital stock. The estimated coefficient on Q^E of 0.011, whose reciprocal is 91, means that if investment deviates by 1 percent of the capital stock from its usual value, the adjustment costs will be 0.45 percent of the capital stock. This is perhaps plausible. If, on the other hand, investment were to deviate by 10 percent of the capital stock from its normal value, adjustment costs would be 45 percent of the capital stock, and that seems too high. Carrying this further, if a firm attempted to double its capital stock in one year (beyond its usual investment), it would incur adjustment costs equal to 45 times its capital stock. That really seems astronomically too high, but then again, doubling the capital stock in a year is perhaps outside the range of investment that is relevant to investment function estimation. The higher estimated coefficient (0.110, whose reciprocal is 9) obtained when $\hat{V}$ is used implies that attempting to increase one's capital stock by 10 percent in a year beyond the usual investment would incur a cost equal to 4.5 percent of the value of the capital stock. That still seems too high unless perhaps we interpret adjustment costs very broadly.

An important contribution of this paper is its model of intangible investment in appendix A, which leads to equation A13 and is the basis of an estimated investment equation. This model is important, since the assumptions of the traditional Q model seem less believable for new economy firms that rely less on physical capital. Notably, in the time-series cross-sectional regressions reported in the tables, their simple model in equation A5 would imply that software firms, for example, which have little physical capital, would be steadily investing a great deal in physical capital. The additional regressors are thus a fundamental improvement to the model.

The essential element of this model is the assumption of additively separable adjustment costs, as described by equation A9 in appendix A. The authors offer no real justification for the additive separability assumption. To the extent that adjustment costs reflect the scarcity of essential management resources, these costs would not be additively separable. If managers are tied up with installing new tangible capital, they will not have time to launch a new advertising campaign. Moreover, the idea that scarcity of management time is the essential adjustment cost might also suggest that, if one is adjusting physical capital, the cost of adjustment of associated advertising costs might be lower than usual, since managers likely assume that these costs are essential costs to ensure the success of the business expansion that they are attempting with the physical capital adjustment.

In any case, if one accepts the authors' assumption of additively separable adjustment costs, how do they arrive at equation A13? It seems hardly intuitive on looking at it. I find that a simple way of motivating this equation is to assume that the production function is also additively separable in the two kinds of capital. Since the production function is not the focus of the analysis here (its parameters are not even being estimated), we might as well simplify it for expositional purposes. If we do that, we can represent the firm's problem as two completely separate and unrelated problems, one relating to fixed investment and the other to intangible investment. Obviously, then, the simple Tobin's Q investment model (equation A6 or A7) holds separately, both for tangible investment and intangible investment, but with the value of the fixed investment component of the firm in the numerator of Q for tangible investment, and with the value of the intangible investment component of firm value in the numerator of Q for intangible investment. But we do not observe the values of the two components of the firm separately, only the overall value of the firm. Then the terms I_{2t}/K_{1t} and K_{2t}/K_{1t} in equation A10 appear just as corrections of the overall value of the firm due to tangible investments.

I find the step of assuming that $K_1 = K_2/c_i$ in equation A11 a little abrupt. Why should there be fixed proportions between the two kinds of capital? This would be so, given the model, only under some unusual patterns of prices. And why should $p_1 = p_2/d_i$ (equation A12)? The authors offer no justification. The entire empirical analysis that follows would be called into question if we disallowed these assumptions.

In any event, in the estimated results in tables 1 and 2, the coefficients of the I_2 variables, the advertising and research and development variables, do come out with the negative sign predicted by theory, although they are not always statistically significant. The inclusion of these variables does not have much effect, in general, on the estimated Q coefficient.

I found it at first rather surprising that the authors so often obtain a negative coefficient on advertising and R&D. I would have thought that when firms are investing heavily (something that is not well explained by the Tobin's Q variable), they would tend also to be advertising heavily and doing a lot of R&D. So the coefficients on these variables should be positive. But in understanding these results, we must bear in mind that these are time-series cross-section regressions, and that they must therefore also explain cross-firm variation. Firms that rely little on physical capital, and therefore have high Qs, are not steadily investing a lot in physical capital, and the only variables in the regressions that might capture this fact are the advertising and R&D variables. For software firms, which employ relatively little physical capital, R&D and advertising probably tend to be higher relative to the capital stock than for other firms, and thus the regression gives these variables a negative coefficient to prevent overpredicting the investment of these firms.

I think that the authors have "saved" the Q model for such time-series cross-section regression analysis from the obvious criticism that some new economy firms have so little capital that Q ought to be high for them. I am not sure that this is the best model to achieve this result, however. Some big problems in my mind are, first, that the intangible investment variables the authors use are not comprehensive measures of the broader intangible investments that a firm makes, and second, that the constant-returns-to-scale assumption is certainly wrong for individual firms. Thus, for example, a mature software firm that has a very high Q because it does not need physical capital for production might not be making heavy R&D or advertising expenditures either, and for this firm the model would not fit well. But in the context of a general theoretical framework to apply to a broad array of firms, theirs is a successful effort.

Their results are indeed suggestive that managers who make investment decisions are more influenced by the present value of projected earnings than by the market price of the firm. And as I see it, their results add a little more fuel to the argument that the high valuations we see in the stock market today are not right.

General discussion: Several panelists, while recognizing the difficulty of constructing a direct measure of intangible capital, expressed reservations about the variables used by the authors as proxies. There was general agreement that R&D is more plausibly related to intangible investment than is advertising. Pierre-Olivier Gourinchas pointed out, however, that R&D, presumptively the best measure, did not perform as well as advertising in the regressions; typically, coefficient estimates for R&D in regressions using the authors' preferred measure of q were insignificant. He also suggested that, if advertising is to be used as a proxy for intangibles, an effort should be made to construct stock measures from the expenditure data, taking account of depreciation. Jason Cummins responded that the imprecise coefficient estimate on R&D in the paper's table 1 reflected the fact that most firms in the full sample do not do any R&D spending. Table 2, which focuses on those firms that do R&D, reports the finding of a precisely estimated effect, as predicted by the model. Cummins also agreed that it is potentially interesting to construct measures of the stock of intangibles. However, the paper relied on a model-based approach because accountants believe that company accounts data are not yet informative enough to allow such measures to be constructed with accuracy.

Christopher Sims observed that the authors' interpretation of advertising suggests that it, like investment in tangible capital, could just as well be taken as a left-hand-side variable. Estimating an equation with the ratio of advertising to capital as the dependent variable would help assess the theory presented in the paper. Sims was curious to know whether equations of the type estimated in the paper did a better job explaining advertising than explaining physical investment. William Dickens agreed with those who thought that R&D expenditure, even for information technology firms, may be very noisy and probably underestimates intangible investment. He cited as an example how, in its early days, Cisco Systems had acquired proprietary code by bartering Cisco routers for it. It seems almost certain that Cisco's intangibles greatly exceeded any estimate based on R&D expenditures.

William Brainard observed that the success of $\hat{Q}$ should not be seen as a success for the original q theory. One of the supposed virtues of the original theory was that it avoided the need for researchers to estimate either expected future profits or a risk-adjusted discount rate. Differences in market discount rates across time and across firms were taken to be reflected in market valuations. The paper found that market valuations are less useful for explaining investment than a simple measure consisting of analysts' earnings projections with an arbitrary discount rate, suggesting that these virtues are illusory. The $\hat{Q}$ regressions in the paper are closer in spirit to equations explaining investment by earnings or sales. Stephen Bond reported, however, that $\hat{Q}$ contains different information than is in those variables; in other work the authors have found that sales and cash flows appear to be uninformative conditional on $\hat{Q}$.

Edmund Phelps viewed the paper as suggesting that share prices are too noisy to predict long booms and slumps. He reported that, in contrast, his own work with Gylfi Zoega found that, at the aggregate level, share prices had considerable power to forecast long swings, but not year-to-year fluctuations. They also found that the stock market variable worked best with a lag of three or four years, a much longer lag than those explored by the authors.

William Nordhaus complimented the authors on a stimulating and informative paper. He thought, however, that the paper in some respects took a step backward from earlier work that had taken into account industry and cyclical variables in forecasting firms' earnings. He hoped that the authors would improve the earnings forecasts by basing them on more realistic assumptions about growth rates using econometrically estimated earnings equations. He particularly found troubling the assumption that the firm's growth rate returned to the economy's growth rate after five years. This would make it impossible for firms whose earnings are currently low, and whose payoffs on current investments are far in the future, to obtain high valuations in their approach. He also noted that the earnings forecasts used by the authors are not likely to be consistent with the view of intangibles they are testing. If R&D expenditures are a good measure of intangible investment, they should be so treated in the accounting. To implement such an approach, current net investment in R&D should be added to accounting earnings, and the net stock of R&D should be added to the denominator of an intangibles-augmented Q ratio.

Nordhaus raised the new and interesting possibility that the recent runup in stock valuations may reflect a change in the social appropriability of returns from inventions. Various studies have suggested that the total return to invention is much greater than the private return captured by the inventors. If inventors could capture the present value of all returns from their contributions to technological progress, the market values of technology-improving firms would be much higher. If recent advances in technology have been accompanied by an increase in the appropriability of returns, it could explain some of the rise in stock prices, but it would also imply higher profits than would be predicted on the basis of historical experience. Nordhaus believed it was difficult to judge whether current stock valuations reflect such an increase in appropriability. On the one hand, protection of intellectual property rights has strengthened. On the other hand, the product cycle seems to have shortened in the Internet era, and the potential returns from many recent inventions seem inherently less appropriable than those in the old economy. Olivier Blanchard remarked that the outcome of the Microsoft litigation would have clear significance for the future of appropriability.

References

Abel, Andrew B., and Olivier J. Blanchard. 1986. "The Present Value of Profits and Cyclical Movements in Investment." *Econometrica* 54(2): 249–73.

Arellano, Manuel, and Stephen Bond. 1991. "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations." *Review of Economic Studies* 58(2): 277–97.

———. 1998. "DPD for GAUSS: A Guide for Users." http://www.ifs.org.uk/staff/steve_b.shtml.

Blanchard, Olivier, Changyong Rhee, and Lawrence Summers. 1993. "The Stock Market, Profit, and Investment." *Quarterly Journal of Economics* 108(February): 115–36.

Blanchard, Olivier J., and Mark W. Watson. 1982. "Bubbles, Rational Expectations, and Financial Markets." In *Crises in the Economic and Financial Structure,* edited by Paul Wachtel. Lexington, Mass.: Lexington Books.

Blundell, Richard, and others. 1992. "Investment and Tobin's *q*: Evidence from Company Panel Data." *Journal of Econometrics* 51(1-2): 233–57.

Brainard, William, and James Tobin. 1968. "Pitfalls in Financial Model Building." *American Economic Review* 58(2): 99–122.

Brealey, Richard A., and Stewart C. Myers. 1996. *Principles of Corporate Finance,* 5th ed. McGrawHill.

Brown, Lawrence D. 1996. "Analyst Forecasting Errors and Their Implications for Security Analysis: An Alternative Perspective." *Financial Analysts' Journal* 52(January/February): 40–47.

Caballero, Ricardo J. 1999. "Aggregate Investment." In *Handbook of Macroeconomics,* Volume 1b, edited by John Taylor and Michael Woodford. Elsevier Science.

Campbell, John Y., and Albert S. Kyle. 1993. "Smart Money, Noise Trading and Stock Price Behaviour." *Review of Economic Studies* 60(l): 1–34.

Chirinko, Robert S. 1993a. "Business Fixed Investment Spending: Modeling Strategies, Empirical Results, and Policy Implications." *Journal of Economic Literature* 31(4): 1875–1911.

———. 1993b. "Multiple Capital Inputs, *Q*, and Investment Spending." *Journal of Economic Dynamics and Control* 17(5-6): 907–28.

Cummins, Jason G., and Matthew Dey. 2000. "Taxation, Investment, and Firm Growth with Heterogeneous Capital." Unpublished paper. New York University.

Cummins, Jason G., Kevin A. Hassett, and R. Glenn Hubbard. 1994. "A Reconsideration of Investment Behavior Using Tax Reforms as Natural Experiments." *BPEA, 2:1994,* 1–74.

———. 1996. "Tax Reforms and Investment: A CrossCountry Comparison." *Journal of Public Economics* 62(1-2): 237–73.

Cummins, Jason G., Kevin A. Hassett, and Stephen D. Oliner. 1999. "Investment Behavior, Observable Expectations, and Internal Funds." Unpublished paper. New York University.

Financial Accounting Standards Board. 1985. *Status of Statement No. 86, Accounting for the Costs of Computer Software to be Sold, Leased, or Otherwise Marketed.* Stamford, Conn.: Financial Accounting Standards Board (August).

Fried, Dov, and Dan Givoly. 1982. "Financial Analysts' Forecasts of Earnings: A Better Surrogate for Market Expectations." *Journal of Accounting and Economics* 4(2): 85–107.

Froot, Kenneth A., and Maurice Obstfeld. 1991. "Intrinsic Bubbles: The Case of Stock Prices." *American Economic Review* 81(5): 1189–1214.

Hall, Robert E. 1999. "The Stock Market and Capital Accumuation." NBER Working Paper 7180. Cambridge, Mass.: National Bureau of Economic Research (June).

Hayashi, Fumio. 1982. "Tobin's Marginal *q* and Average *Q*: A Neoclassical Interpretation." *Econometrica* 50(1): 213–24.

Hayashi, Fumio, and Tohru Inoue. 1991. "The Relation Between Firm Growth and *Q* with Multiple Capital Goods: Theory and Evidence from Panel Data on Japanese Firms." *Econometrica* 59(3): 731–53.

Horngren, Charles T., Gary L. Sundem, and John A. Elliott. 1996. *Introduction to Financial Accounting,* 6th ed. Prentice Hall.

Hubbard, R. Glenn. 1998. "Capital Market Imperfections and Investment." *Journal of Economic Literature* 36(l): 193–225.

Hulten, Charles R., and Frank Wykoff. 1981. "The Measurement of Economic Depreciation." In *Depreciation, Inflation, and the Taxation of Income from Capital,* edited by Charles R. Hulten. Washington: Urban Institute.

Keane, Michael P., and David E. Runkle. 1998. "Are Financial Analysts' Forecasts of Corporate Profits Rational?" *Journal of Political Economy* 106(4): 768–805.

Lach, Saul, and Mark Schankerman. 1989. "Dynamics of R&D and Investment in the Scientific Sector." *Journal of Political Economy* 97(4): 880–904.

Lev, Baruch, and Paul Zarowin. 1999. "The Boundaries of Financial Reporting and How to Extend Them." *Journal of Accounting Research* 37(2): 353–85.

Nickell, Stephen J., and Daphne Nicolitsas. 1996. "Does Innovation Encourage Investment in Fixed Capital?" London School of Economics Centre for Economic Performance Discussion Paper 309. London School of Economics (October).

Salinger, Michael, and Lawrence H. Summers. 1983. "Tax Reform and Corporate Investment: A Microeconometric Simulation Study." In *Behavioral Simulation Methods in Tax Policy Analysis,* edited by Martin S. Feldstein. University of Chicago Press.

Shiller, Robert J. 1981. "Do Stock Prices Move Too Much to be Justified by Subsequent Changes in Dividends?" *American Economic Review* 71(3): 421–36.